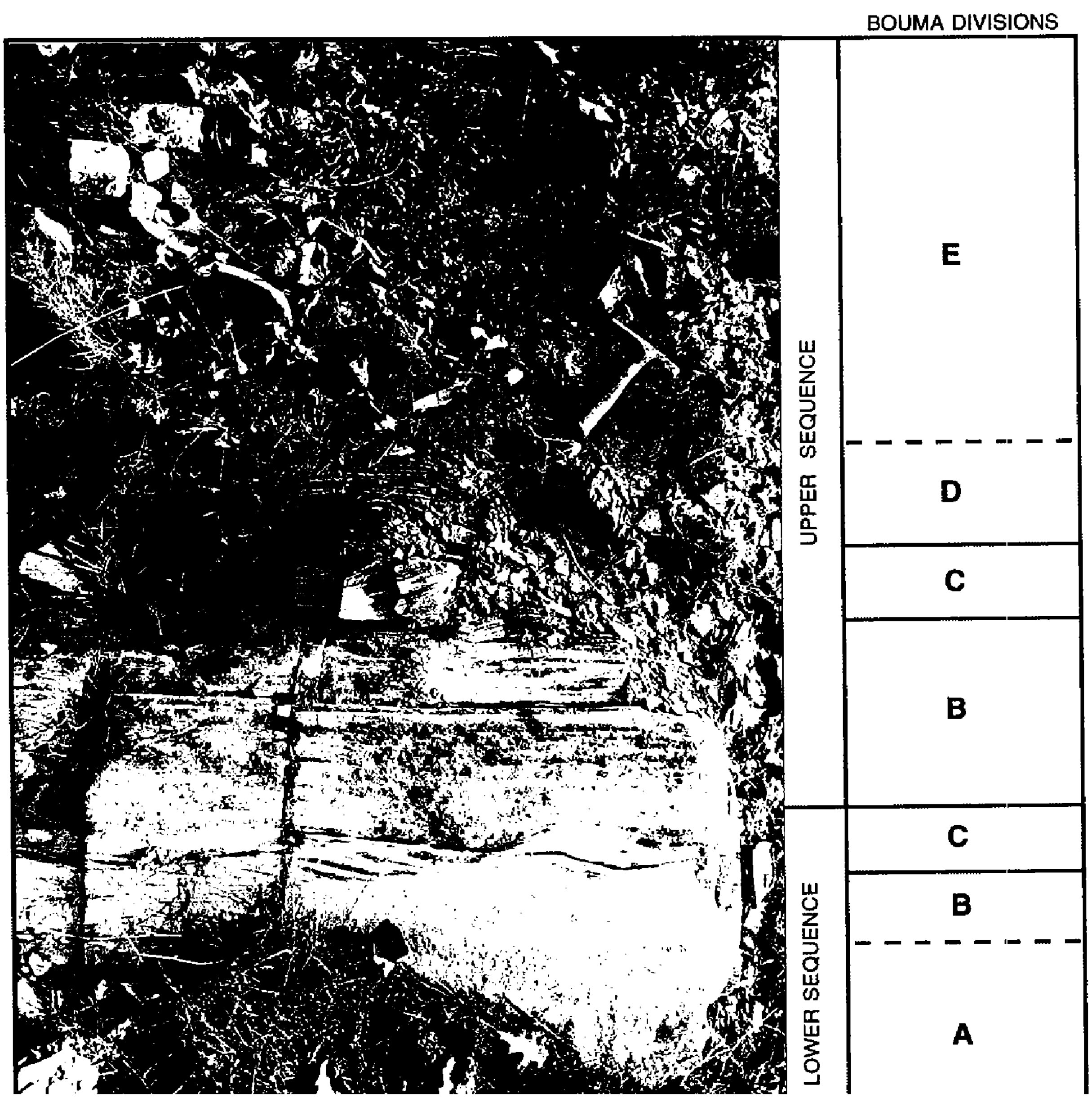
OKLAHOMA GEOLOGY

Oklahoma Geological Survey Vol. 53, No. 6 December 1993



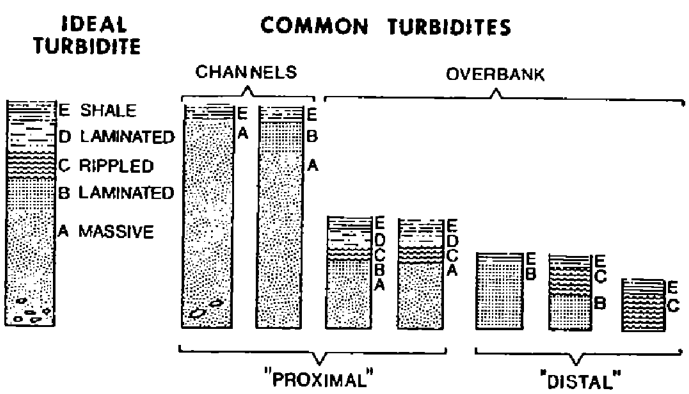
On the cover—

Incomplete Bouma Sequence, Atoka Formation, Ouachita Mountains

The cover photograph shows two partial Bouma sequences in a turbidite deposit of the Atoka Formation, Ouachita Mountains, Latimer County, Oklahoma. Shown, from lower to upper, are: a lower, graded massive sand interval (Bouma division A); a lower parallel laminated bed (Bouma division B); a ripple cross-laminated interval with climbing/migrating ripples (Bouma division C); a second division B; a second division C; a thinly interlaminated silt and shale (Bouma division D); and a dark-gray to black shale (Bouma division E). Division A indicates upper flow regime and quick deposition, division B records upper flow regime, and division C indicates a weaker current in the lower flow regime. Divisions D and E represent low-energy environments. In the photograph, stratigraphic up is to the top and current flow was to the southwest (left to right). Complete Bouma sequences are rare and the divisions seldom occur in reversed order. A diagram showing an ideal Bouma sequence is shown below.

The lower sequence (intervals A,B,C) was apparently an overbank deposit in the middle (proximal) fan section of a submarine fan system. The upper sequence (intervals B,C,D,E) also appears to be an

(continued on p. 226)



Comparison of the ideal turbidite bed sequence with those commonly found in turbidite sandstones. From Berg (1981), used by permission.

OKLAHOMA GEOLOGICAL SURVEY

CHARLES J. MANKIN
Director

KENNETH S. JOHNSON
Associate Director

OKLAHOMA GEOLOGY NOTES

Editor
Christie Cooper

Publications Assistant
Jo Lynn Pierce

Cartography
T. Wayne Furr, *Manager*
James H. Anderson
Charlotte Lloyd

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This publication, printed by the Oklahoma Geological Survey, Norman, Oklahoma, is issued by the Oklahoma Geological Survey as authorized by Title 70, Oklahoma Statutes 1981, Section 3310, and Title 74, Oklahoma Statutes 1981, Sections 231–238. 1,500 copies have been prepared for distribution at a cost of $708 to the taxpayers of the State of Oklahoma. Copies have been deposited with the Publications Clearinghouse of the Oklahoma Department of Libraries.

OKLAHOMA GEOLOGY

CONTENTS

OKLAHOMA
GEOLOGICAL
SURVEY

VOL. 53, NO. 6

DECEMBER 1993

THE CRUDE OIL PRICE COLLAPSE OF 1993: ASSET OR LIABILITY FOR OKLAHOMA?

Charles J. Mankin[1]

The petroleum industry in Oklahoma is being rocked once again by a collapse in world oil prices. Over the past two months, the price of crude oil in Oklahoma has declined by about $4.00 per barrel. This decline has been translated into much lower gasoline prices, bringing a smile to the transportation industry and the driving public. Some economists have noted that these lower transportation fuel costs will have a strong, positive effect on the nation's economy and, thus, presumably will benefit Oklahoma as well.

If low oil prices are so good for the economy, why aren't Oklahomans dancing in the streets? Perhaps it is because these short-term benefits derived from low gasoline prices spell long-term problems for the State's economy. For starters, a drop of $4.00 per barrel in the price of crude oil means a loss to the State's economy of $30 million per month, a decline of about 20% in the contribution that crude oil makes to our economy. That effect is now more pronounced than ever because most of Oklahoma's crude oil production is from leases operated by small companies and independent operators; thus, much of the revenue generated by that production remains in the State. In 1992, the value of crude oil production in Oklahoma was more than $1.9 billion.

The decline in crude oil prices also has a negative effect on Oklahoma's tax revenue. The $4.00 per barrel decrease translates into a loss of $2 million per month in Gross Production taxes to the State's treasury, assuming that all oil-producing wells continue to produce. Loss of production from wells that are shut-in or abandoned because of this price decline will increase this loss in revenue. While small in comparison to the total monthly tax collections, any reduction in revenue will have a negative effect on the public sector in these times of tight budgets.

It may be argued that, in the short term, the losses from crude oil production to both the State's economy and tax revenue will be more than offset by the positive effects of lower costs for transportation fuel. That argument might have some merit if Oklahoma's economy were particularly sensitive to transportation fuel cost. However, given the structure of the State's economy and the annual transportation fuel consumption in Oklahoma, that position is difficult to defend. Oklahoma's per capita consumption of transportation fuel is about 500 gallons per year, slightly below the national average of 550 gallons. Moreover, as reported in the December 20, 1993, issue of the *Oil and Gas Journal*, the constant-dollar price of gasoline is already the lowest it has been in history. In 1993, prior to the present decline, the average price in constant dollars (including taxes) was 76¢ per gallon, compared to 87¢ per gallon in 1973, the previous all-time low.

In addition, Oklahoma has an employment pattern that is low in manufacturing jobs compared with other sectors. Based upon information from the *Statistical Abstract of Oklahoma* (Wickham, 1993), nonfarm employment in the State is dis-

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[1] Director, Oklahoma Geological Survey.

tributed among services (27%), wholesale and retail trade (26%), government (25%), manufacturing (15%), construction (4%), and petroleum and mining (3%). In Oklahoma, the farming and the petroleum and mining components of the employment pattern are important to the State's economy: in 1991, the gross value of farm commodities was $3.8 billion and that of petroleum and mining was $5.6 billion. Fuel costs are 5% of total farm production expenses.

Nothing in this pattern indicates that Oklahoma's economy will benefit materially from low transportation fuel costs, but the effect of low crude oil prices will adversely impact the State's petroleum industry. It should be noted that the 34,000 producing oil leases in the State are equivalent to 34,000 small businesses. Each lease produces revenue, pays taxes, generates jobs, and pumps money into the local economy. Thus, each time a producing lease is abandoned, it has the same effect as the closing of a small business.

If world oil prices remain low, what longer-term consequences might be anticipated for the State? Of the 34,000 producing oil leases in Oklahoma, almost 22,000 produce less than 4 barrels of oil per day (Fig. 1). At present, a large number of these oil-producing leases are operating below cost in order to maintain access to the lease (the exact number is not known). Most lease agreements with royalty owners require continuing production beyond the primary term of the lease, normally two to five years, in order for the lease holder to maintain control of the producing property. Once production stops and the lease is abandoned, future access to the property can be obtained only through the negotiation of a new lease. If oil prices remain low for only a few weeks to a few months, many operators will attempt to continue operations in anticipation of better economic conditions after the current situation passes. The decision whether or not to continue depends upon the individual operator's economic situation and expectations for the future. If prices remain low, more operators will decide to abandon production. At least two-thirds of the producing oil leases in the State are very marginal producers, at less than 4 barrels per day, and the risk of large-scale abandonment is high.

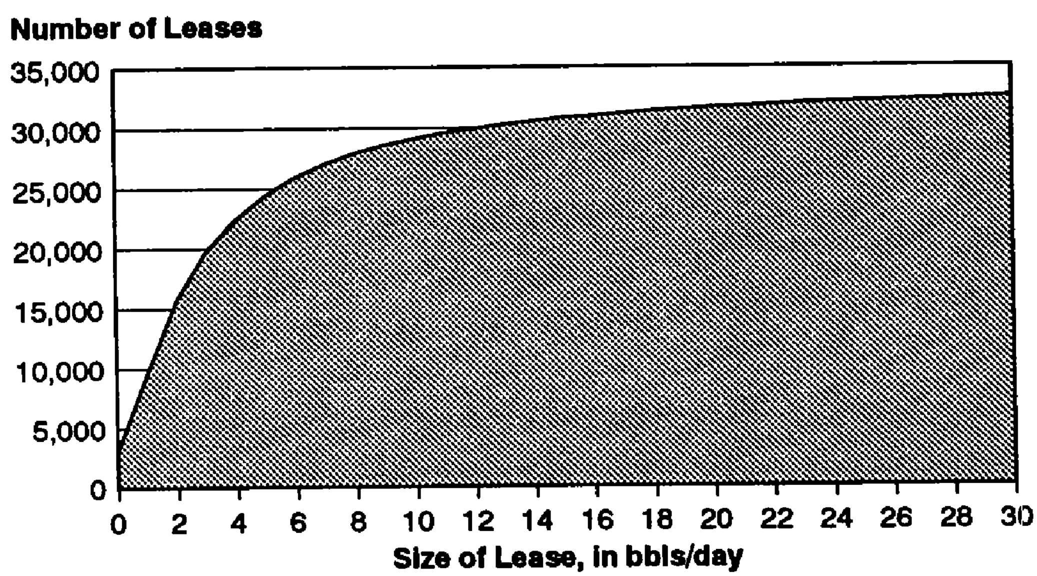

Figure 1. Cumulative number of producing oil leases vs. size of lease. Only those leases (32,463) that produce ≥30 barrels/day are shown on the chart. Source: NRIS (1993).

Unfortunately, information is not available to determine the number of producing oil wells on each lease in the State. However, if a uniform distribution of producing wells is assumed, then each lease would have about three producing wells. Thus, the 22,000 producing leases that seem to be especially at risk could have as many as 60,000 wells. Even if that number is too high by a factor of two, the number of wells at risk still is extremely high.

While the direct impact of low crude oil prices is felt initially in crude oil production in the State, its implications for natural gas and natural gas liquids cannot be ignored. Natural gas is used as a winter heating fuel in the residential and commercial markets, as a source of process heat in the industrial sector, and in gas turbines and steam boilers for electric power generation. Many individual operations in the industrial sector and in steam boilers for electric power generation could use fuel oil and residual oils in place of natural gas. Low crude oil prices lead to low prices for these "byproducts" of refining and, thus, constrain the market price for natural gas. Furthermore, low prices for gasoline discourage the use of alternative fuels and, thus, impede the conversion of vehicles to natural gas for transportation.

Natural gas liquids (e.g., butane and propane) also are affected by low oil prices. Many of the natural gas liquids are recovered from natural gas that is produced in association with crude oil. To the extent that those oil wells become unprofitable because of low oil prices, the associated gas also is at risk.

Thus, low oil prices not only have an impact on the oil producer; they also have a ripple effect throughout other sectors of the energy industry and eventually affect many members of the unsuspecting public. The obvious long-range consequence of continued low oil prices is the loss of the domestic petroleum industry. Given the importance of this industry to Oklahoma's economy and the absence of alternative economic opportunities, the aftermath of such a loss is too depressing to consider.

References Cited

Natural Resources Information System (NRIS), 1993, Oil and gas production data base: Available from Geological Information Systems, University of Oklahoma, Norman.

Oil and Gas Journal, 1993, U.S. real price of gasoline: Dec. 20, v. 91, no. 51, p. 23.

Wickham, Patricia (ed.), 1993, Statistical abstract of Oklahoma: Center for Economic and Management Research (CEMR), University of Oklahoma, Norman, and Oklahoma Department of Commerce, Oklahoma City, p. 86, 307.

Incomplete Bouma Sequence *(continued from p. 222)*

overbank deposit; however, deposition was probably in a middle to outer (more distal) part of the submarine fan. This is indicated by the lack of Bouma division A at the base of the upper sequence. The juxtaposition of these sequences was in response to channel location and flow regime.

Reference Cited

Berg, R. R., 1981, Exploration for sandstone stratigraphic traps [revised edition]: American Association of Petroleum Geologists Continuing Education Course Note Series No. 3, 47 p.

Mark W. Allen
EnecoTech
Tulsa, Oklahoma

NEW OGS PUBLICATION

CIRCULAR 95. *PETROLEUM-RESERVOIR GEOLOGY IN THE SOUTHERN MIDCONTINENT, 1991 SYMPOSIUM,* edited by Kenneth S. Johnson and Jock A. Campbell. 267 pages, 33 contributions. Price: Paperbound, $10.

From the editors' preface:

This is the fourth symposium in as many years dealing with topics of major interest to geologists and others involved in petroleum-resource development in Oklahoma and adjacent states. These symposia are intended to foster the exchange of information that will improve our ability to find and recover our nation's oil and gas resources. Proceedings of the first symposium (the Anadarko basin) were published as OGS Circular 90, proceedings of the second symposium (Late Cambrian–Ordovician geology of the southern Midcontinent) were published as OGS Circular 92, and proceedings of the third symposium (Source rocks in the southern Midcontinent) were published as OGS Circular 93.

To facilitate the exchange of information on petroleum occurrence, reservoir characterization, and petroleum recovery, the Oklahoma Geological Survey (OGS) and the Bartlesville Project Office of the U.S. Department of Energy (BPO-DOE) co-sponsored this symposium dealing with reservoir characterization and petroleum geology in the southern Midcontinent. The symposium was held on March 26–27, 1991, at the Oklahoma Center for Continuing Education, the University of Oklahoma, in Norman. This volume contains the proceedings of that symposium.

Research reported upon at the symposium focused on the geology and characterization of petroleum reservoirs in the southern Midcontinent. These reservoirs can be divided into three major categories: clastic, carbonate, and fractured reservoirs. The distribution and character of these reservoirs can be influenced by their depositional environment, sedimentation, diagenesis, karstification (in carbonates), and subsequent tectonic history. All these factors can affect reservoir heterogeneity and our ability to efficiently recover the hydrocarbons they contain. We hope that the symposium and these proceedings will bring such research to the attention of the geoscience and energy-research community, and will help foster exchange of information and increased research interest by industry, university, and government workers.

Nineteen papers were presented orally at the symposium, and they are presented here as full papers or abstracts. An additional 14 reports were given as posters, and they are presented here as short reports or abstracts. About 250 persons attended the symposium.

Circular 95 can be purchased over the counter or by mail from the Survey at 100 E. Boyd, Room N-131, Norman, OK 73019; phone (405) 325-3031, fax 405-325-7069. Add 10% to the cost of publication(s) for mail orders, with a minimum of 50¢ per order.

GSA SOUTH-CENTRAL SECTION MEETING
Little Rock, Arkansas, March 21–22, 1994

The Arkansas Geological Commission, the Department of Earth Sciences of the University of Arkansas at Little Rock, and the geology department of Arkansas Tech University will sponsor the 1994 meeting of the South-Central Section of the Geological Society of America. The meeting will be held jointly with the Texas Section of the National Association of Geology Teachers (NAGT) and the South-Central Section of the Paleontological Society.

The following symposia and field trips are planned:

Symposia

Ouachita Mountains of Arkansas and Oklahoma
Industrial Minerals, with Emphasis on Diamonds
New Madrid Seismic Zone
Hydrogeology and Environmental Geology
Planetary Geology in Geological Education
GIS Technology for the Environmental Earth Sciences

Field Trips

Karst Hydrogeology and Environmental Geology of the Southern Ozarks, Arkansas and Missouri, *March 19–20*
Eastern Ouachita Mountains, *March 20*
Crater of Diamonds State Park, *March 20*
Center for Earthquake Research and Information at Memphis, Tennessee, *March 20*
Spillway Cut at DeGray Lake. The Jackfork Formation of Arkansas: A Test of the Walker–Mutti–Vail Models for Deep-Sea Fans, *March 23*
Industrial Minerals, Central and West-Central Arkansas, *March 23*
ALCOA—Bauxite Mines, *March 23*

For further information about the meeting, contact William V. Bush, Arkansas Geological Commission, 3815 W. Roosevelt Rd., Little Rock, AR 72204; (501) 324-9165, fax 501-663-7360. *The preregistration deadline is February 18.*

SIMPSON AND VIOLA GROUPS WORKSHOP
Norman, Oklahoma, March 29–30, 1994

A workshop on "Simpson and Viola Groups in the Southern Midcontinent," cosponsored by the Oklahoma Geological Survey and the Bartlesville Project Office of the U.S. Department of Energy, will be held March 29–30, 1994, at the University of Oklahoma in Norman.

The Simpson and Viola Groups (Ordovician in age) are major sandstone and carbonate reservoirs that have already yielded large volumes of oil and gas, and they have a great potential for yielding additional hydrocarbons by the use of advanced-recovery technologies. The workshop will present discussions and reports on surface or subsurface studies dealing with the geologic setting, depositional environments, and diagenetic history of these strata and/or reservoirs, as well as reservoir characterization and the engineering factors that influence hydrocarbon accumulation or hydrocarbon production.

Provisional titles and speakers are listed below:

March 29

Simpson Group Stratigraphy of the Southern Midcontinent, by Raymond W. Suhm, Consultant, Oklahoma City

Contrasting Sedimentation Inside and Outside of the Southern Oklahoma Aulacogen during Middle and Late Ordovician Times, by Rodger E. Denison, University of Texas at Dallas

Major Simpson and Viola Oil and Gas Reservoirs in Oklahoma, by Robert A. Northcutt, Consultant, Oklahoma City, and Kenneth S. Johnson, Oklahoma Geological Survey

Stratigraphy and Petroleum Production of the Simpson, Viola, and Maquoketa in Kansas and Nebraska, by Marvin P. Carlson, Nebraska Geological Survey, and K. David Newell, Kansas Geological Survey

Tobosa Basin-Related Sediments of West Texas, by David V. LeMone, University of Texas at El Paso

Facies and Karst Development in the Viola Limestone in Southern Oklahoma, by Zuhair Al-Shaieb and Jim Puckette, Oklahoma State University

Viola Fractures—Friend or Foe in Horizontal-Drilling Programs, by Carlos Gonzales, G&G International Consultants, Oklahoma City

The Viola Group as a Petroleum System—Implications for Horizontal-Drilling Prospects, by D. A. Wavrek, University of South Carolina, and M. A. Garcia, ARCO, Houston

Geochemical Characteristics of Viola Oils and Source Rocks, by R. Paul Philp, H. Wang, J. Allen, and A. Bishop, University of Oklahoma

Source-Rock Characteristics of the Viola Springs Formation on the South Flank of the Arbuckle Anticline, by Alton Brown and Joe Senftle, ARCO, Plano, Texas

March 30

Ordovician Sea-Level Changes as Seen from an Off-Shore, North American Perspective, by Stanley C. Finney, California State University, Long Beach

Structural and Stratigraphic Factors Which Influence Simpson Group Production in Central Oklahoma, by Paul W. Smith, Norman, Oklahoma

Stratigraphy, Paleogeomorphology, and Structure of Simpson, Viola, and Mississippian Strata, and Their Integral Relationships to Second Wilcox Production in Lincoln and Logan Counties, Oklahoma, by Kurt Rottmann, Beard Oil Co., Oklahoma City

Facies, Depositional Environments, and Reservoir Properties of the Simpson Group in Scully Field (Marion County, Kansas), by Jim Mazzullo and Martha McRae, Texas A&M University

Middle Ordovician Ironstones in Kansas: Subsurface Markers of Paleoshorelines for the Midcontinent, by Pieter Berendsen and John D. Doveton, Kansas Geological Survey

Simpson–Arbuckle Contact Revisited in Northwest Oklahoma County, Oklahoma, by Michael D. Allison, Consultant, Gainesville, Texas, and Bob Allen, Kabodi, Inc., Ardmore, Oklahoma

Influence of Vertical Permeability Barriers on the Ultimate Recovery from Oil Creek Reservoirs, by James M. Forgotson and Roy M. Knapp, University of Oklahoma; Paul W. Smith, Norman, Oklahoma; and Huaibo Liu, University of Oklahoma

Characterization of High-Molecular-Weight Paraffins in Simpson Group Reservoirs—Implications for Advanced-Recovery Techniques, by N. F. Dahdah and D. A. Wavrek, University of South Carolina

Diagenetic Banding as a Sealing Mechanism in Bromide Sandstone Reservoirs in Central Oklahoma, by James Puckette, Azhari Abdalla, and Zuhair Al-Shaieb, Oklahoma State University

Optimized Recovery from Simpson Sandstones in the Noble Townsite Field, by James M. Forgotson and Roy M. Knapp, University of Oklahoma; Paul W. Smith, Norman, Oklahoma; and Jorge Luis Carmona, University of Oklahoma

Poster Session, March 29

Sequence Stratigraphic Model for Simpson Group of the Southern Midcontinent: The Key to a New Stratigraphic Play, by Magell P. Candelaria, ARCO, Midland, Texas; C. Robertson Handford, ARCO, Plano, Texas; and Christy L. Reed, ARCO, Midland, Texas

Correlation and Distribution of Reservoir and Sealing Facies Within the Viola Formation, South-Central Kansas, by K. David Newell, Kansas Geological Survey

Controls of Quartzarenite Diagenesis, Simpson Group, Oklahoma: Implications for Reservoir-Quality Prediction, by Mark E. Mathisen, Mobil E&P Technical Center, Dallas

Hydrocarbon Microseepage Signature of the Clarita Prospect, Coal County, Oklahoma, by Daniel C. Hitzman, Geo-Microbial Technologies, Inc., Ochelata, Oklahoma

Wettability Alteration in Reservoir Rocks Due to Polar Constituents in Crude Oil, by Anuj Gupta, University of Oklahoma

Reservoir Analysis of a Horizontal Well Completion: Viola Limestone "Chocolate Brown Zone," Marietta Basin, Oklahoma, by Brian Roux and Magell P. Candelaria, ARCO, Midland, Texas

Seismic Evidence of the Development of Abrupt Sedimentary Buildups in the Simpson Group of the Marietta Embayment, Oklahoma, by Gary L. Garner, Garner Resources, Inc., Oklahoma City

Shallowing-Upward Events and Their Implications for Internal Correlations and Depositional Environment of the St. Peter Sandstone in the Forest City Basin, Northeast Kansas, by Lynn Watney, Kansas Geological Survey; Bryan Stephens, Texaco, New Orleans; and David Newell, Kansas Geological Survey

Tobosa Basin Karsting in West Texas, by David V. LeMone, University of Texas at El Paso

S.O.A.P. Data Base—Forecasting Trends in Crude-Oil Quality, by S. Neeley and D. A. Wavrek, University of South Carolina

Stratigraphy and Depositional Environments of the Middle Ordovician Everton Formation, St. Peter Sandstone, Joachim Dolomite, and Plattin and Kimmswick Limestones (Simpson Group Equivalents), Northern Arkansas, by William W. Craig, University of New Orleans

Advance registration (prior to March 4) is $50, which includes two lunches and a copy of the proceedings. Late and on-site registration will be $65 per person. Lodging will be available on the OU campus or at local motels.

For more information, contact Kenneth S. Johnson, General Chairman, Oklahoma Geological Survey, University of Oklahoma, 100 E. Boyd, Room N-131, Norman, OK 73019; phone (405) 325-3031, fax (405) 325-7069.

AESIS on CD-ROM Available at OU Geology Library

The Australian Mineral Foundation has presented a first release of the Australian Earth Sciences Information System (AESIS) on CD-ROM to the Youngblood Energy Library of the University of Oklahoma, in appreciation of the assistance given to the Foundation by Claren Kidd, librarian, during her sabbatical year in Australia when she gathered information on about 2,200 university theses for AESIS.

This GEOPAC CD-ROM actually contains six data bases: AESIS, which is the main file and is the Australian national geoscience reference system, and five other data bases from three state departments covering mostly their open-file and unpublished reports. These data bases are: MINFINDER, COREFINDER, and TITLEFINDER from the New South Wales Department of Mineral Resources; SAMREF from the South Australian Department of Mines and Energy; and QERI from the Queensland Department of Minerals and Energy.

The AESIS data base covers Australia-wide mineral- and petroleum-documented information, both published and unpublished, from exploration through to development, inclusive of mining, extractive metallurgy, energy, and associated areas such as analytical chemistry, climatology, computer applications, remote sensing, management, policy and legislation, and the growing literature on environmental protection. Some 40% of the 110,000 references in AESIS covers open-file and unpublished reports from state and federal agencies.

The data bases all have appreciable depth covering most of the post-World War II documented material, especially in exploration. AESIS has extended this depth through a program covering geosciences material in all major Australian learned-society publications right from their inception.

For more information, contact Claren Kidd, Librarian, Youngblood Energy Library, University of Oklahoma, Energy Center, Room R-220, Norman, OK 73019; phone (405) 325-6451, fax 405-325-7069; E-Mail: CKIDD@UOKNOR.EDU.

UPCOMING MEETINGS

Lunar and Planetary Science Meeting, March 14–18, 1994, Houston, Texas. Information: LeBecca Simmons, Publications and Program Services Dept., Lunar and Planetary Institute, 3600 Bay Area Blvd., Houston, TX 77058; (713) 486-2158, fax 713-486-2160.

Geological Society of America Penrose Conference, "Interdisciplinary Perspectives on the History of the Earth Sciences," March 19–21, 1994, San Diego, California. Information: Léo F. Laporte, Earth Sciences Dept., University of California, Santa Cruz, CA 95064; (408) 459-2248, fax 408-459-3074.

Ground-Water Ecology, International Meeting, March 27–30, 1994, Atlanta, Georgia. Information: John Simons, U.S. Environmental Protection Agency, Ground-Water Protection Division, Mail Code WH550G, 401 M St., S.W., Washington, DC 20460; (202) 260-7091.

Application of Geophysics to Engineering and Environmental Problems, Seventh Annual Symposium, March 27–31, 1994, Boston, Massachusetts. Information: Mark Cramer, Environmental and Engineering Geophysical Society, P.O. Box 4475, Englewood, CO 80112; (303) 771-6101.

American Institute of Hydrology, Annual Meeting, "Toxic Substances and the Hydrologic Sciences," April 10–13, 1994, Austin, Texas. Information: American Institute of Hydrology, 3416 University Ave., S.E., Minneapolis, MN 55414; (612) 379-1030, fax 612-379-0169.

Mid-America Paleontology Society, National Fossil Exposition: Dinosaurs, April 15–17, 1994, Macomb, Illinois. Information: Marvin Houg, 3330 44th St., N.E., Cedar Rapids, IA 52402; (319) 395-0577.

Geological Society of America Penrose Conference, "Triple Junction Interactions at Convergent Plate Margins," April 21–26, 1994, Eureka, California. Information: Lois Elms, 4881 Evening Sun Lane, Colorado Springs, CO 80917; (719) 597-9201, fax 719-591-4852.

SEPM, Permian Basin Section, Annual Meeting, April 22–24, 1994, Ruidoso, New Mexico. Information: Bob Lindsay, Chevron U.S.A. Production Co., P.O. Box 1150, Midland, TX 79702; (915) 687-7233, fax 915-687-7666.

New Mexico Conference on the Environment, "Environmental Economics: Prevention vs. Cleanup," April 24–26, 1994, Albuquerque, New Mexico. Information: Conference Coordinator, New Mexico Environment Dept., 1190 St. Francis Dr., P.O. Box 26110, Santa Fe, NM 87502; (505) 827-2850, fax 505-827-2836.

AAPG Hedberg Research Conference, "Near-Surface Expressions of Hydrocarbon Migration," April 24–27, 1994, Vancouver, British Columbia. Information: Continuing Education Dept., American Association of Petroleum Geologists, Box 979, Tulsa, OK 74101; (918) 584-2555, fax 918-584-0469.

Third International Conference on the Abatement of Acidic Drainage, April 25–29, 1994, Pittsburgh, Pennsylvania. Information: D. Lowanse, U.S. Bureau of Mines, P.O. Box 18070, Pittsburgh, PA 15236; (412) 892-6708, fax 412-892-4067.

NOTES ON NEW PUBLICATIONS

Maps Showing Areal Extent of Selected Paleozoic Shales in the Northern Midcontinent, U.S.A.

The shale maps in this publication were prepared as an aid to regional appraisal and prospecting for Mississippi Valley-type lead/zinc sulfide deposits in the region. Compiled by W. P. Pratt, this USGS miscellaneous field studies map contains seven maps showing the subsurface extent of eight principal Paleozoic shale units ≥5 ft thick. The lowest unit mapped is the Upper Cambrian Davis Formation and equivalents, and the highest is the Pennsylvanian Cherokee Group and equivalents. Latitude 36° to 46°, longitude 88° to 100°. Scale 1:1,000,000 (1 in. = ~16 mi). Each sheet measures 42½ × 52 in.

Order MF-1835-H from: U.S. Geological Survey, Map Distribution, Box 25286, Bldg. 810, Federal Center, Denver, CO 80225. The price is $26.25; add 25% to the price for foreign shipment.

Strategic and Critical Minerals in the Midcontinent Region, United States — Chapter D: Paleohydrology of the Central United States

D. G. Jorgensen describes the paleohydrology of the central United States, especially the Ozark uplift and the Ouachita and Anadarko basins, in this 32-page USGS bulletin, edited by W. C. Day and D. E. Lane. Ground-water flow systems, water chemistry, and hydraulic properties of aquifers can be evaluated or estimated from paleohydrologic analysis, reconstruction of paleogeography, paleoclimate, and past heat-flow conditions to infer the hydrologic cycle.

Order B 1989-D from: U.S. Geological Survey, Books and Open-File Reports Section, Federal Center, Box 25425, Denver, CO 80225; phone (303) 236-7476. The price is $2.50; add 25% to the price for foreign shipment.

Quaternary Geologic Map of the Ozark Plateau 4° × 6° Quadrangle, United States

This USGS miscellaneous investigations series map was edited and integrated by G. M. Richmond and D. L. Weide. Prepared in cooperation with the Missouri Department of Natural Resources, Kansas Geological Survey, Arkansas Geological Commission, Illinois State Geological Survey, and Oklahoma Geological Survey, the map contains state compilations by J. W. Whitfield, R. A. Ward, J. E. Denne, D. F. Holbrook, W. V. Bush, J. A. Lineback, K. V. Luza, K. M. Jensen, and W. D. Fishman. Latitude 36° to 40°, longitude 90° to 96°. Scale 1:1,000,000 (1 in. = ~16 mi). Color sheet measures 50 × 35 in.

Order I-1420 from: U.S. Geological Survey, Map Distribution, Box 25286, Bldg. 810, Federal Center, Denver, CO 80225. The price is $3.75; a $1 handling charge is applied to orders of less than $10. Add 25% to the price for foreign shipment.

OKLAHOMA ABSTRACTS

The following abstracts were presented as part of the Geology Section program at the Oklahoma Academy of Science 82nd annual meeting, Ada, Oklahoma, November 12, 1993.

Marine Condensed Sections in Late Carboniferous and Early Permian Strata

DARWIN R. BOARDMAN, II, School of Geology, Oklahoma State University, Stillwater, OK 74078

Marine condensed sections represented by dark organic rich shales and glauconitic, phosphatic carbonates have been identified in Late Carboniferous and Early Permian strata of the Midcontinent. These marine condensed sections are characterized by their great lateral extent and abundant pelagic fauna (conodonts >100 platforms/kilogram).

Early and middle Virgilian marine condensed sections represented by black, fissile, phosphatic shales (core shales of Heckel, 1986) have been identified in the basal Robbins Shale (Douglas Group), Heebner Shale, Queen Hill Shale, Larsh-Burroak Shale, Holt Shale (Shawnee Group) and the Shanghai Creek Shale basal Wabaunsee Group). All of these shales contain an abundant offshore conodont fauna (*Gondolella–Idioprioniodus* Biofacies), as well as other pelagic taxa such as radiolarians, and ammonoids.

Late Virgilian marine condensed sections represented by gray to dark gray nonfissile, and slightly phosphatic shales have been identified in Burlingame Limestone, Wakarusa Limestone, basal Harveyville Shale (associated with Reading Limestone), Willard Shale (associated with Elmont Limestone), Wamego Shale (associated with Tarkio Limestone), and basal Dry Shale (associated with Dover Limestone). These shales contain locally abundant ammonoids along with abundant offshore conodonts (*Streptognathodus* Biofacies). The Brownville Limestone contains a marine condensed section at the top of the member and is characterized by abundant offshore conodonts (*Streptognathodus* Biofacies).

The Admire Group contains only one marine condensed section (Five Point Limestone). This marine condensed section is a carbonate marine condensed section with abundant glaucony, phosphatized molluscs, and abundant conodonts (*Streptognathodus* Biofacies).

The Council Grove Group contains several black shale marine condensed sections: two in the upper Americus Limestone, two in the middle and upper Hughes Creek Shale, two in the Bennett Shale, and one near the base of the Neva Limestone. All of these occur in northern Kansas and Nebraska. In southern Kansas and Oklahoma these marine condensed sections are represented by carbonates with abundant glaucony, phosphatized molluscs, black shale whisps, and abundant offshore conodonts (*Streptognathodus* Biofacies). In addition, the Cottonwood Limestone is represented by a carbonate marine condensed section similar to those previously mentioned from southern Kansas.

The only marine condensed section in the Chase Group occurs at the base of the Florence Limestone. This is a shaly, glauconitic, phosphatic carbonate with abundant offshore conodont fauna dominated by *Streptognathodus.*

Although many other sedimentary sequences have been identified in this stratigraphic interval, the water depths and rates of sedimentation were such that no marine condensed section is present in the modern outcrop belt. Additional studies from available cores and gamma-ray logs will focus in tracing these sequences from the outcrop belt to the basin.

Deformation Stage of the Southern Oklahoma Aulacogen: Evidence for Strike-Slip Movement from the Collings Ranch and Deese Conglomerates of the Arbuckle Mountains

IBRAHIM CEMEN, KEVIN PYBAS, CRAIG STAFFORD, and ZUHAIR AL-SHAIEB, School of Geology, Oklahoma State University, Stillwater, OK 74078

Aulacogens are first defined by Schatski (1946) as large long-lived graben-like tectonic depressions located at right angles to major mountain chains. However, major contributions to our understanding of the aulacogens were made during the 1970s and 1980s. Aulacogens are initiated as failed arms during the continental breakup. When fully developed they show three major stages of development: (a) rifting (graben or incipience) stage; (b) subsidence (sagging or downwarping) stage; and (c) deformation (compressional or inversion) stage. The southern Oklahoma aulacogen experienced these three major stages of development in Paleozoic.

The tectonic style during the deformation stage of the southern Oklahoma aulacogen is recorded, among other geological features, by the Pennsylvanian conglomerate units of the Arbuckle Mountains. Two of these conglomerates are the Middle Virgilian Collings Conglomerate, exposed along the Washita Valley fault zone in the Turner Falls area, and the Desmoinesian Deese Conglomerate, exposed in the Mill Creek syncline area between the Reagan and Mill Creek fault zones.

We have investigated clast size, clast geometry, clast content, primary sedimentary structures, petrography, petrology, and diagenesis of the two conglomerate units; as well as the geometric relationship of their basins with the nearby faults. Our data suggest that the two conglomerates were deposited in basins formed by strike-slip movements. The Collings Ranch Conglomerate was deposited in a basin which was formed as a result of a left-stepping along the nearby Washita Valley strike-slip fault zone. The Deese Conglomerate was deposited in a basin which was formed due to combined effect of strike-slip and dip-slip movements along the Reagan and Mill Creek fault zones. In the Collings Ranch basin, the deposition was accomplished primarily by channel fill and sieve deposits in the proximal region of the fan. The Deese Conglomerate deposited as alluvial fan or possibly a fan-delta complex which included several channel deposits while in the deeper parts of the basin fine-grained materials and limestones were being deposited.

These observations and their possible interpretations suggest to us that the Washita Valley, Mill Creek and Reagan fault zones have experienced substantial strike-slip motion during the deformation stage of the southern Oklahoma aulacogen.

Facies Analysis of the Pennsylvanian Cottage Grove Sandstone ("Osage/Layton Sand")—Conoco 33-5 Well, East Newkirk Field, Kay County, Oklahoma

JAMES R. CHAPLIN, Oklahoma Geological Survey, 100 E. Boyd, Room N-131, Norman, OK 73019

Detailed sedimentological and stratigraphic characterization using wireline logs and cores is required to understand the heterogeneity found in deltaic reservoirs and for planning advanced production methods and related enhanced oil recovery processes.

The lithostratigraphic framework characterized in the Conoco 33-5 well ranges from the Barneston Limestone (Chase Group/Early Wolfcampian) at the top, to the Lagonda Sandstone Member of the Senora Formation (Cabaniss Group/Desmoinesian) below. The stratigraphic interval comprises a total stratigraphic thickness of 3,067.1 ft (934.8 m) of which 1,373.5 ft (418.6 m) was cored.

Facies observed in cores were correlated with their appropriate geophysical log signatures; in uncored wells, facies were identified from log signatures that enabled the subsurface stratigraphic units to be correlated with outcrop analogs. Core-to-log correlations are being used in a series of stratigraphic sections to delineate depositional environments throughout the test hole facility and in selected parts of the immediate area.

One of the main sandstone reservoirs of interest in the cored sequence is the upper part of the "Osage/Layton Sand" interval (Chanute Formation/Cottage Grove Sandstone Member/Missourian). Eight core facies, or reservoir zones, are recognized in this 123 ft (37.5 m) thick sandstone-dominated sequence. The core facies boundaries are defined by lithofacies, sedimentary structures, and wireline log responses, particularly gamma-ray log markers. Compositionally, the eight core facies consist of, in ascending order: *Core facies 1*—1.4 ft (0.43 m), sandstone, very fine-grained, noncalcareous, with carbonaceous shale laminae. *Core facies 2*—2.2 ft (0.67 m), interlaminated, fissile, black shale (60%) and noncalcareous, very fine-grained sandstone (40%). *Core facies 3*—27.5 ft (8.38 m), sandstone (98%) very fine-grained, very calcareous with very thin bands of interlaminated shale (2%) and ripple-marked sandstone. *Core facies 4*—3.4 ft (1.04 m), interlaminated noncalcareous, very fine-grained sandstone (60%) and shale (40%). *Core facies 5*—12.7 ft (3.87 m), sandstone (98%), very fine-grained, noncalcareous with wavy laminae of shale (2%); conglomeratic lag at base. *Core facies 6*—53.1 ft (16.2 m), sandstone (99%), very fine-grained, noncalcareous, massive, with abundant carbonized plant fragments. *Core facies 7*—10.9 ft (3.3 m), sandstone (98%), very fine-grained, noncalcareous with abundant carbonized plant fragments; rare beds of shale (2%) showing low-angle crossbedding. *Core facies 8*—9.9 ft (3.0 m), sandstone, very fine-grained, noncalcareous, massive with abundant carbonized plant fragments.

Preliminary data suggest the Cottage Grove Sandstone Member was deposited as a regressive sandstone body in a fluvial-dominated, wave-influenced delta front setting. Closely spaced distributary channels formed a continuous delta front composed locally of coalesced distributary mouth bar sands that were reworked after distributary channel abandonment. The Cottage Grove Sandstone is bounded by hot, potassium-rich, transgressive black shales.

Genetic Sequence Stratigraphy, Systems Tracts, and Mapping Strategies for the Middle and Upper Pennsylvanian of Oklahoma and North-Central Texas

ARTHUR W. CLEAVES, School of Geology, Oklahoma State University, Stillwater, OK 74078

Subsurface mappers of Pennsylvanian fluvial-deltaic, cyclothemic facies tracts in shelf areas of north-central Texas and Oklahoma basins have commonly utilized the *format method* for defining genetic stratigraphic intervals. This approach involves identifying regionally continuous, presumably marine transgressive, carbonate markers and generating a variety of map types based on the lithologic contents of the interval contained between the tops or bottoms of these markers. It is assumed that there are no widespread disconformity surfaces either within or between each of the format units. Facies change is invoked to explain all lateral and vertical lithologic changes on the shelf.

With the recent development of sequence stratigraphy, it has become apparent that major eustatic changes of sea level had a strong influence on the overall pattern of Pennsylvanian cyclic sedimentation. Shelf-wide disconformity surfaces and marine transgressive, deep-water black shale units are two consequences of glacially induced eustasy that can be employed to construct mappable genetic units. The black shale-defined units, which can be recognized from natural gamma-ray logs, are much easier to identify with genetic intervals 50–500 feet thick than are the erosional surfaces. Each of these *genetic stratigraphic sequences* will contain a disconformity in the middle of the unit (beneath the incised valley-fill channel) and be bounded by the uranium-rich black shales. One must be careful to identify both the updip, highstand fluvial-deltaic reservoir fairway and the downdip, lowstand deltaic-submarine fan fairway for each of the sequences.

Morrowan Pressure Regimes in the Anadarko Basin

J. PUCKETTE, Z. AL-SHAIEB, A. ABDALLA, and A. RICE, School of Geology, Oklahoma State University, Stillwater, OK 74078

Reservoir fluid pressures are classified with respect to a reference pressure-depth gradient of 0.465 psi/ft. Reservoirs whose pressure-depth gradients exceed 0.465 psi/ft are considered overpressured. Those with gradients less than 0.465 psi/ft are classified as underpressured. Reservoirs whose gradients approach or equal 0.465 psi/ft are considered normally pressured.

The analysis of over 28,000 pressure measurements from the Anadarko basin and Hugoton embayment in Oklahoma and Texas reveals that this region contains over-, normal-, and underpressured reservoirs. Within the Morrowan interval, the three types of pressure regimes are easily identified.

Morrowan reservoirs found below 8,000 to 10,000 ft deep in the central and eastern part of the Anadarko basin are generally overpressured. Pressure data for reservoirs located on the northern shelf of the basin delineate a transition from under- to normal- to slight overpressure. Morrowan reservoirs in the Hugoton embayment are typically underpressured.

Integration of reservoir geometry and distribution, pressure, and fluid data reveals the Morrowan reservoirs are often discrete compartments with distinct pressure regimes. In the North Geary area of the Watonga Trend, thicker channel-fill sandstones have lower reservoir pressures and different gas/oil ratios than shallower thin delta-fringe sandstones. Upper Morrowan Chert Conglomerate reservoirs within the same stratigraphic interval display lateral changes in pressure which identify the distinct facies-related compartments.

Data from the Texas and Oklahoma Panhandles indicate that the Morrowan reservoirs also are distinctly underpressured. In the Keyes field area, the Keyes Sandstone is abnormally underpressured and has different gas/liquid ratios than the shallower Upper Morrowan sandstones.

The various pressure regimes of the Morrowan reservoirs indicate inter-reservoir pressure equalization has not occurred and that the reservoirs have remained isolated compartments over geologic time.

Teaching Evolution Using General Systems Theory

VERNON P. SCOTT, School of Geology, Oklahoma State University, Stillwater, OK 74078

The teaching of evolution in the public schools elicits skepticism and occasional hostility on the part of students whose religious views presuppose the creation of life by miraculous means. The traditional methods of teaching evolution usually fail to sway authoritative beliefs because, lacking a time machine, the past is not personally encountered and therefore, any evidence can be dismissed whether it be circumstantial, documentary, or experimental. But there is another evidence for evolution that significantly impacts a person's life—philosophic evidence. Approaching evolution as a philosophy of change, rather than from biologic specifics, enables people to understand it based on the changes they see evidenced in their own lives and the society about them. After this preparation, biologic evolution can be taught as a subset of general evolution.

General systems theory is a composite of many philosophical notions such as information theory, game theory, decision theory, cybernetic theory, catastrophe theory, and, more recently, chaos theory. Evolutionary aspects of general systems theory can be illustrated using statistical curves to define populations and their stability. A "normal curve" represents a dynamic equilibrium between entering and exiting elements of a population—fluxes. To describe the basic types of change possible in any given population, I propose a flux nomenclature. *Equiflux* represents a stable population displaying minimal change through time. *Transflux* represents an unstable population that undergoes change. There are several forms of transflux: *uniflux* (growth or reduction of a population through time), *biflux* (shifts in the variation of a population), *triflux* (fission or fusion of a population), and *multiflux* (complex variations of the foregoing that cause a statistical hierarchy to diverge or converge). To these, I add five cyclic variants under the general caption of *cycloflux*. These basic types of change can be illustrated by statistical graphics with examples drawn from history, personal experience, free enterprise, etc. Once people understand and accept that these types of change are more or less universal, then it becomes possible to pose the key question: Why would biologic change be an exception?

Use of Common Computer Graphic Programs for Simple Geologic Contouring Applications in the Classroom

TIM WALSH, Oklahoma State University, Stillwater, OK 74078

Numerous mapping or charting applications that may use contours or require their creation exist in the classroom, such as isobaric, topographic, structural or isopach maps. The student use of computer graphic programs for the creation of contours can provide a variety of immediate benefits. These may include increased quality of output, increased interest and degree of participation, and improvements in accuracy and precision of work.

The recent advancements in the power of microcomputers have opened avenues for graphic applications previously possible only with higher-end more expensive computer systems, specific contouring software and graphic workstations. When combined with relatively inexpensive general purpose computer graphic programs, small computers can provide users (students) with drafting capacities far exceeding the norm. Small computer systems in schools and universities are becoming increasingly accessible, although some creativity and open-mindedness may be necessary. The use of journalism computer labs or computers in the art department for science instruction is unusual, but these systems may have open time and the potential to have the appropriate graphic programs installed.

The majority of common computer graphic programs may be divided into two broad categories; bitmapped (paint) and object-oriented (draw/vector). Bitmapped programs are usually the least expensive and easiest for users to learn but are more limited in their drafting capacity and are normally not recommended for contouring applications. Object-oriented programs can provide the user with much better graphic controls and output. Unfortunately these programs may also be more intimidating to a student or beginner. Contours, or curves, in this category of program may be either polygonal or Beziér. This distinction creates variations in the type of tools and control the user may have over the curve, with advantages and disadvantages specific to each. More advanced features such as measurements and multi-layer images may also be employed in higher-level programs. In addition, files usually may be saved, printed, or exported in an EPS (Encapsulated PostScript) format resulting in excellent quality output.

Many of the object-oriented graphic programs on the market are multiplatform tools; versions of *Aldus—Freehand*, *Adobe—Illustrator*, and *Deneba—Canvas* are available for the two more common small computer operating systems. Some applications, such as *Corel—CorelDraw* and *Claris—MacDrawPro*, are system specific but may be the best choice. Several other programs with the capacity to use objects exist on MS-DOS, Macintosh, and other platforms. Student usage of any of these common graphic programs should be further explored.

INDEX[1]

Volume 53, 1993

[1]Reference is to first page of article containing indexed item.