FEASIBILITY STUDY FOR A KANSAS GEOLOGICAL SURVEY QUARTERLY JOURNAL

by

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Introduction

The purpose of this project was to study the feasibility of a quarterly journal for the Kansas Geological Survey, create a prototype journal using desktop publishing, and make recommendations about such an endeavor based on the findings and results. Although the study was conducted specifically with the Survey in mind, much of the information can be applied to periodicals produced for other organizations. For example, data collected on 24 journals and magazines can be used to determine costs, staffing needs, and other operating requirements of a new or existing periodical on any topic.

Although some of the information compiled here could be of use to commercial publications, the main intent of the study was to provide data and recommendations for government agencies and nonprofit organizations, specifically the Kansas Geological Survey. The purpose of these groups is generally to provide information rather than to make a profit. Thus, the study is focused on publication requirements for organizations with limited budgets and little or no advertising revenue.

The Kansas Geological Survey is a research division of the University of Kansas with a $4 million operating budget. It has approximately 130 permanent and student employees, including about 50 full-time researchers who specialize in a variety of disciplines, such as geohydrology, geochemistry, mathematical geology, engineering geology, mineral economics, and computer science. Books and maps have been published by the Survey since the late 1800s, but no regular periodical is produced now. Survey publications, both technical and nontechnical, provide information on the Survey's research and the state's geology. Many of these publications, however, take several years to produce and require a great deal of research. Publication of information is often delayed.

A quarterly journal could serve as a quicker, more widely distributed, multi-purpose outlet of information. Many articles, reports, maps, and data bases are produced by the Survey each year, but no central source exists for informing outsiders about the Survey's research and publications. A catalog of publications and a list of open-file reports are available but generally are given out only on request. To request those catalogs, a person must already be aware that they are available or that the Survey produces reports. Many Kansans who might be interested in geological information are not even aware that the Survey exists. A journal, if properly promoted, would reach potentially interested people who are not aware of the types of research the Survey conducts or what type of publications it produces. The journal would also keep people who are already aware of the Survey and its projects updated on new and continuing research. It would be a central source of information, not only for the interested public and geologists and other professionals in industry, but for other agencies that are doing projects similar to the Survey's. A centralized source of information could help bridge the communication gap between agencies as well as between the Survey and the interested public.

Based on my findings, I have created a prototype journal, named *Geologic Kansas,* that contains both technical and nontechnical articles. It is divided into two distinct sections. The section for technical articles would be an outlet for preliminary findings, research too specific to Kansas to be publishable in outside technical journals, and short studies that otherwise would become unpublished open-file reports. Open-file reports are unpublished reports, maps, data, and theses based on geological and related research in Kansas. Condensed versions of open-file reports and publications would also be published in the journal to let the readers know what information is available. Articles in the technical section would be reviewed by at least two outside reviewers to maintain the credibility of the journal and the research. Articles in the nontechnical section would require a basic understanding and interest in geology but not a knowledge of technical terms. Nontechnical articles would be reviewed by at least one Survey staff member specializing in the field the article covers. That would help insure quality.

By producing a journal with both technical and nontechnical information, the Survey would provide information for several publics. Interests of those publics often overlap, and many potential readers would use both technical and nontechnical materials. Scientists and other specialists would be provided specific information from research in technical articles but be served by nontechnical articles as well. Many professionals have become so specialized that they read technical articles in their area of interest, such as water quality or petroleum, but not others. However, nontechnical articles would provide them with an easy-to-read overview of research in other areas. At the same time, many people who would be primarily interested in the nontechnical articles may read technical articles as well. For example, secondary school teachers with a background or interest in earth science would be able to understand technical information.

Several scientific journals and magazines, such as *American Scientist, Scientific American, Science, Chemical and Engineering News, E&MJ: Engineering and Mining Journal*, and *Oil and Gas Journal* provide both technical and nontechnical material. This helps make their periodicals more appealing to a wider audience and enables them to produce generalized information as well as information on a specific scientific method or site location. A majority of state geological surveys and other organizations who produce journals that are included in this study also take a technical/nontechnical approach. Sixteen of 24 journals surveyed indicated they publish both technical and nontechnical articles (see Table 2). As professionals, and even lay people, become more specialized in their interests, fewer of them read specialized technical articles, although the information may be important and should be published for future reference. By producing a journal that contains both technical, reviewed articles and nontechnical general-information articles that explain survey research and Kansas geology, the Survey would provide both an outlet for publication and a source of information not now available. It also would help fulfill the Survey's responsibilities as articulated in its mission statement:

The mission of the Kansas Geological Survey, operated by the University of Kansas in connection with its research and service program, is to conduct geological studies and research and to collect, correlate, preserve, and disseminate information leading to a better understanding of the geology of Kansas, with an emphasis on natural resources of economic value, water quality and quantity, and geologic hazards (Lee C. Gerhard, Director, March 11, 1988, Memorandum to the Kansas Geological Survey Advisory Council).

Method

The following steps were taken to complete this project:

1. Reviewed *Journalism Quarterly* and *Journal of Communication* for articles related to producing a journal;

2. Sent a two-page questionnaire to the editors of 31 government and nonprofit organizations that published or potentially could publish journals and magazines;

3. Obtained statistics from several sources to determine the potential audience and circulation for the journal; telephoned or mailed a short survey to 17 organizations about the availability of newsletter space for announcing a journal and mailing lists for rent or exchange;

4. Obtained estimates of printing costs from other journals and from the University of Kansas Printing Service, which does the Survey's printing;

5. Made recommendations based on the results of the study;

6. Wrote specifications and a prospectus and created a dummy copy of *Geologic Kansas* using desktop publishing.

Method expanded and results—Journal studies, questionnaire, audience and circulation, and printing costs

1. Study of *Journalism Quarterly* and *Journal of Communication*

Journalism Quarterly and *Journal of Communication* were selected as the most likely academic journals to have research articles on magazine design and production, specifically concerning desktop publishing. The Spring 1986 to Summer 1989 issues of *Journalism Quarterly* and the Winter 1986 through the Spring 1989 issues of the *Journal of Communication* were studied. Journals published before 1986 were not included because of the rapid changes in desktop publishing.

Neither journal had articles on desktop publishing. *Journal of Communication* had no articles concerning magazines or layout and production. *Journalism Quarterly* contained two articles on design and graphics and two on electronic editing and typesetting, but all pertained to newspapers. Only three articles were clearly magazine-related. One, "Uses and Gratifications Motives as

Indicators of Magazine Readership" by Gregg A. Payne and others (Winter 1988) focused on trade magazines. The second was "Research Activity of Magazine Publishers" by Thomas Jacobson (Summer 1988), which summarized the state of magazine research in one sentence—"most academic research addresses either magazine content or magazine advertising effects." The third was "Research About Magazines Appearing in *Journalism Quarterly*" by Peter Gerlach (Spring 1987).

The only article that pertained in any way to producing and distributing a journal was "Post-Card Questionnaires May Boost Response Rate" by Robert C. Kochersberger, Jr. (Winter 1987), which explained how to use postcards to increase the rate of questionnaire returns. This study could be useful if sample copies are sent to the initial mailing list or if direct mailings are used.

2. Questionnaire

A 16-question survey (Fig. 1) was sent to 31 organizations (Table 1). Seventeen of the 31 are state geological surveys or equivalent. A follow-up letter was sent to editors who did not respond to the first inquiry. Twenty-four editors, including 14 from other geological surveys, returned the completed questionnaire. Four organizations did not respond and three (all geological surveys) did not have journals. Information from the returned questionnaires was compiled into five tables (Tables 2-6). Sample copies of most of the publications were also received and studied.

The questionnaire was sent to organizations that were state agencies or nonprofit organizations. The organizations were chosen because of similarities to the Kansas Geological Survey, such as size or geographic location. Many of the organizations have journals of similar content and size to the one the Survey would be able to produce. They also have similar budget constraints. Some have circulations approximately in the same range (1,000-3,000) that a Kansas Geological Survey journal would likely have.

1. How frequently is your magazine or journal published?

2. What is the price? subscription ______ single copy ______

3. How do you get subscribers?

a) in-house mailing list
b) advertise in other media
c) brochures
d) obtain mailing lists from other organizations
e) other (please specify)

If you were on staff when the publication started, what initial steps were taken to get subscribers?

4. What is the staff size? Please list staff members' titles, responsibilities, and percentage of time spent on the publication.

5. Articles in your publication are: technical ______ nontechnical ______ both ______

6. Contributors are from: inside your organization ______ outside your organization ______

7. Do contributors have to meet specific qualifications? Yes (if yes, check below) _____ No _____

a) advanced degrees b) specialists in the field your publication covers c) other (please specify)

8. Are the articles reviewed? Yes _____ No _____
If yes, how many reviewers per article?
Reviewers are: from your organization ______ outside specialists ______ both ______

9. How do you get contributors? If you were on staff when the publication started, what initial steps were taken to get contributors?

10. On the average, how much does it cost to produce each issue of your publication?

11. What is your press run?

12. How many pages does your publication average?

13. What paper type and weight do you use?

14. Is the publication all black and white? If color is used, approximately how many pages? Is color used on the cover? Please be specific about color—is it 2-color, 3-color, or 4-color?

15. Do you use desktop publishing? If so, what hardware and software are used?

16. If you have any other suggestions or problems related to publishing or beginning a journal or magazine, please include them here.

Person completing questionnaire:
Title:
Organization or agency:

Figure 1. Questionnaire that was sent to 31 government and nonprofit organizations

Table 1

Organizations receiving the questionnaire, publication names, and responses

Organization	Publication	Responded
Archaeological Society of New Jersey	Arch. Soc. of NJ Bulletin	yes
Arizona Bureau of Geology	Arizona Geology	yes
Arizona Archaeological and Historical Society	Kiva	yes
Arizona Historical Society	Arizona History	no
Calif. Division of Mines and Geology	California Geology	yes
Idaho Historical Society	Idaho Yesterdays	no
Illinois State Geological Survey	Doesn't produce a journal	—
Indiana Historical Bureau	Indiana History Bulletin	no
Iowa State Geological Survey	Iowa Geology	yes
Kansas State Historical Society	Kansas History	yes
Kansas State Univ. College of Engineering	Kansas State Engineer	yes
Kansas University Engineering Department	Kansas Engineer	yes
Kansas Univ. Museum of Natural History	Panorama	yes
Kansas Wildlife and Parks Department	Kansas Wildlife and Parks	yes
Kentucky Geological Survey	Doesn't produce a journal	—
Michigan Department of State	Michigan History	no
Minnesota Archaeological Society	Minnesota Archaeologist	yes
Nebraska Conservation and Survey Division	Resource Notes	yes
Nebraska State Historical Society	Nebraska History	yes
N. Mexico Bureau of Mines and Min. Res.	New Mexico Geology	yes
North Dakota Geological Survey	NDGS Newsletter	yes
North Dakota State Historical Society	North Dakota History	yes
Oklahoma Geological Survey	Oklahoma Geology Notes	yes
Oregon Department of Geology	Oregon Geology	yes
Pennsylvania Geological Survey	Pennsylvania Geology	yes
South Dakota State Historical Society	South Dakota History	yes
Tennessee Archaeological Society	Tennessee Archaeologist	yes
Texas Bureau of Economic Geology	Doesn't produce a journal	—
Texas State History Association	Texas Historian	yes
Utah Geological and Mineral Survey	Survey Notes	yes
West Virginia Geological Survey	Mountain State Geology	yes

Table 2

Survey results—frequency, price, subscribers, and type of articles

Publication	Frequency	Price	How they get subscribers	Type of articles
Archaeological Society of New Jersey Bulletin	Once or twice a year.	With membership (varies).	In-house mailing list; word of mouth and sale of journal at various archaeological meetings; announcements in various local/regional historical society publications.	Technical and nontechnical.
Arizona Geology	Quarterly.	U.S.—no charge; foreign—cost of postage.	In-house mailing list; mailing lists from other organizations (Arizona Geological Society, State Board of Technical Registration (geologists), science teachers, Geol. Society of America members in Arizona, etc.).	60-70% nontechnical; 30-40% technical.
California Geology	Monthly.	Subscription: $7.00; Single copy: $1.00; No discounts-sold at cost.	"Core" group of long-term subscribers; exchange addresses with other professional nonadvertising journals; started as a free 4-page brochure in 1948. Size and price gradually increased.	Technical and nontechnical.
Iowa Geology	Annual.	No charge.	In-house mailing list; obtain mailing lists from other organizations; announce magazine's availability in other organization's newsletters.	Nontechnical; intended to communicate geology to the public.
Kansas Engineer	Semiannual (up to 3 times/yr in 1990).	No charge to eng. students, faculty, and alumni; single copy for others: $3.	Distributed to engineering students, faculty, and alumni.	Technical and nontechnical.
Kansas History	Quarterly.	With membership (eg. $15 for individuals); single copies: $4.	In-house mailing list; brochures; tried obtaining mailing lists from other organizations, but had low success rate.	Technical and nontechnical.
Kansas State Engineer	Quarterly (Oct, Dec, March & May).	Subscription: $6/yr.; no cost to students on campus.	In-house mailing list; students sell subscriptions to friends and relatives.	Technical and nontechnical.
Kansas Wildlife and Parks	Six issues per year.	Subscription: $8/yr.; single copy: $2.25.	In-house mailing list; advertising in other media's brochures.	Technical and nontechnical.
Kiva (Arizona Archaeological and Historical Society)	Quarterly.	Subscription: $15; single copy: $5.	Advertising in other media; brochures; obtain mailing lists from other organizations; word of mouth.	Technical and nontechnical.
Minnesota Archaeologist	Semiannual.	Free to Minnesota Archaeological Society members.	Advertise in other media; brochures; commercial subscription service.	Technical and nontechnical.
Mountain State Geology (W.Va. Geological Survey)	Annual.	No charge.	In-house mailing list; subscription cards and free magazines taken to meetings, conferences, presentations, etc.; occasionally sample copies sent to groups, ie. all high school teachers in state.	Nontechnical.
NDGS Newsletter (North Dakota Geological Survey)	Semiannual.	No charge.	In-house list; mostly word of mouth; sign-up sheets and copies at trade shows, etc., started with a few hundred people, card in early issue asking if those people wanted to stay on list; sent to some newspapers—some wrote articles.	Technical and nontechnical.

Table 2 (continued)

Survey results—frequency, price, subscribers, and type of articles

Publication	Frequency	Price	How they get subscribers	Type of articles
Nebraska History	Quarterly.	Subscription: $15 (Society Membership); single copy: $3.	Brochures; informal methods of getting Society memberships, which include subscription as part of benefit.	Technical and nontechnical.
New Mexico Geology	Quarterly.	Subscription: $6/yr.; single copy: $2.	Word of mouth; faculty, student and staff referrals; regional geological and mineral society meetings; renewal letter with envelope.	Technical.
North Dakota History	Quarterly.	Subscription with SHSND membership ($10 individuals); single copies: $3.	Brochures.	Nontechnical.
Oklahoma Geology Notes	Bimonthly.	Subscription: $6/yr.; single copy: $1.50.	Brochures.	Technical and nontechnical.
Oregon Geology	Bimonthly.	Subscription: $6/yr. $15/ 2 yrs;. single copies: $2.	Word of mouth.	Technical and nontechnical.
Panorama	Three times per year.	Subscription with museums associates membership ($20 for individuals).	Brochures; membership includes discount on museum educational programs so many people join for that reason.	Nontechnical.
Pennsylvania Geology	Bimonthly.	No charge.	In-house mailing list; general public may request subscriptions; periodically questionnaire to everyone on mailing list to find if they want to stay on; those who don't respond or want off list are deleted.	Technical and nontechnical.
Research Notes (Neb. Conservation and Survey Division)	Annual (Originally planned as quarterly).	No charge.	In-house mailing list; obtain mailing lists from other organizations, eg. The Water Center and the Nebraska Geological Society; hand out request forms at events.	Nontechnical; some technical rewritten to be less technical.
South Dakota History	Quarterly.	Subscription with membership ($15 for individuals); single copy: $5.00.	In-house mailing list; brochures; obtain mailing list from other organizations, direct promotional mailings; displays at conferences; press releases.	Nontechnical (scholarly).
Survey Notes (Utah Geological Survey)	Quarterly.	No charge.	In-house mailing list; by request.	Technical and nontechnical.
Tennessee Anthropologist	Semiannual.	Subscription depends on type of membership; single copies: $3.50.	In-house mailing list; memberships; the association was started among professionals and other interested people in the state.	Technical and nontechnical.
Texas Historian	Five times a year.	Subscription: $6/yr.; single copies: $1.50.	Most are members of Junior Historian Club.	Nontechnical.

Table 3

Survey results—staff and reviewers

Publication	Staff, duties, and percentage of time (based on 40 hr. week ave.)	Are articles reviewed?
Archaeological Society of New Jersey Bulletin	Editor and one other person solicit manuscripts, type, edit, layout and produce Bulletin; provide photo-ready copy to printer. A few volunteers help with proof reading and mailing. (No % given.)	Somewhat—reviewers from inside and outside organization.
Arizona Geology	Editor and Writer—edit, write features and fillers, format text, design layout, supervise paste-up, printing, and circ. (35-40%). Ed. Asst.—compile lists and format (2%). Artist—draft, develop photos, mechanicals (10%). Artist Supervisor—occasional illustrations and drafting (3%). Clerk Typist—maintain mailing list (10%).	By editor, director, and one staff geologist.
California Geology	Two Associate Geologists (100%). Editorial Technician (50%). Graphic Artist (100%).	Two peer reviews (from inside and outside organization).
Iowa Geology	Editor—coordinate article selection process; work w/graphic artist and authors on illustration; review; edit. proof typesetting and illus. (25%) 2. Graphic Artist—Help select articles; design publication (layout, cover art and illus., etc.); specify and order typesetting; prepare mock-up. Prepare bid specs and work with printer (35%).	By editor.
Kansas Engineer	Editor—Organize efforts (articles, ads, photos) into cohesive whole, collect articles, arrange meetings (25%). Business mgr.—handles ads and budget (8%). Graphic Designer—design mag., layout (3%). Photo mgr.—direct photo efforts, develop film (no % given). Writers (no % given.)	By editor and an English professor.
Kansas History	Director of Publications—edit; proof; arrange copyrights and releases; gets illus.; work with printers and authors (60%). Associate Editor—encode and type articles on computer; make corrections; proof printouts (75%). Part-time Associate Editor—Check citations; places footnotes in standard form; some searches for illustrations (50%).	Four reviews (ave.) per articles (by in-house and outside reviewers).
Kansas State Engineer	Editor; Business Manager; Advertising Sales Representatives; Photo Editor; Staff Writers; Circulation Manager; Adviser; Production Manager; Photographers. (No % given.)	No.
Kansas Wildlife and Parks	Editor (100%); Photographer (100%); Associate Editor (60%); Illustrator (20%); Numerous agency personnel provide articles once or twice a year.	One or two reviews per article (in-house and outside reviewers).
Kiva	Editor—Acquire articles; manage publications, proof; edit; handle correspondence. Assistant Editor—assist editor in production aspect. Technical Editor (only paid position)—copy edit, proof. Reviews Editor—responsible for book reviews. (No % given.)	Two reviews—if lucky (in-house and outside reviewers).
Minnesota Archaeologist	Editor; Associate Editor; Production Editor; Five-member editorial board. (No % given.)	By editorial board (peer review)—board is composed of archaeologists.
Mountain State (West Virginia Geological Survey)	Editor—coordinates prod. and reviews; most editing, proofing and rewriting; oversee printing and dist. (20%). Editor (asst)—Some editing, rewriting, and proofing (5%). Draftsman/Photog.—some drafting; all non-author photog. (10%). Two Draftsmen—most drafting (10% each). Prod. Asst. —copy drafts, make Itek shots (5%).	Four reviews (ave.) per articles (by in-house and outside reviewers).
NDGS Newsletter (North Dakota Geological Survey)	Editor (also Asst. State Geologist)—(7-8%). Administrative Secretary—Types and formats articles (5%). Individual geologists—Write articles (2%). Draftsperson—minor drafting for some articles (2%).	One or two in-house reviews.

Table 3 (continued)

Survey results—staff and reviewers

Publication	Staff, duties, and percentage of time (based on 40 hr. week ave.)	Are articles reviewed?
Nebraska History	Editor—(about 50%); Assistant Editor—(about 90%).	Three reviews per article (in-house and outside reviewers).
New Mexico Geology	Editor—responsible for everything except circulation records and mailing (40-50% of time). Assistance from drafting department with peel coats for color separation.	Three reviewers per article on the average (one in-house and two outside reviewers).
North Dakota History	Managing Editor—edit journal and newsletter, including book reviews (50%); Curator of Education—proof, review (13%); Assistant—proofread, secretarial tasks, such as letters, mailing of publications, etc. (13%).	Usually one outside reviewer; sometimes in-house also.
Oklahoma Geology Notes	Geologist/Editor—technical editing of text and figures; offer advice and suggestions (5%). Assistant Editor—Compile technical articles and news items; oversee and assist in production (30%). Publications Clerk—type and proofread (30%).	Some articles reviewed and some aren't; number of reviewers vary (In-house and outside reviewers).
Oregon Geology	Publication Manager—(20%); Editor Librarian—(40%); Two Cartographers—(5%).	Number of reviews varies (in-house and outside reviewers).
Panorama	Editor (1)—typesetting and production on Macintosh (20%). Editor (2)—(5%). KU University Relations provides editorial, design, and photography assistance.	No.
Pennsylvania Geology	Co-editor (also Survey Director and State Geologist)—(5%). Co-editor (also Geologist Supervisor of Editing Section)—(15-20%). Cartographic Supervisor—draft illustrations (5-10%).	One to three reviews per article.
Research Notes (Nebraska Cons. and Survey Division)	Editor—edit and write (10-15%). Secretary—secretarial plus some writing (no % given). Administrative Assistant—help with editing and writing (no % given).	Reviewed by director and source; anything technical is already reviewed by director.
South Dakota History	Dir. of Pub. Program—acquisition, budget, edit, design, layout (75%). Asst. Ed.—research, edit, layout, correspondence (75%). Ed. Asst,—photo search, write short features, postal-record keeping, some correspondence, copyright paperwork (25%). Editorial Proofreader—proofread galleys, proofs, and blue lines, indexing (15%).	One or two reviews per articledepending on topic (outside reviewers).
Survey Notes (Utah Geological Survey)	Editor—(13%); Typesetter—(9%); Graphic Artist—(15%); Three cartographers—(3%).	One to two reviews per paper (usually in-house and occasionally outside reviewers).
Tennessee Anthropologist	Editor—(50%); Secretary—(50%).	One to three reviews per article (in-house and outside reviewers).
Texas Historian	Editor—(15%-20%).	Number of reviews varies (in-house and outside reviewers).

Table 4

Survey results—contributors

Publication	Contributors	Contributors' qualifications	How they get contributors
Archaeological Society of New Jersey Bulletin	In-house and outside organization.	No specific qualifications required.	Encourage members to submit. Call on certain people to write. Encourage those who presented good papers at State meetings to submit for publication.
Arizona Geology	In-house and outside organization (accept only solicited material).	Specialist in field or solicited by Survey director or editor.	Solicit manuscripts from individuals conducting geologic research or engaged in geologic projects in Arizona.
California Geology	In-house and outside organization.	No specific qualifications required.	Solicited; paid ads in newspapers and magazines did not bring in expected results; staff members originally required to submit articles on projects.
Iowa Geology	In-house; two exceptions in case of joint authorship.	Specialist in field.	Suggestions solicited from staff and screened by section supervisors, editor, and graphic artist; editor & graphic artist work closely with authors.
Kansas Engineer	In-house and outside organization.	No specific qualifications required.	Student volunteers.
Kansas History	99% from outside organization; about 50% from out-of-state.	No specific qualification required.	Don't solicit except for specific topics, manuscripts sent in unsolicited. Currently journal filled for two years.
Kansas State Engineer	In-house.	Ability to write on topics of interest to college engineering students.	Volunteers; if necessary, would use materials from other publications, puts ads in their magazine, and ask professors and administrators to write articles.
Kansas Wildlife and Parks	In-house and outside organization.	No specific qualifications required.	Writers query or magazine requests specific articles.
Kiva (Arizona Archaeological and Historical Society)	In-house and outside organization.	No specific qualifications required.	Articles sent in unsolicited; rarely solicit.
Minnesota Archaeologist	In-house and outside organization.	No specific qualifications except ability to write factual stories.	Solicit and twist arms.
Mountain State Geology (W. Va. Geological Survey)	In-house.	No specific qualifications required.	Articles are volunteered or assigned.
NDGS Newsletter (North Dakota Geological Survey)	In-house and very occasionally outside organization.	No specific qualifications required.	Editor asks staff to write articles and often suggests topics; editor writes 1/3 of articles; some unsolicited outside articles received; initial articles—Survey staff met and agreed on.

Table 4 (continued)
Survey results—contributors

Publication	Contributors	Contributors' qualifications	How they get contributors
Nebraska History	In-house and outside organization.	No specific qualifications required.	Society members; graduate history students and history department faculty members; authors not paid but $400 annual award given for best article.
New Mexico Geology	In-house and outside organization.	Specialist in field.	Word of mouth; faculty, student, and staff referrals; regional geological and mineral society meetings.
North Dakota History	Outside organization.	No specific qualifications required.	Attend conferences to locate appropriate papers; talk to scholars within the state.
Oklahoma Geology Notes	In-house and outside organization.	Specialist in field.	Requests to staff; occasionally send form-letter requests for contributions to college geoscience departments and other state surveys.
Oregon Geology	In-house and outside organization.	No specific qualifications required.	Lots of encouragement.
Panorama	Mostly in-house; some from other organization on campus	Science-writing skills.	Requests made by editor—make personal contacts for contributions and get a few volunteers.
Pennsylvania Geology	In-house (mostly) and outside organization.	Depends on nature of article.	Most articles are volunteered, but some are solicited. In first issue, director wrote lead article explaining nature of magazine and stated outside contributors were welcome.
Research Notes (Nebraska Conservation and Survey Division)	In-house (90-95%) and outside organization	No specific qualifications required.	Get story ideas from Survey's "project notebook," which describes current survey projects; most of the articles are written by the editor and editorial staff.
South Dakota History	Outside organization.	No specific qualifications required.	Get to know people and their work; go to conferences, listen to papers, etc.; initially, requests sent to state historians; also profs. asked to recommend good graduate papers or theses.
Survey Notes (Utah Geological Survey)	In-house.	No specific qualifications required.	Assigned by management team.
Tennessee Anthropologist	In-house and outside organization.	No specific qualifications required.	Encourage students and professionals in state to write about their research; initially encouraged new members to write articles.
Texas Historian	Members of the Junior Historian organization.	Members.	Articles are submitted in writing contest.

Table 5
Survey results—cost, press run, number of pages, paper, and color

Publication	Press run	Average cost per copy ($)	Average no. of pages	Paper type and weight	Color
Archaeological Society of NJ Bulletin	500	4.00	80 (recently grown from 32 to 72 or 80 pages).	60#.	Black and white.
Arizona Geology	5,000 (4,100 on mailing list)	.265	12	80# white Shasta dull.	Black and white.
California Geology	18,000	.19	24	70# stock, #2 glossy.	2-color cover with some 2-color inside; otherwise, black and white.
Iowa Geology	6,000	1.00	28 (6" x 9")	Coated two sides, 80# white #1 enamel text.	4-color cover and throughout.
Kansas Engineer	2,000-2,500	.80	20	Coated.	2-color cover and throughout.
Kansas History	4,500-5,000	1.50	50	Cover—100# gloss/varnished Inside—60# flat gloss.	4-color cover or duotone; black and white inside.
Kansas State Engineer	2,300	Cost was down with desktop pub. w/out: .47, with: .36, (incl. postage).	8 or 12	80# glossy.	Black and white unless advertiser pays for some color.
Kansas Wildlife and Parks	48,000	.85	45	Javelin 70# offset.	4-color cover and throughout except 12-page one-color center section.
Kiva (Arizona Archaeological and Historical Society)	1,200	1.93	80-96	60# or 70# white; varnished cover.	Color on cover only—2-color ink with silk screened shades.
Minnesota Archaeologist	500	2.00	50-60	Not given.	Usually black and white.
Mountain State Geology (W. Va. Geological Survey)	5,000	.90	48	70# Wedgewood, coated embossed.	2-color cover; occasional color inside but usually black and white.
NGDS Newsletter (North Dakota Geological Survey)	2,500 (1,875 on mailing list)	.52	30-40	Mimeo paper.	Black and white.

Table 5 (continued)

Survey results—cost, press run, number of pages, paper, and color

Publication	Press run	Average cost per copy ($)	Average no. of pages	Paper type and weight	Color
Nebraska History	4,800	1.70	50	10 pt. Caroline coated cover 60# Paloma matte.	4-color cover; usually black and white inside, occasionally color.
New Mexico Geology	1,400 + reprints as purchased (circ. about 1,600)	1.30	24	70# mountie matte.	2-color (black and PMS 320) front and back and some inside. Use screens and patterns in place of color.
North Dakota History	1,850	1.60	40	60# text laid finish; planning to change to matte paper for better photo reproduction.	Black-and-white cover with a field cover; black and white inside.
Oklahoma Geology Notes	1,800	.70 (6" x 9")	44	70# white enameled book stock.	2-color cover; usually black and white inside; occasionally color.
Oregon Geology	3,250	.62	24	60# white matte coated offset boah paper.	Black and white.
Panorama	2,000	.30-.40	6-8	White gloss coated offset 70# book.	2-color cover with black and white text and photos.
Pennsylvania Geology	6,000	16 p.—.29 32 p.—.425 (6" x 9")	16 or 32	White Kromecote cover, C-1-5, 10 pt. or equiv. Inside Old Forge coated offset, white, 70# or eqiv.	2 PMS colors on cover; inside black with one PMS color from cover.
Research Notes (Nebraska Conservation and Survey Division)	1,050	1.00	20-25	Vintage dull; 80# cover; 70# inside.	4-color cover; black and white inside.
South Dakota History	2,600	Ave. $2.00 (ranges from $1.70 to $3.00)	96-100	60# matte.	Cover varies from 2- to 5-color depending on art and available $; inside up to 3-color (usually black & white).
Survey Notes (Utah Geological Survey)	4,500	.45	16-28	60# white Patina matte.	4-color cover; black and white inside.
Tennessee Anthropologist	400	1.25-1.50	90	65# cover stock; 703 offset inside.	Black and white.
Texas Historian	2,200	.90	32	Not given.	Black and white.

Table 6
Survey results—desktop publishing and comments

Publication	Desktop publishing	Comments and suggestions
Archaeological Society of NJ Bulletin	Framemaker package on a Sun micro.	Extremely satisfying in the end but a lot of work; publishing makes a lasting contribution; they encourage both professional archaeologists and avocational archaeologists, which works well.
Arizona Geology	Hardware: Digital Equip. Corp.; Laserjet Printer. Software: WordPerfect 4.2; Weaver Graphics.	Start small (8-12 p.); if charge, give first one or so free; charge foreign mailing cost; get bids from several printers. Develop mailing list from published membership lists (GSA, state societies, science teacher assoc., geoscience profs., etc.). Send free sub. to state legis.; in-house, not outside, mailing list.
California Geology	No.	Maintain strict deadlines on all aspects: review, edit, and layout.
Iowa Geology	No.	
Kansas Engineer	Hardware: Apple Macintosh Software: WordPerfect and PageMaker.	Kansas Engineer funded primarily by adv.; difficult to obtain so, if use adv., recommends using a national agent; second biggest problem—meeting deadlines. Takes about twice as long as anticipated.
Kansas History	No, but sends material to publisher on computer disk.	Establish a set design and format for the publication and have a stated publication editorial policy; advertising and promoting journal (particularly before it starts) is important; with desktop publishing, need someone who knows the system beforehand.
Kansas State Engineer	Zenith 386 with Hewlett-Packard Laserjet Series II Printer Software: Ventura Publisher.	
Kansas Wildlife and Parks	No.	
Kiva (Arizona Archaeological and Historical Society)	No.	
Minnesota Archaeologist	Personal computer and laser printer.	Pay as many people as possible—publication by volunteers is an onerous task; be liberal with response times for authors; arrange scheduling (if possible so it doesn't interfere with people's field time (ie. so authors aren't in the field when you need galleys from them).
Mountain State Geology (W. Virginia Geological Survey)	Hardware: IBM P5/2 model 80 Software: WordPerfect, PageMaker, Imagedit, Microsoft Windows.	Even with in-house authors, helpful to have handouts for new authors explaining magazine's style, writing level, deadline, purpose, audience, also, general topics, review procedures, author responsibilities, where to get help, etc.; this sets down the ground rules and answers a lot of questions right off.
NGDS Newsletter (North Dakota Geological Survey)	No, but do compile with WordPerfect 5.0.	

Table 6 (continued)
Survey results—desktop publishing and comments

Publication	Desktop publishing	Comments and suggestions
Nebraska History	No.	
New Mexico Geology	No; text is sent to press as computer files coded for photosetter; all of authors' final figures are camera-ready.	
North Dakota History	No, but plan to in the next two years.	
Oklahoma Geology Notes	No, but are getting a Macintosh II-cx; plan to use Microsoft Word 4.0 and Pagemaker.	Have had problems acquiring feature articles and cover pictures and need more Survey staff and input.
Oregon Geology	No, but will start next year with an IBM AT and Ventura software.	Always in crisis with magazine; sometimes have trouble filling it, but that drives staff to innovative solutions that make the magazine more interesting; easiest issues are the ones with long articles, but those are dullest for readers.
Panorama	Macintosh SE with Microsoft Word and Pagemaker; photo-ready printout produced on Linotronic laser printer.	Changing to desktop publishing hasn't saved much money and has made editor the typesetter so didn't save time, but did make changes easier (can size stories without going through galley stage and waiting for corrections); requires someone with interest and ability. University Relations helps with design, etc.
Pennsylvania Geology	No, but trying to get; now compose text on a Compugraphic Power View 10, use Compugraphic typesetter.	
Research Notes (Nebraska Conservation and Survey Division)	No.	When started, good response from outside Survey, but some inside complaints about length of time spent; wanted research staff to write but not many did; ed. staff ended up writing; run list of new pubs and back selected publications on topics related to articles; some issues on one topic (eg. drought).
South Dakota History	No, but use Displaywrite 4 word processing and supply printer with ASCII/DOS files for typesetting.	If quality is important, be sure to build time into the schedule for insuring it—both in design and printing and in editing and research.
Survey Notes (Utah Geological Survey)	No, but use Ventura software and HP Laserjet 500+ for lower quality publications.	Decide purpose; determine readership; rough-out beginning budget; do first two issues before releasing first (have backup ideas and filler so you don't have to scramble on the second); codify so contributors, etc. know what to expect; get a masthead, page format, illus., and review rules, etc.
Tennessee Anthropologist	Hardware: IBM Display Writer; Software: Tex-pac; camera-ready copy; printed by off-set; illus.—PMTs.	You are going to have to work very hard getting people to contribute quality articles unless there is a need for your publication in you area; Use personal contacts to get writers to finish articles or research that will result in articles.
Texas Historian	No, but articles are edited on a computer.	

3. Audience and circulation

Information about audience and circulation came from several sources. First, questionnaire respondents provided production numbers and insight into how they get subscribers. Responses to the question "how do you get subscribers?" fit into 11 categories (Table 7).

Table 7

Questionnaire respondent's replies to the question "How do you get subscribers?" (The number of responses exceeds the number of respondents because several respondents listed more than one method.)

Method used to get subscribers	No. of respondents using this method
In-house mailing lists	14
Publication comes with organization membership or university department	11
Brochures	9
Used mailing lists from other organizations or exchanged addresses	7
Word of mouth	7
Displays, sales, handouts, etc. at meetings and conferences	6
Advertise in other publications, newsletters, or other media	6
Free copies with renewal letters or update renewal letters	3
By request or referrals	3
Direct promotional mailings	1
Commercial subscription service	1

Second, data on a number of organizations that could provide names of potential subscribers or could announce the availability of *Geologic Kansas* in a newsletter were obtained. Each of the organizations fit into one of the following categories:

1) professional organizations

2) geology faculties and students at Kansas universities

3) environmental and educational organizations

4) libraries

Professional societies and organizations

Several professional organizations with available membership lists or mailing lists containing names of potential subscribers were found. The Kansas Geological Survey already maintains a mailing list for its publications that contains about 1,500 names. The list includes a variety of people and organizations, such as geologists, politicians, libraries, other state surveys, and nonscientists. The Survey's mailing list, however, is not comprehensive. Other than specific organizations, such as state agencies, or office holders, such as state administrators, names have been added to the list randomly upon request. Some names of people who have purchased Survey publications also have been added. Potential readers, including many Kansas geologists and teachers, do not appear on the list.

Other professional geologic organizations also maintain membership lists that could be used. Most of the active geologists in the state belong to one or more of three organizations—the Kansas Geological Society (a private organization not related to the Survey), the Geological Society of America (GSA), and the American Association of Petroleum Geologists (AAPG). All three have published membership lists (see Table 8 for membership numbers). Both GSA and AAPG are national organizations, but names of Kansas members can be easily identified. By eliminating duplicate addresses from the Kansas Geological Survey, GSA, and AAPG mailing lists, a list of most of the state's geologists and related professionals could be compiled.

Table 8

Number of people on available membership lists from professional organizations

Organization	Number of members
Kansas Geological Society	1,168 (includes 725 Kansans. Of the remaining 443 members, 348 are from Okla. (142), Colo. (135), Tx. (59), and Mo. (12).
Geological Society of America	111 Kansas members (not including Kansas Geological Survey staff members)
Am. Assoc. of Petroleum Geol.	708 (as of 1986)
TOTAL	1,987 (likely to have many duplications)

University geology faculties and students

Data on university geology departments in Kansas were obtained from the American Geological Institute (AGI). A 1987-1988 survey by AGI showed 80 geology faculty members and 302 students in seven geology departments at Kansas universities and colleges. Lists of faculty and students can be obtained from each department.

Environmental and educational organizations

A four-question survey was mailed or telephone calls were made to 17 organizations requesting information on the availability of their mailing list or space for announcement of the availability of *Geologic Kansas*. The organizations that were chosen had mailing lists or membership lists containing names of people who would have an interest in Kansas, geology, and the environment. The following questions were asked:

1) Does your newsletter have space available for announcement of publications from other organizations?
2) Do you have a mailing list that you are willing to lend, exchange, or rent?
3) If your mailing list is for rent, what is the cost per hundred?
4) If your mailing list is available, or if you do have space available in your newsletter, how many people are on your mailing list or belong to your organization?

Fourteen of 17 questionnaires were completed. The results are shown in Table 9.

Information on contacting primary- and secondary-education teachers, librarians, and administrators was obtained from the Kansas State Department of Education. The Department sends regular mailings to different groups, including teachers, principals, school librarians, and superintendents, and it would be willing to include information about the journal's availability. The list of teachers contains 16,000 names. This is the same list of people who would receive the Kansas Department of Wildlife and Parks newsletter (see Table 9).

Libraries

Information on state libraries was obtained from the *American Library Directory*. The directory lists addresses for 306 public libraries, 22 four-year college libraries, and 19 two-year college libraries in Kansas.

Table 9

Responses to mailing list and newsletter survey.

Organization	Responded	Newsletter available	Mailing list available	Number who will receive newsletter or on mailing list
Dillon Nature Center	Yes	Yes	No	1,000
Extension 4-H Youth Programs	Yes	Yes	Yes	170
Kansas Assoc. of Biology Teachers	Yes	Yes	Yes (exchange)	not given
Kansas Assoc. of Conservation	Yes	No	Yes (lend)	not given
Kansas Assoc. of Teachers of Science	No	n/a	n/a	n/a
Ks. Council for Geographic Education	Yes	No	No (developing)	n/a
Kansas Dept. of Wildlife and Parks —Educational list	Yes	Yes (limited space)	No	16,000
Kansas Historical Society	Yes	Yes (limited space)	No	not given
Kansas Natural Resource Council	Yes	Yes	Yes (lend+cost of labels)	800
Kansas NEA	Yes	Yes	No	not given
Kansas Rural Center	Yes	Yes	Yes (rent—$2/100)	950
Kansas Wildlife Federation	Yes	Yes	No	8,000
National Audobon Society —West Central Regional Office	No	n/a	n/a	n/a
The Land Institute	Yes	No	No	n/a
Univ. of Ks. Natural History Museum	Yes	No	Yes (exchange)	200
University Press of Kansas —Natural science, natural history, geology and geography list	Yes	No	Yes (exchange)	1,900
Wildwood Outdoor Education Center	No	n/a	n/a	n/a
TOTAL				29,020*

*lists include some duplication
n/a = not applicable

4. Printing Costs

Questionnaire respondents provided the average cost and press run of their publication per issue. Based on these data, the average cost-per-copy for each publication was computed (Table 5). Respondents also supplied information on number of pages, paper type and weight, and color (Table 5) and indicated whether desktop publishing was used (Table 6).

In addition, printing costs were requested from the University of Kansas Printing Service. The following specifications were given for a 32-page publication:

Finished size: 8.5" x 11"

Signatures: two 16-page signatures, self-cover

Paper type: White dull-coated offset

Substance: Book 70 lb.

Halftones: 8

Binding: Saddlestitch

Customer furnishes Mac disk. Printing Service will provide camera-ready copy produced on its Linotronic.

Estimates were obtained for three different color combinations and three different press runs for each of those combinations (Table 10).

Table 10

Estimates from the University of Kansas Printing Service for a self-cover, 32-page, 8.5" x 11" publication. (The number in parentheses is cost per copy.)

Color combination	Cost for 2,000	Cost for 5,000	Cost for 8,000
Option 1 signature 1: black front and back signature 2: 2-color front, black back	$1937.84 (.97)	$3316.53 (.66)	$4695.23 (.59)
Option 2 2-color throughout	$2524.99 (1.26)	$4129.29 (.83)	$5733.58 (.72)
Option 3 signature 1: black front, black back signature 2: 4-color front, black back	$2488.20 (1.24)	$4007.37 (.80)	$5526.53 (.69)

Recommendations

Many factors must be considered before production of a journal begins. How much staff time will be required and production cost, although important issues, are not the only considerations. For a journal to be successful, decisions about format, subscription rate, circulation, publicity, contributors, and editorial policy have to be made. Following are observations and recommendations based on the findings in this study.

Staff

Estimated total staff time required is approximately 80 to 90 percent of one full-time person's job. This, however, would be divided among several people, with the editor of the journal getting the bulk of the responsibility at 50 to 60 percent of full time (see prospectus). The estimate is based on responses to the survey question "What is the staff size? Please list staff members' titles, responsibilities, and percentage of time spent on the publication."

Responses of three geological surveys with quarterly journals of similar size and formats to *Geologic Kansas* were used to make the estimate (Table 11). The percentages of time (based on a 40 hour week) allocated to publication duties by each staff member were added to give full-time equivalencies (100%). For example, 150% translates to one and one-half full-time person. The three journals have similar contents—all were produced by state geological surveys—and have about the same average number of pages. The journals are *Arizona Geology*, *New Mexico Geology*, and *Survey Notes,* produced by the Utah Geological and Mineral Survey.

The respondents' estimated percentages of time spent on the journal are likely to vary based on their interpretations of the question. Some respondents were more thorough in including duties than others. In particular, some included time spent on circulation and mailing lists while others didn't. Also, the length and complexity of text, illustrations, and the design of the publications vary. Therefore, only a rough estimate can be made based on these responses.

The estimate for *Geologic Kansas* of 80 to 90 percent was made because it includes circulations (which all but *Arizona Geology* did not include) and because it is based on a 32-page journal; more pages than the three journals have that were chosen for comparison.

Table 11

Percentage of a full-time persons time spent on quarterly journals similar in size and content to *Geologic Kansas*

Publication	**Percentage of full-time equivalency**	**number of pages**
Arizona Geology	65	12
New Mexico Geology	50	24
Survey Notes	40	16-28

Content

I would recommend that a quarterly journal with technical and nontechnical articles be published by the Survey in order to provide information for several publics, both technical and nontechnical. A journal with only technical articles would have a limited audience in Kansas. Although more than 1,000 geologists are active in the state, many are petroleum geologists; their interests are often limited to that field. Other areas, such as water and geochemistry, have a limited technical audience although research in those areas is important and should be made available. Nontechnical articles in those fields of study, however, would be appropriate for a wider range of people interested in their environment but lacking technical knowledge. A totally nontechnical journal would serve as large an audience as a combined journal, but technical information that has been gathered, but not published, could remain inaccessible or unknown.

Articles, both technical and nontechnical, should be on a variety of subjects and should cover different areas of the state. Several different topics should be covered in each issue.

Format and design

The dummy journal included in this project illustrates possible formatting and design for a Kansas Geological Survey quarterly journal. Such a journal should contain interesting articles with illustrations to enhance the text; many scientific concepts can be more easily explained with illustrations, and photographs help the reader conceptualize the state's geology. A standard format should be established before work on the first issue begins.

Printing costs obtained from the University of Kansas Printing Service indicate, as expected, that the cost of printing increases as more color is added (Table 10). Color, however, can make a publication more appealing and illustrations more interesting and sometimes more understandable. Use of some color is recommended. The cost estimates show that adding two-color to one form of one signature (eight pages) is the cheapest. Adding four-color to one form is next in cost, and adding two-color to all four forms is the most expensive.

A four-color cover would cost about $500 more than a two-color cover for 2,000 copies but could make the journal more attractive to a potential audience. Having a color cover (front and back) on a self-cover publication would also allow for color on six inside pages because they are in the same printing form. Increased cost for additional color negatives would be only about $8 per page.

Subscription rate

Although the purpose of the journal is to provide information, not to make a profit, charging a minimal subscription rate would help defray printing and distribution costs. For an organization on a tight budget, this may be the only way to finance a journal. Of the 24 respondents to the questionnaire, 16 charge for their journals or include it as part of a paid membership (Table 2). Of the eight that offered subscriptions that were not based on membership, five charged $6, one charged $7, one $8, and one $15. The price of single copies ranged from $1 to $5. Based on these findings, a subscription price of $6 and a single-copy price of $2 are recommended.

Circulation (mailing list)

The success of a journal is based as much on the ability to attract an audience and to maintain a current mailing list as on design and format. Initial attempts to find interested subscribers are critical. Several methods can be used to reach a potential audience, including informing people who buy other Survey publications about the journal's availability; using other organizations' membership lists and mailing lists; placing announcements in other organizations' newsletters; press releases; and providing brochures and order subscription forms at meetings and presentations. Several of the respondents to the questionnaire advertised in other media. However, in the Survey's case, the result may not be worth the expense of advertising. Many interested people will be reached through other means.

Obtaining as many names of potential subscribers as possible is important, especially before the first issue is published. Information gathered about potential membership lists, mailing lists, newsletters for announcing availability of a journal, and state libraries revealed that more than 33,000 names are on available address lists or mailing lists for newsletters that could be used to promote the journal. Some of those names, however, are duplicates. Determining the number of duplications at this point is impossible, but at least 20,000 of those names (16,000 are teachers) would not be duplicates. Of the 33,000 names, about 7,300 (minus duplications) are on membership lists or mailing lists that could be rented, exchanged or borrowed. The others are on lists to receive newsletters that would potentially have space to promote the journal.

Once a mailing list for the journal is created, it must be maintained and updated. This is as important as editorial policies and decisions in making the journal successful and cost effective.

Promoting a journal

Promoting the journal before it is produced is important in order to determine audience size, thus the press run and cost. Announcing the availability of the journal in newsletters with instructions on where to write or call for more information would help determine that number. Sending fliers to people on mailing lists would have the same effect. Promotional information should be the same quality as the journal and should be well-designed. Sending free copies of the first issue to potential subscribers, particularly those on the current Survey mailing list, would also pique interest, although that would be more expensive. An order form for a subscription should be included with promotional materials. Even after a journal has begun publication, promotion should continue, although not on such a large scale.

Contributors

One of the most frequent comments by the questionnaire respondents was that they had problems getting contributions, particularly from noneditorial staff members. Many staff members have little incentive to spend time on articles for an in-house journal that is not as prestigious as outside publications. However, research that is seldom published or preliminary findings could be published with a little extra effort. This would benefit both the author, who would have another reference, and the readers, who would have more information. Probably the easiest way to get staff members to contribute information would be for the editorial staff to help mold information into a publishable form.

Some data collected by Survey staff members is never published or takes years to get into final form. Staff members could be required to present preliminary findings after a certain length of time, such as one year, or be required to publish summaries of presentations or poster sessions that would otherwise not be published. In that way, more of the information collected by the Survey would become available to the public. Such a requirement, however, would have to be made and enforced by the Survey's administration.

Nontechnical articles could be solicited from noneditorial staff members in their areas of interest. Articles could also be written by the editorial staff or as a joint effort between an editorial staff member and a staff scientist. Another source of nontechnical stories is technical articles rewritten in nontechnical terms. This could be done by an editorial staff member and checked by the original author.

Working with authors would be easier if specific written guidelines were provided to state manuscript and illustration specifications, editorial policy, and style requirements.

Summary

Producing a journal at the Kansas Geological Survey would provide information for Kansans and other interested people on the state's natural resources. It would be an outlet for information that normally would not be published and would not be easily accessible to the public. It would also provide a centralized place to explain Survey research and announce publications.

Whether a journal would be successful depends on the amount of time the staff, both editorial and scientific, could devote to it and the financial and moral support it would receive from the administrative staff.

Specifications for the dummy journal

A dummy copy was created using desktop publishing on an Apple Macintosh computer. The listed software was used: Microsoft Word and Aldus PageMaker. Some of the illustrations were originally created using Adobe Illustrator.

Specifications

Trim size: 8.5" x 11"

Type of Paper: white dull-coated offset

Internal spacing:

- between columns: 1 pica for three column pages, 1.5 picas for 2 column pages
- between adjacent illustrations: 1 pica
- between illustrations and captions: .5 pica
- between captions and body copy: 1.5 picas

Folios: page numbers, journal name, and issue date

Rules and borders: .5 point rules used to offset abstracts in technical articles and in running heads; 1 point rule boxes for illustrations.

Width of body copy columns: All technical articles and departments are two column with 21-pica columns. Nontechnical articles are three column with 14-pica columns.

Cover treatment: The four-color front cover has a logo (journal's name), issue date, and issue number and volume at the top. A color photograph is featured.

Typography:

- Body copy: 10-point Times
- Heads: 18-point Times for technical articles, 48-point Times for nontechnical articles and, 24-point Times for departments.
- Subheads: 12-point Times with 12-point leading
- Running heads at the beginning of each technical article: 14-point Times
- Captions: 9-point Times, small caps

Prospectus

What is *Geologic Kansas*

Geologic Kansas is a quarterly journal designed to provide both technical and nontechnical information about the geology and physical environment of Kansas. It is produced by the Kansas Geological Survey, a research division of the University of Kansas, and is directed toward both the professional scientist and the informed and interested nonscientist.

Audience

The audience will include both scientists and nonscientists. Although the journal provides nontechnical articles, a basic understanding and interest in the geologic environment by readers is assumed. Because the journal is Kansas specific, readership will be generally limited to the state, although it may also be of interest to out-of-state people in industries, such as oil and gas, who do work in Kansas.

Competition

No magazine or journal exists that covers only the geologic environment of Kansas. Technical contributors to *Geologic Kansas* publish their research in a variety of other publications, such as *Geology, Geological Society of America Bulletin, Oil and Gas Journal, American Association of Petroleum Geologists Bulletin, Geophysics,* and *Journal of Geohydrology*. However, *Geologic Kansas* does not compete with these publications because of the types of articles it publishes, concentrating on specialized Kansas-specific articles and preliminary research. The closest competitor is *The Transactions of the Kansas Academy of Science*, which includes technical articles on different sciences, including geology, geography, and biology, from academic scientists around the state. *Geologic Kansas* is also directed toward a nontechnical audience that is interested in Kansas-specific articles, such as Kansas geologists and earth-science teachers. No journals exist that compete directly with *Geologic Kansas's* nontechnical articles.

Geologic Kansas's content: articles and departments

Technical articles will include short research articles, abbreviated versions of theses and papers, preliminary studies, and papers from Survey guidebooks and symposiums. Nontechnical articles will include feature articles on Kansas geology and reports on Survey research. Each issue contains two or three technical articles, two or three nontechnical articles, and regular departments. Three regular departments will be included in each issue. They are "GK Abstracts," which includes several abstracts from articles or presentations that appear in other journals, such as the *American Association of Petroleum Geologist's Bulletin*; "GK Geologic Site," which features an interesting Kansas geologic site; and "GK New and related publications."

Ideas for technical articles

1. "Notes on the class Arachnida from the quarries at Hamilton, Kansas" by Johna Hanson, Thomas E. Bridge, and Royal H. Mapes This paper, published in the Survey guidebook, *Regional geology and paleontology of Upper Paleozoic Hamilton quarry area in southeastern Kansas*, is one of 35 papers published in this guidebook on the Hamilton Quarry region, an area rich in marine and terrestrial fossils.
2. "Major magnetic features in Kansas and their possible geologic significance" by Harold Yarger. One of 27 papers in Survey bulletin *Geophysics of Kansas,* this article describes findings from magnetic research in Kansas and features maps of collected data.
3. "Seismic-reflection study in Rice County, Kansas" by Nelda L. Reohl, Ralph W. Knapp, and K. David Newell. This paper, from *Geophysics in Kansas*, discusses the results of seismic-reflection work used to help determine the underground geology in an area of Rice County. Seismic profiles are included.
4. "Determination of groundwater recharge for sites in the Great Bend Prairie Region of Kansas" by Geoffrey R. Coble. This article would be an abbreviated version of Coble's master's degree thesis.
5. "Remote sensing and geophysical investigations of glacial buried valleys in northeastern Kansas" by J. Denne, H. Yarger, P. A. Macfarlane, R. Knapp, M. Sophocleous, J. Lucas, and

Don Steeples. This article describes the remote sensing and geophysical techniques used in the study and several case studies.

6. "Revelation of small features in Kansas cyclothems using high-resolution reflection seismology" by Ralph Knapp. This paper in the Survey subsurface geology series *Sedimentary modeling: computer simulation of depositional sequences* gives information on how to use seismic-reflection techniques to find cyclothems in eastern Kansas.

Ideas for nontechnical articles

1. "Guide to mined-land problems and reclamation in southeast Kansas" by Larry Brady, James McCauley, Larry Knoche, and Rex Buchanan. This article would include a description of the problems and reclamation efforts and would also include a road log.
2. "Paleontological collecting in Kansas" by Rex Buchanan and Chris Maples. This article discusses the problems with commercial and private collecting of fossils and a discussion of proposed legislation to alleviate those problems.
3. Seismic-reflection survey investigating surface subsidence at the Buerki farm near Wichita. This would be a nontechnical report on the preliminary findings on the Buerki project with a brief, nontechnical description of seismic-reflection techniques.
4. History of the Kansas Geological Survey by Rex Buchanan. This article would examine the first 100 years of the Survey's existence, beginning in 1889.
5. Topographic maps by Catherine S. Evans. This article explains the different types of topographic maps available for Kansas.
6. Geophysical exploration by Don W. Steeples. This article explains geophysical techniques used in oil-and-gas exploration.

Regular departments

1. "GK abstracts"—This includes several abstracts from recent publications, presentations, or papers on Kansas-related topics. The abstracts are originally published elsewhere and will be

used with permission.

2. "GK Kansas geologic sites"—This features one geologically interesting site per issue.
3. "GK new and related publications"—This includes Survey publications and ones related to Kansas geology produced by other organizations. Related publications are on topics covered by articles in the current issue of *Geologic Kansas.* A short order form is also included.

Staff

Editor—Does long-term planning and organizes editorial efforts. Copy edits manuscripts, formats text, designs layout, coordinates compilation of manuscripts, printing, and circulation. Designs promotional materials. Communicates with authors and reviewers, and provides some of the nontechnical materials (50-60% of of an average 40-hour week).

Graphic Designer—Helps design publication and provides illustrations (10% of of an average 40-hour week).

Photographer—Takes and develops any photographs not provided by author (3% of an average 40-hour week).

Student Assistant—Proof reads (10% of an average 40-hour week).

Circulation manager—Maintains the mailing list, accounts and billing records, and renewals. Provides mailing labels for the Printing Service, which does the bulk mailings. This may be done by the editor and student assistant or it may be done by another staff member (10% of an average 40-hour week).

Contributors—Technical articles are from the Survey staff and from specialists at other universities and agencies. Nontechnical articles are written by Survey staff, including the editorial staff, and outside contributors.

Circulation

Geologic Kansas will be sold mostly by subscription, but single copies also will be available. The Survey mailing list and lists from other organizations, such as the Kansas Geological

Society and the Kansas Teachers Association, will be used initially to contact potential subscribers. Fliers and free samples will be available at meetings and conferences. The estimated base circulation is approximately 1,000 to 3,000.

Subscription and single-copy rates

A single copy is $2 and a subscription is $6 per year. Initially, copies will be sent to some potential subscribers at no cost.

Printing

The journal will be printed on an offset web press and will be bound with saddlestitch binding.

geologic kansas

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geologic kansas

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The Kansas Geological Survey

In 1889, the State, realizing the importance of its natural resources, established the Kansas Geological Survey at the University of Kansas. The Survey's mission is to conduct geological studies and research and to collect, correlate, preserve, and disseminate information, leading to a better understanding of the geology of Kansas. Special emphasis is placed on natural resources of economic value, water quality and quantity, and geologic hazards.

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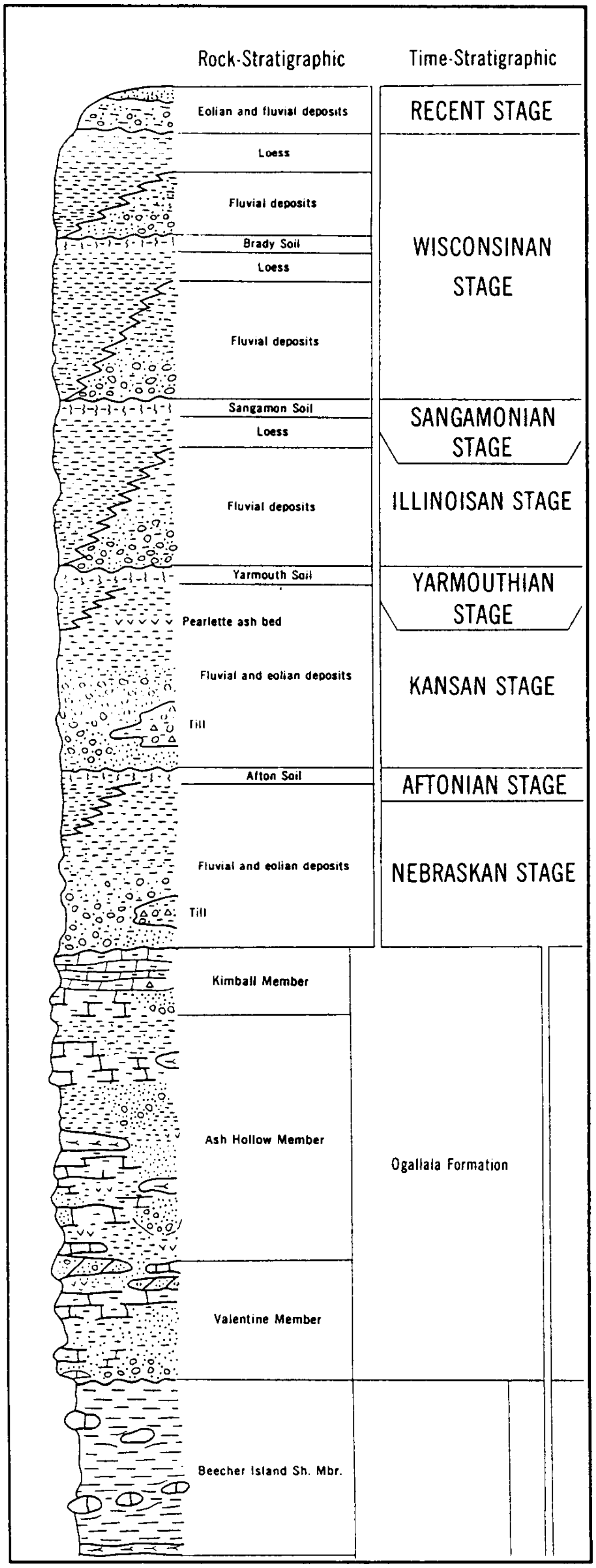
Cover: Gargoyle on the front of the Marion County courthouse in Marion carved from Kansas limestone. The courthouse was completed in 1907.



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Notes on the class Arachnida from the quarries at Hamilton, Kansas

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Abstract

Two arachnids, a whip scorpion, and a scorpion have been collected from the quarries at Hamilton, Kansas. Arachnids are among the rarest of fossil invertebrates at this locality.

Introduction

Two rare specimens of the class Arachnida have been recovered from the tan-to-gray limestone bed above the conglomerates (see stop description by Bridge and Mapes, this volume). The whip scorpion and a scorpion (figures 1, A-D) were collected from the Willow Creek and main pit areas, respectively, of the Hamilton quarry system by Walter Lockard who donated them to Emporia State University in about 1975. The scorpion was collected from the tan-to-gray limestone at this locality, which has also yielded numerous articulated vertebrates (fish, sharks, amphibians), articulated terrestrial arthropods (cockroaches, millipeds), and exceptionally well-preserved plants, including walchian conifers.

Discussion and description

Hanson (1973; p. 6-7) briefly discussed and described the whip scorpion as follows "Because of the limited preservation of the specimen . . ., it could only be classified on the shape of the cephalothorax [= prosoma] and the division of the body. The cephalothorax [= prosoma] and abdomen [= opisthosoma] of this specimen resembles the arachnid *Prothelyphonus* (Moore, 1955 p. P120-P121). This specimen is 58 mm long. The length of the carapace is 22 mm and its width is 10 mm." [Note: literature citation is taken from plate 3 explanation by Hanson, 1973; the correct citation is Petrunkevitch, 1955; brackets within the quote indicate current preferred chelicerate terminology.]

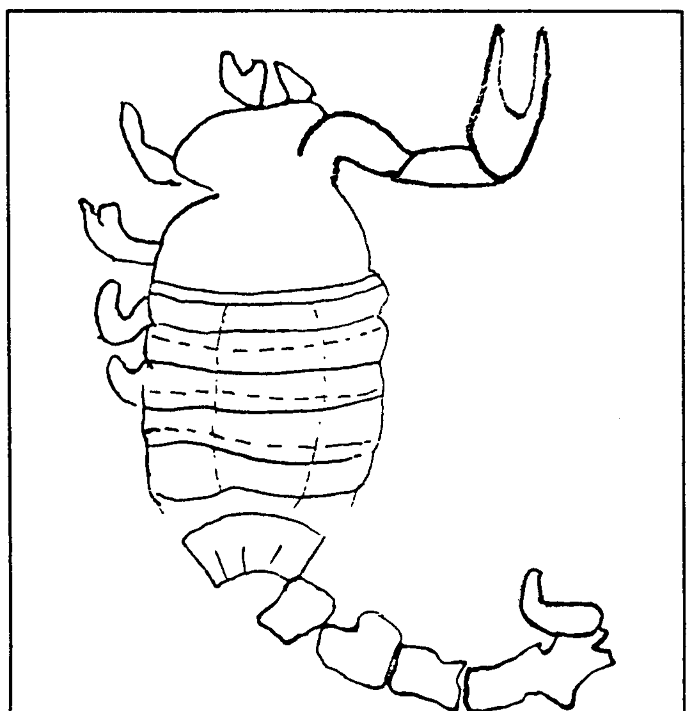

FIGURE 1-A. Photograph of the only known scorpion specimen recovered from the beds at the Hamilton quarries (at x4.8). 1-B. Drawing reproduced and enlarged from Hansen, 1973.

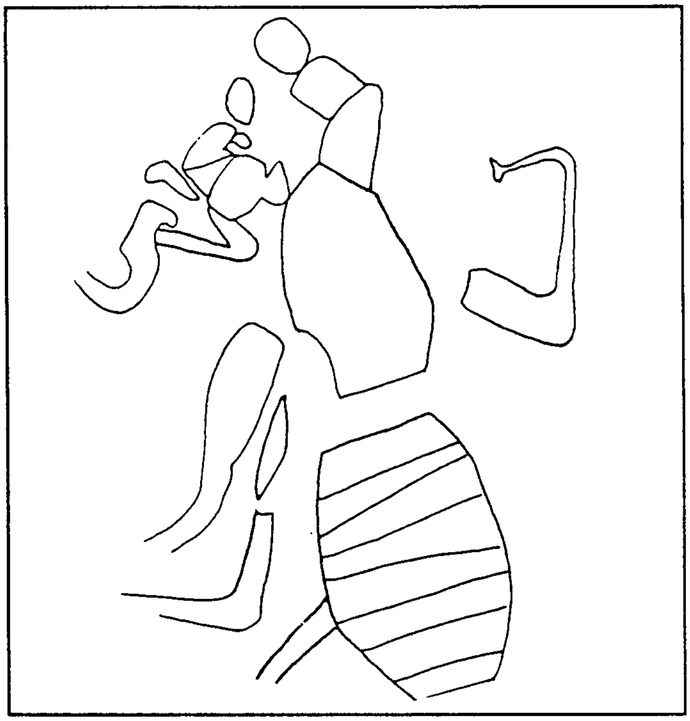

FIGURE 2-A. PHOTOGRAPH OF THE ONLY KNOWN SCORPION SPECIMEN RECOVERED FROM THE BEDS AT THE HAMILTON QUARRIES (AT x4.8). 2-B. DRAWING REPRODUCED AND ENLARGED FROM HANSEN, 1973.

This specimen is the youngest Paleozoic representative of the Order Uropygida (= Thelyphonida) and occurs in what is probably a paralic deposit with an upland flora (see Rothwell and Mapes, in this volume). All other Paleozoic uropygids are from lowland deltaic and paralic deposits. This genus is long ranging with specimens known from the Upper Namurian to the Stephanian (Beall, personal communication, 1987).

Hanson (1973, p. 7) also briefly discussed and described the single specimen of a scorpion thus far recovered and reposited from the Hamilton exposures. She describes the specimen as "similar to *Archaeoctonous glaber* (Moore, 1955, p. P73-P74)". [Note: correct citation is Petrunkevitch, 1955.] "This species has been recorded as only being found in Europe. The general shape of the abdomen [= mesosoma] and even the tail segments [= metasoma] are similar. The hand is shorter than the fingers in [= the chelae of the pedipalps of] both specimens. The front leg is nearly perfect. Portions of other legs are present but very fragmented. The chelicerae can barely be recognized at the top [= anterior] of the head [= prosoma]. The total length of the specimen is 30 mm. The tail [= metasoma] is 10 mm. The abdomen [= mesosoma] being [*sic.*] 10 mm. long and 8 mm. wide." Kjellesvig-Waering's (1986) restudy of the holotype of *A. glaber* indicates that the Hamilton specimen is slightly larger. This suggests that the two specimens might represent different ontogenetic stages. However, two other factors bring the tentative taxonomic assignment of the Hamilton scorpion into question. First, *A. glaber* is known only from the Lower Carboniferous of Scotland. Secondly, the ventral surface of the Hamilton specimen is not visible. Because the major taxonomic subdivisions of the Scorpionida are based on the morphology of the coxosternal region, it is really not possible to assign the Hamilton scorpion to the rank of suborder, let alone a generic or specific identity with confidence. The dorsal morphology of scorpions tends to be conservative, and this is the best exposed surface on the Hamilton specimen. However, detailed investigation of the pedipalpal chela may provide additional insights into the affinity of the Hamilton specimen.

In summary, both of these Hamilton specimens are compressed but preserve part of the original chitinous exoskeleton. Further study of these extraordinary specimens is highly desirable. At the present time both specimens are reposited at the Department of Geology, Emporia State University, Emporia, Kansas.

ACKNOWLEDGMENTS—We wish to thank G. Mapes, G. Rothwell, and J. Faber, Department of Botany, Ohio University, for rephotographing the scorpion and the whip scorpion; both specimens were generously made available by T. Bridge, Emporia State University, Emporia, Kansas. We also wish to thank B. Beall, Field Museum of Natural History, Chicago, Illinois; C. Durden, Texas Memorial Museum, Austin, Texas; and A. Jeram, University Manchester, England, for their positive suggestions and helpful criticism of this report.

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Revelation of small features in Kansas cyclothems using high-resolution reflection seismology

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Resolution is directly related to the bandwidth of a signal, and detection of thin beds is directly related to the wavelength of the signal. High-frequency data generally are also broader band and are also shorter wavelength. In other words, improving the high-frequency content of a signal improves the resolution and tin-bed-detection capabilities of a seismic signal dramatically. Typical bed thicknesses of cyclothems in Kansas are generally less than 10 m (33 ft) and often about 2 m (7 ft). Given an average velocity of about 3,200 m (10,560 ft)/sec, this suggests that frequencies of at least 400 Hz are needed to resolve the beds as thin as 2 m (7 ft). This is based on the resolution of thin beds being one-quarter wavelength. This generalization is related to the rock type of the bed; low-velocity shales (~2,000 m [6,600 ft]/s) require only about 250 Hz and high-velocity limestones (~4,000 m [13,200 ft]/s) require about 500 Hz for the same resolution. Furthermore, tuning will occur in a thin bed such that the instantaneous frequency of a reflection response will depend on the thickness and interval velocity of the bed.

With standard exploration reflection seismology, the frequency band is generally less than 100 Hz. As a consequence, the seismic response is greatly generalized. For instance, the Kansas City-Lansing groups are commonly seen as a strong ringy (tuned to 50-60 Hz) reflection. The low-frequency content of the signal is not only unable to resolve the individual beds of the groups, it is only able to return the reflection response of the two groups combined.

It is found that when the reflection signal content includes frequencies as high as 500 Hz or greater that the reflection response will include all but the thinnest of the individual beds. Instantaneous frequency response will depend on the bed thickness and the velocity of the bed, and the amplitude of the reflection will depend on the frequency (high frequencies having lower amplitudes), the the bed thicknoss, cyclic repetition (constructive interference), and the strength of the reflector. In other words, a limestone of 2-m (7-ft) thickness will respond with a small amplitude reflection of about 500-Hz signal. A series of alternating shales and limestones will respond with a relatively large amplitude reflection and a frequency appropriate for the tuning character of the cycles.

The reflection character of the eastern Kansas cyclothems for signals as high as 500 Hz is generally that of thin beds because bed thicknesses are usually less than 10 m (33 ft). For thick-bed response there is an isolated reflector for both the top and the bottom of the bed. For thin-bed response the top and bottom reflectors interfere, resulting in a single response for the bed as a whole. Consequently, individual reflectors in the eastern Kansas cyclothems generally represent beds rather than interfaces. With the simple application of a phase-shift filter, it is possible to process the data such that positive reflectors (troughs) represent thin-bed shales and sandstones. This simplification may make classical interpreters shudder because it is one of the first generalizations that they are taught to avoid; however, in the case of cyclothems it is valid for much of the section.

When high-resolution, high-detail data are obtained, Kansas cyclothems are revealed to not be the typical layer-cake that most geophysicists and even many geologists think. The section (see fig. 1) is of sufficient detail that inspection of it is reminiscent of looking at an outcrop from the distance of a few tens of meters. It is found that lateral sampling (trace interval of the section) of less than 1 m (3.3 ft) is necessary to see the lateral changes that are taking place in the section. Beds are found to change character in the distance of only a few meters. Most of the lateral changes are occurring in sandstones, and shales, but even limestones can change character within a few tens of meters. These changes include presence of sand channels and sandstone-bedding structure, small faults, thickness variation, and facies changes.

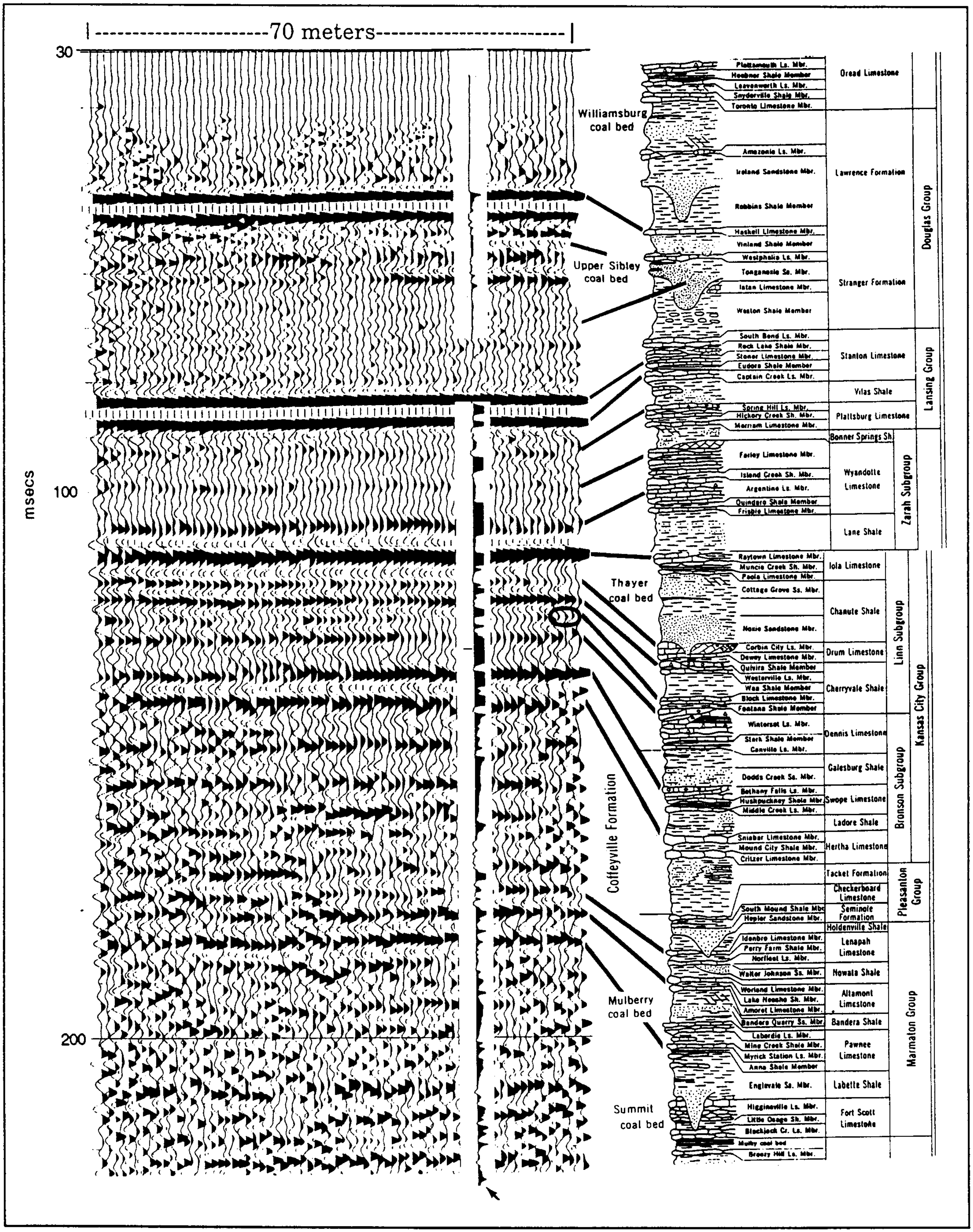

FIGURE 1. Seismic section of the Pennsylvanian beneath Lawrence, Kansas, with a velocity log (arrow) and formation indentification, 1-m (3.3-ft) trace interval.

Seismic-reflection study in Rice County, Kansas

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Abstract

During the summer of 1983, a MiniSOSIE seismic-reflection study was conducted in Rice County in which an 11.2-km (7-mi) 12-fold common depth point (CDP) profile was shot to investigate several local structural and stratigraphic features. The seismic line was oriented east-west, perpendicular to the local structural grain. Several units, ranging from the Arbuckle through the Mississippian limestones, subcrop beneath the basal Pennsylvanian angular unconformity in this area. The subcrop pattern is dominantly north-south and is related to the eastward dip of these units off the Central Kansas uplift. Reflectors in excess of 1,070-m (3,500-ft) depth are detectable on the seismic profile. The deepest reflectors (0.850 secs) correspond to the Precambrian Rice Formation. Good reflectors occur in the lower Paleozoic section corresponding to a local limestone in the Chattanooga Shale and the subjacent Maquoketa–Viola formations. Several limestones in the Upper Pennsylvanian and Permian section also are good reflectors of seismic energy. Stratigraphic features such as local thinning or thickening and channel cuts can be detected in this part of the stratigraphic section. The Lyons anticline, a local north-south-trending structure currently used for gas storage, also is expressed on the seismic line. The seismic profile shows the structural history of this anticline to be long and complex. Initially, the anticline was a broad, symmetric feature possibly related to the formation of the Precambrian Keweenawan rift. Minor growth may have occurred prior to the deposition of the Chattanooga Shale. A third major period of movement occurred during Late Mississippian to Early Pennsylvanian time when a reverse fault developed on the west flank of the structure, thereby making the structure an asymmetric anticline. Minor structural movement occurred again subsequent to the development of the basal Pennsylvanian angular unconformity.

Introduction

The purpose of this study is to identify local structural and stratigraphic features and to interpret structural history associated with the southeastern edge of the Salina basin using reflection seismology and the methods of seismic stratigraphy. Ongoing analysis of well logs has resulted in questions about the subsurface geology. Early Paleozoic stratigraphic relationships and structural interaction between the Salina basin, Sedgwick basin, and Central Kansas uplift vary over much smaller distances than well control illuminates. The lateral continuity of a seismic section, controlled by the well data, is needed for a more correct interpretation.

Rice County is located over part of a structural saddle formed by the intersection of the Salina basin, the Central Kansas uplift, and the Sedgwick basin. Since the Middle Ordovician, Kansas has undergone five periods of deformation (Lee, 1956; Merriam, 1963). In Rice County, along the southern flank of the Salina basin, deformation has resulted in complex folding and faulting of differing alignments. In general, thickening and thinning of formations as encountered in wells indicate the deformational events. Through reflection seismology, a continuous geologic cross section can be constructed to reveal the particular erosional and depositional sequence, boundary relationships, folding, and faulting for this area.

Of particular interest is the extent and character of a limestone within the Mississippian–Devonian Chattanooga Shale. Well-log data indicate thinning or faulting of this Chattanooga limestone (fig. 1). Wells have encountered the limestone at a depth averaging 1,050 m (3,450 ft) below ground surface. The seismic-reflection survey conducted in Rice County for this study is located over the limestone unit, which has a maxiumum thickness of 21 m (70 ft) at the western edge of the seismic section. The limestone thins to the east and is missing under the eastern edge of the seismic section. Modeling, using synthetic

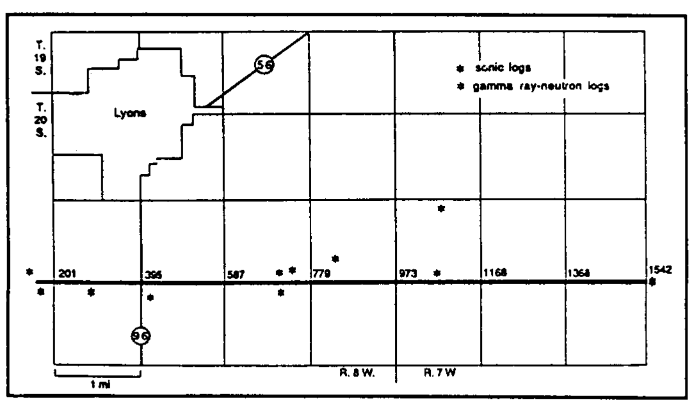

FIGURE 1. Location of Rice County seismic-reflection section. Common-depth-point (CDP) numbers are shown for each mile.

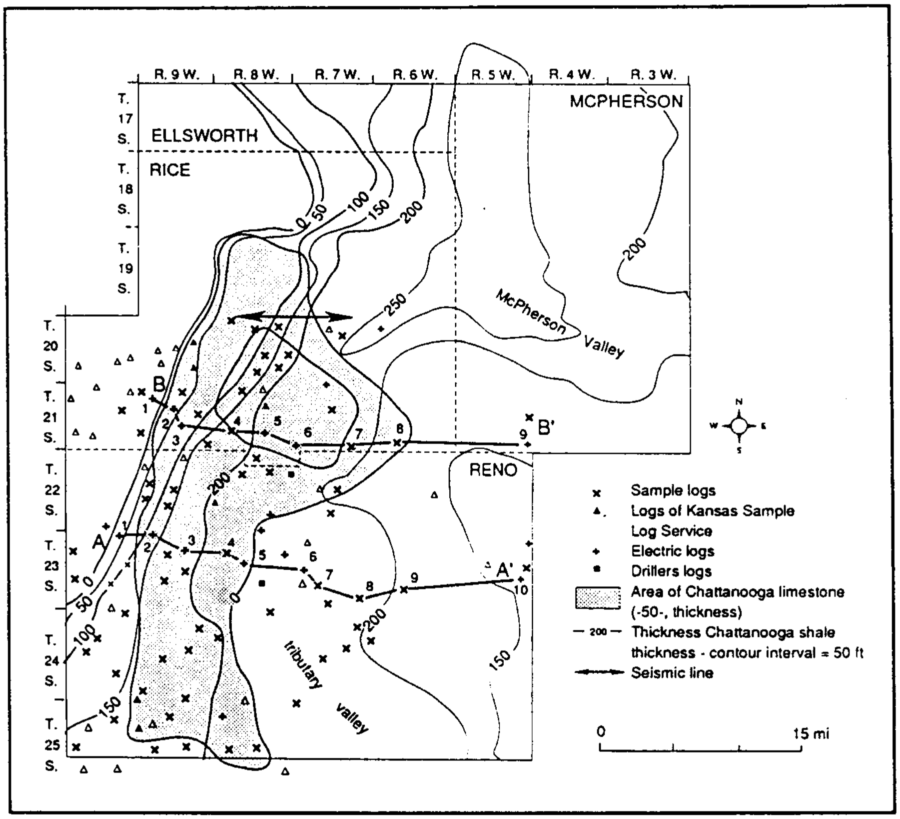

FIGURE 2. Topography of pre-Chattanooga McPherson Valley with thickness contours of Chattanooga limestone member in stippled area (from Lee, 1956). Rice County seismic line is shown in T. 21 S., R. 7-8 W.

seismograms, and interpretation, using seismic stratigraphic analysis, have helped to define this and other subsurface features in the area.

Local geology

Rice County is situated on the eastern flank of the Central Kansas uplift and the western side of the unnamed saddle marking the boundary between the Salina and Sedgwick basins. Geologic structures in this saddle generally trend north and north-northeast. Formation thicknesses are generally intermediate to those reported for the Central Kansas uplift and the Salina basin, although the basal conglomerate developed at the basal Pennsylvanian unconformity is thicker than in the Salina basin. The Misener sandstone, a transgressive sand developed at the base of the Chattanooga Shale, is well-developed along the eastern flank of the Central Kansas uplift but thins to a featheredge eastward in the Salina basin. To the west, it is truncated beneath younger conglomerates developed at the basal Pennsylvanian unconformity.

Although no wells along the reflection profile penetrate the Precambrian, aeromagnetic and gravity data suggest the presence of the arkosic sandstones of the Rice Formation under the eastern half of the seismic line (Yarger, 1983). A magnetic low, indicating an anomalously deeper and less magnetic source in the Precambrian, underlies the entire line. This material is considered a transition zone between the rocks of the northern (1,610–1,650 m.y.B.P.) and southern (1,460–1,480 m.y.B.P.) terranes of Van Schmus and Bickford (1981) and Yarger (1983). A deeper seismic investigation may give a greater understanding of the Precambrian mechanics involved in this type of suture zone.

From Ordovician to Devonian time, uplift and erosion along the flanks of the ancestral Central Kansas uplift and local erosion of a large pre-Chattanooga valley named the McPherson Valley by Lee (1956) resulted in the absence of the Silurian–Devonian Hunton group over much of Rice County. The crest of the Central Kansas uplift is just to the west of the cross section in fig. 2. The McPherson Valley begins east of a local anticline (the Lyons anticline), which presently serves as a gas-storage structure for Northern Natural Gas. This anticline is one of a series of north-trending en echelon anticlines developed in western Rice County, which subcrop underneath the basal Pennsylvanian unconformity (fig. 3). Although Chattanooga Shale is present on the flanks of the anticline, Viola Limestone and even Simpson Group subcrop along the crest of the anticline in the vicinity of the seismic line. Farther to the east, the Viola Limestone subcrops beneath the older pre-Chattanooga unconformity in the deeper parts of the McPherson Valley (fig. 4).

Accelerated structural activity in Late Mississippian to Early Pennsylvanian time is attributed to be the main deformational event that formed most of the local structures in this region. In the subcrop map of the pre-Pennsylvanian unconformity (fig. 3), a regional outcrop pattern of progressively older strata from east to west shows the eastward dip off the flank of the Central Kansas uplift.

A closer look at the Lyons anticline (fig. 5) indicates variable dip to the east of less than 2° of all beds below the Pennsylvanian basal conglomerate. Reverse faulting on the west side of the anticline forms a cuesta. The nose was eroded along the fault plane into the Simpson to form a river valley. During the

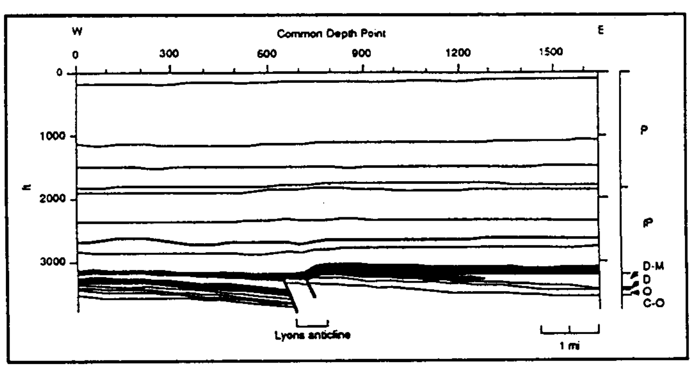

FIGURE 3. Geologic cross section along Rice County seismic section. Wells used are shown in fig. 6. Lyons anticline is shown as are major structural features of early Paleozoic; layers in black are Pennsylvanian basal conglomerate above and Chattanooga limestone member below.

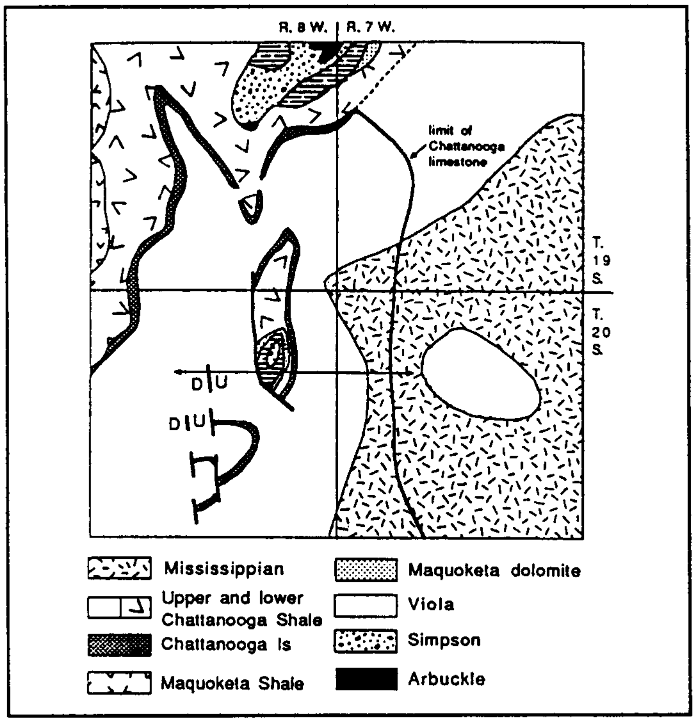

FIGURE 4. Subcrop map at the basal Pennsylvanian unconformity. Heavy line indicates eastward extent of Chattanooga limestone unit within the Chattanooga Shale. Map is 12 mi x 12 mi (19.3 x 19.3 km). Location of seismic line in T. 20 S. is marked by the double-arrow line.

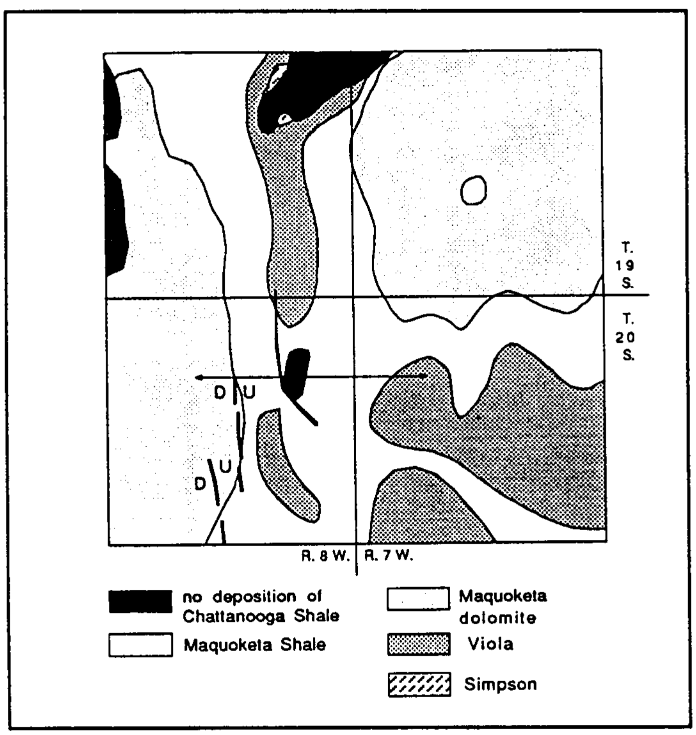

FIGURE 5. Subcrop map of pre-Chattanooga unconformity. Dark areas indicate where Chattanooga Shale is absent due to later erosion at the basal Pennsylvanian unconformity. Subcropping Viola in the southeast quadrant of the map expresses the axis of the east-west-trending McPherson Valley. Location of seismic line is shown with double arrow in T. 20 S. Map is 12 mi x 12 mi (19.3 x 19.3 km).

Middle Pennsylvanian, folding ceased and the valley was filled with Pennsylvanian basal conglomerate.

The subcrop pattern of the Chattanooga limestone unit, as shown on the pre-Pennsylvanian subcrop map (fig. 3), reveals a pattern of folding regionally parallel to the Central Kansas uplift. The exact original extent of this limestone is not known. To the east it seems to have been replaced by siltstones during deposition of the upper part of the Chattanooga Shale.

From Late Pennsylvanian through Permian time, local structural activity was very subdued and cyclic deposition dominated local as well as statewide geology. Regional tilting, first to the south in response to a combination of southeastward and southwestward subsidence during Pennsylvanian and early Permian time, and then to the west and north toward the Hugoton and Denver basins during Permian through Cretaceous time, is indicated by thickening of beds. Regional and local sedimentary deposition are most evident as cyclothems of transgressive marine limestone and shale deposits followed by regressive limestone, lagoonal shale, and channel-sand deposits. Facies are generally consistent throughout the area.

Seismic-study location and acquisition parameters

In an effort to better understand the structure of the southwestern flank of the S basin, MiniSOSI (Barbier et al., 1976) reflection-seismic data were acquired by the Kansas Geological Survey during the summer of 1983. The east-west line, located 3.2 km (2 mi) south of US–56 (Lyons, Kansas), covered 11.2 km (7 mi) from 1.6 km (1 mi) west to 9.6 km (6 mi) east of K–96 (fig. 6). An earth-compactor energy source provided the input signal. End-on common- depth-point (CDP) geometry with twelvefold coverage (table 1) was used. The reflected seismic energy was sensed by a linear array of geophones on the earth's surface and recorded by an Input/Output, Inc., DHR 2400 24-channel recording system.

Rice County reflection seismic profile

Seismic interpretation

Based on the principles of seismic stratigraphy and constrained by previous geological and geophysical studies, the following interpretation is the most accurate picture of Rice County, Kansas, geology produced within the limits of seismic resolution (figs. 7 and 8).

Seismic expression of the Precambrian

Regional well data indicate the Precambrian in this area underlies an average of 183 m (600 ft) of Arbuckle Group dolomites (Cole, 1975). The contact between the Precambrian granites and the Arbuckle dolomites cannot be seen seismically. However, using an average velocity of 4,300 m/sec (14,000 ft/sec), the Precambrian would be more than 90 msec (two-way time) below the top Arbuckle reflector (fig. 9); hence the seismic record probably extends about 600 m (2,000 ft) into the Precambrian. Several parallel reflections, fading in and out with the data quality, are seen within the Precambrian. The reflections generally follow the Paleozoic sequence and may be multiples; however, the high stacking velocities necessary for these events refutes this possibility. The top of the Precambrian is expected to be Upper Keweenawan Rice Formation arkosic sandstones which, according to the COCORP results in northeastern Kansas, should contain very few good reflectors (Brown et al., 1983; Serpa et al., 1984). Gravity and aeromagnetic data (Yarger, 1983; Yarger and Lam, 1982) suggest this sequence thins westward in Rice County to expose granitic igneous rocks in a transition zone between the northern and southern terranes described by Bickford et al. (1981). Inasmuch as the northern and southern terranes are dominantly granitic-metamorphic complexes, the transition zone between them should be expressed by a lack of significant seismic reflections (Serpa et al., 1984; Brown et al., 1983). However, the discontinuous layering shown in the seismic section implies a consistent stratified rock type along the entire length of the seismic section. Layering of the Precambrian in the central part of the seismic section (CDP's 340 to 1180, .750 to 1.0 sec; fig. 7) does not seem to extend as deep as the layering in other parts of the section, and instead, a rock type different than that of the Rice Formation may be present in the basement in the immediate vicinity of the Lyons anticline.

On the assumption that the latter interpretation of two different Precambrian rock types is valid, fig. 10 shows thinning of a Precambrian Rice Formation layer due to upwarping (CDP's 770 to 885, .800 to .840 sec). This implies existence of the Lyons anticline during the Late Proterozoic. Its initial uplift is possibly related to Keweenawan rifting.

Seismic expressions of the Cambrian and Ordovician

The boundary between Arbuckle and Precambrian formations does not yield a distinct reflection of sufficient energy. Lower limits of the Arbuckle are approximated using well information, seismic data, and literature (Cole, 1975; Lee, 1956; Merriam, 1963). Except for reflections from CDP's 185 to 290, the character of the Arbuckle sequence is of continuous high-amplitude parallel reflections. To the west (CDP's 185 to 290,

Data-acquisition parameters	
Record length	1 sec
Sampling interval	2 msec
Source	MiniSOSIE earth compactor
Vertical stack	2,000 pulses/shotpoint
Dominant frequency	80 Hz
Source interval	17 m (55 ft)
Source array	Linear, continuous
Receiver interval	17 m (55 ft)
Receiver array	17 m (55 ft), linear 10 receivers, equally spaced
Recording geometry	End-on, 24-channel, CDP
Near offset	226 m (742.5 ft)
Far offset	612 m (2,007.5 ft)
Filters: low cut	55 Hz (24 dB/octave rolloff)
high cut	125 Hz (24 dB/octave rolloff)
notch	60 Hz (60 dB rejection)

TABLE 1. Rice County seismic-reflection line.

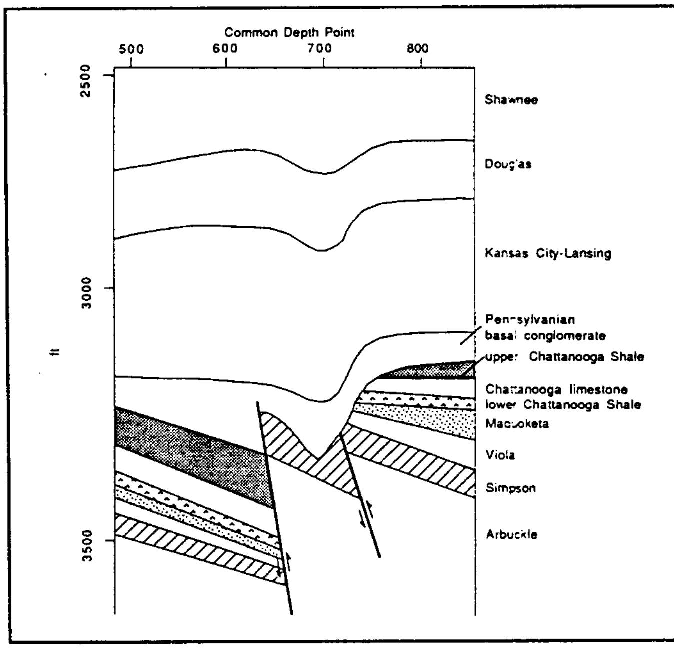

FIGURE 6. Geologic cross section along part of Rice County seismic section showing detail of Lyons anticline; five times vertical exaggeration.

.700 to ~.800 sec; fig. 9) and to the east (CDP's 730 to 780, .680 to ~.800 sec; fig. 11), reflections diverge, indicating uplift of the anticline during the time the Arbuckle was deposited. The westward dip and divergence of reflectors between CDP's 185 and 290 contrast with westerly thinning and eastward dip of the Simpson through Shawnee groups. This suggests an earlier opposing deformation of subsidence to the west into the Southwest Kansas basin. Discordance in the form of erosional truncation under a series of horizontal reflections occurs within the Arbuckle Group (CDP's 200 to 250, .680 to .740 sec) to indicate a period of no uplift along the Lyons anticline prior to renewed activity during the Ordovician to Early Pennsylvanian.

Above the Arbuckle Group, the Simpson Group maintains a constant time thickness and has a noisy, negative-polarity reflection character. The noisy reflection character of the Simpson is a result of the interbedding of shales, sandstones, and dolomites within the group. It is easily identified by the strong positive peaks of the Viola above and Arbuckle below and is distinguished from the lower Chattanooga Shale by the clean, relatively noise-free, negative-amplitude character of the lower Chattanooga. Well-log data indicate that the Simpson crops out beneath the basal Pennsylvanian unconformity on the crest of the Lyons anticline (fig. 11; CDP's 595 to 620, .620 to .650 sec, and CDP's 685 to 710, .620 to .660 sec) and that it thins just east of the major reverse fault (CDP's 595 to 620, .620 to .650 sec), possibly to expose the Arbuckle in the area of multiple diffractions (CDP's 620 to 650, .610 to 1.0 sec). The diffractions are caused by either tight folding or a series of faults that mask reflections below the Pennsylvanian sequence. Unlike the straight-line geologic interpolation of fig. 2, the Simpson is folded down into a river valley between CDP's 650 and 700 (.640 to .660 sec) and underlies weathered deposits of the Viola in the valley center. The abrupt termination of Arbuckle,

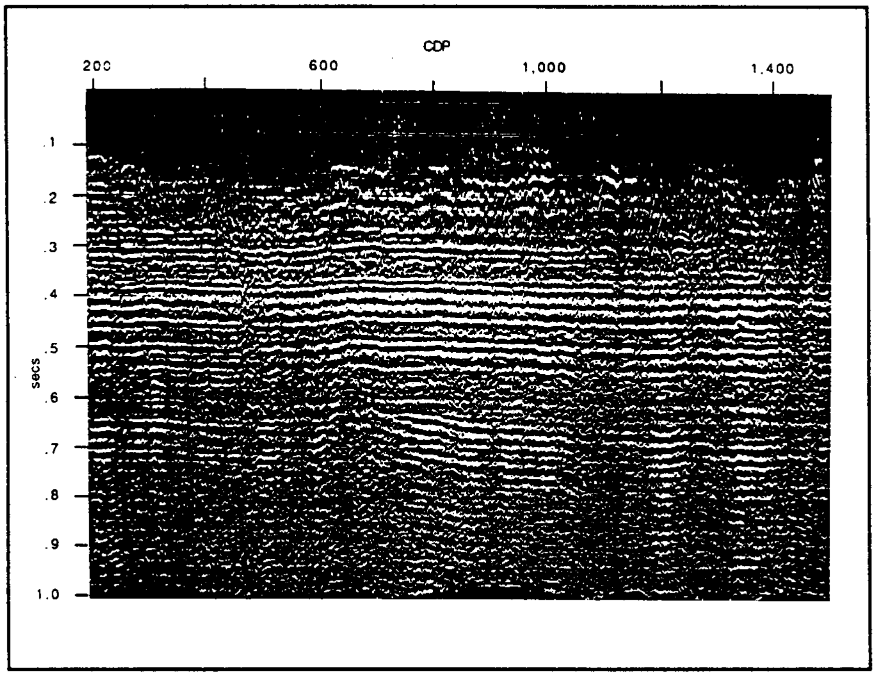

FIGURE 7. Rice County processed seismic section, flattened at the Shawnee/Douglas–Kansas City–Lansing interface (approximately 550 msec). Squash plot scale is 100 traces/inch; 1 mi = ~192 CDP.

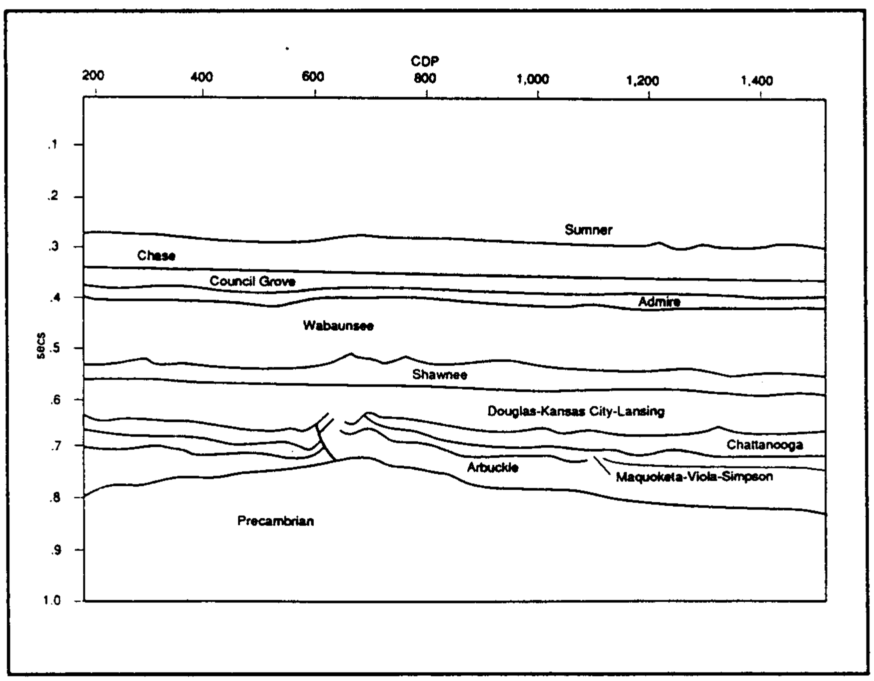

FIGURE 8. Line drawing of Rice County seismic section (fig. 7). Squash plot scale is 100 traces/inch; 1 mi = 192 CDP. Note depth scale is not linear.

Simpson, and Pennsylvanian basal conglomerate reflections on the west side of the valley suggests a fault scarp on the west valley slope.

The velocities of the Maquoketa Formation are intermediate between those of the Chattanooga Shale (and Misener sandstone) above and the Viola below. This results in a transitional, stretched, positive reflection joining the Maquoketa and the Viola. Seismically the Maquoketa and Viola must be considered together. The Maquoketa–Viola reflection character is one of the strongest positive peaks on the section and is easily identified as the first peak below the even stronger positive peak of the Chattanooga limestone. The general trend from west to east shows thinning or dimming of both the Chattanooga limestone and Viola– Maquoketa reflectors in contrast to a brightening of the underlying Arbuckle reflectors. As the layers are traced into the McPherson Valley (fig. 12), much of the Maquoketa has been eroded. The Viola–Maquoketa interval thins over the local anticline and the reflection is lost.

Seismic expressions of the Devonian and Mississippian

The major unconformity that exists above the Ma-quoketa does not produce either the angular terminations or the high-amplitude reflections necessary for seismic detection. It is therefore doubtful that thinning of the Maquoketa would be noticed on seismic sections without geological control.

For purposes of discussion, the Chattanooga Shale is informally broken up into an upper part, which lies above the Chattanooga limestone, and a lower part, which is subjacent to the Chattanooga limestone. Well control indicates the Misener sandstone is present at the base of the Chattanooga Shale in the vicinity of the Lyons anticline and westward to the subcrop limit as it approaches the Central Kansas uplift. Although the Misener significantly thins east of the Lyons anticline, the reflection character of the base of the Chattanooga Shale is consistently a broad negative polarity which does not change to indicate when the basal Misener is present. Throughout the section the lower Chattanooga shale retains a constant time-thickness, except where it crops out over the anticline.

From well-log data, the Chattanooga limestone unit thins to the east and seems to be replaced by siltstones by the east edge of the seismic section. In many parts of the seismic section, the Chattanooga limestone is by far the brightest positive-amplitude reflector. To the east of the Lyons anticline, the width of the peak thins but does not terminate within the areas of good data quality (fig. 12). One zone of apparent partial siltstone replacement can be seen between CDP's 1350 and 1360. Due to good data quality in this area, all reflectors except the limestone have a bright, noise-free character, which suggests the limestone has either thinned or has been replaced by a lower velocity material to produce only a nominal positive kick. The limestone thins over the anticline (CDP's 715 to 735, .630 sec).

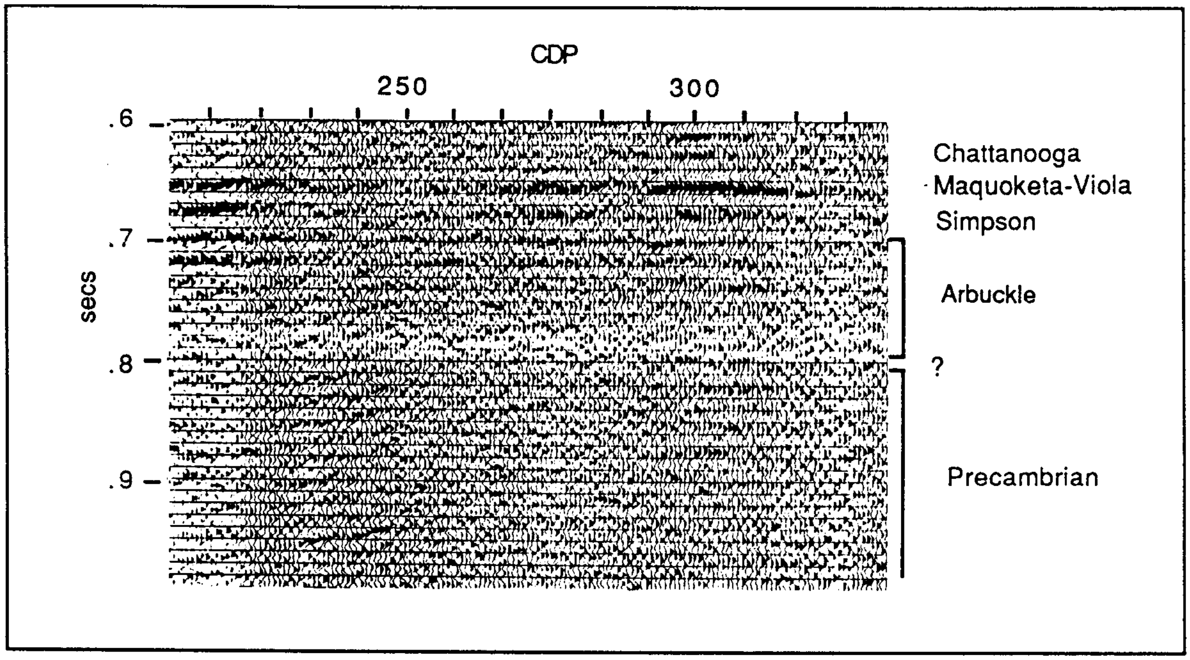

FIGURE 9. Large-scale detail of Rice County seismic section with interpretation showing parallel configuration of Chattanooga through Simpson groups. Discordance of west-dipping Arbuckle and Precambrian reflectors indicates west flank of Lyons anticline during the Proterozoic through Ordovician. Pennsylvanian basal conglomerate is shown to thin to the west as its reflection fades.

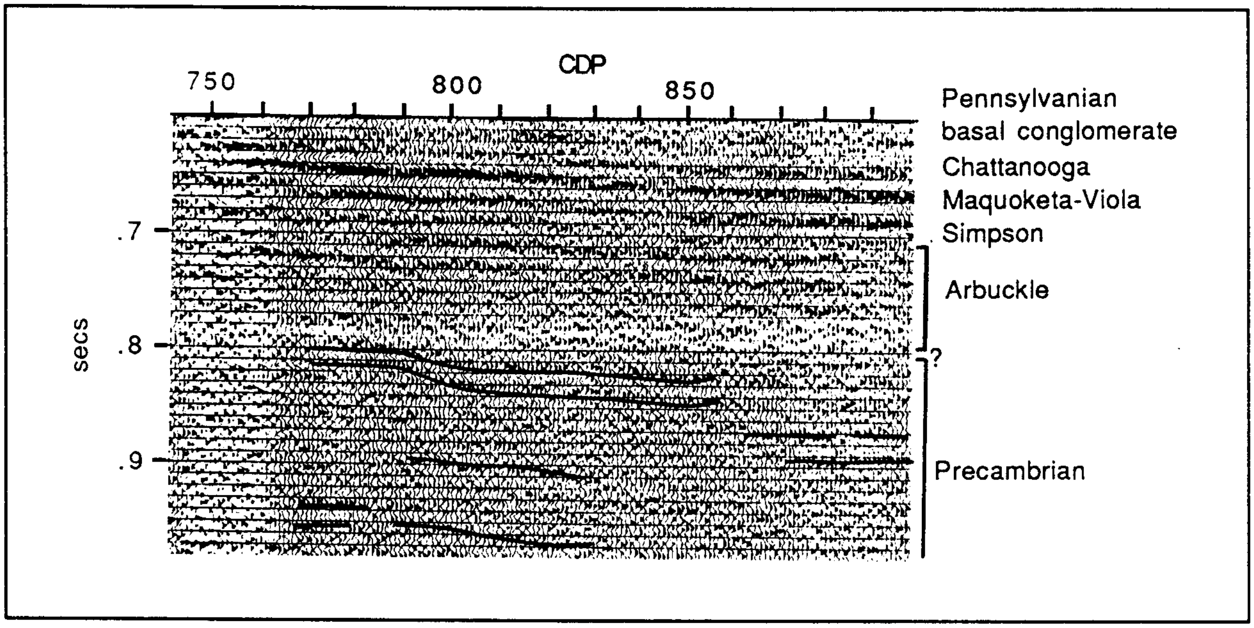

FIGURE 10. Large-scale detail of the Rice County seismic section with interpretation. Uplift of the local anticline is indicated by dipping and thinning of Precambrian Rice Formation reflections.

The upper Chattanooga Shale is expressed as a broad negative reflection above the bright, positive Chattanooga limestone reflection. Eastward, the shale thickens dramatically by CDP 1330 (fig. 12). This is the major diverging layer in the seismic section and indicates thickening into and possibly subsidence of the McPherson Valley just to the east.

Seismic expressions of early Paleozoic structure

The general eastward dip of the lower Paleozoic strata reflects the location of the seismic section on the flank of the Central Kansas uplift. Reflectors become more parallel and nearly horizontal in the Pennsylvanian, thereby indicating that deformation along the Central Kansas uplift had ceased.

The major structural features of the Lyons anticline can be described in greater detail. Continuity of the Chattanooga limestone and other layers between Simpson and the upper Chattanooga Shale indicate that the anticline was not active during the time of their deposition and that not until Late

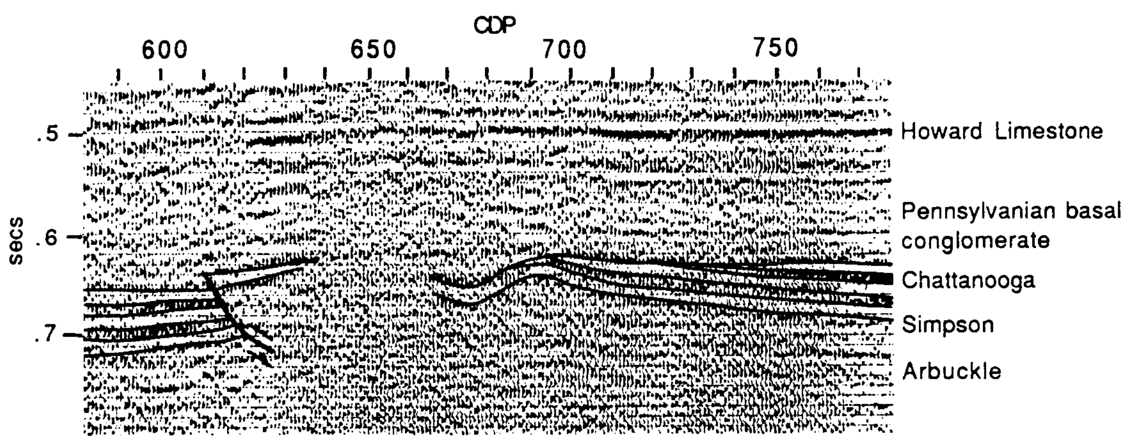

FIGURE 11. Large-scale detail of Rice County seismic section with interpretation. Structure related to Late Mississippian–Early Pennsylvanian deformation of Lyons anticline is shown. Tuning and cancellation due to interference of thinning beds indicates that an erosional flank-outcrop pattern exists immediately below the Pennsylvanian basal conglomerate.

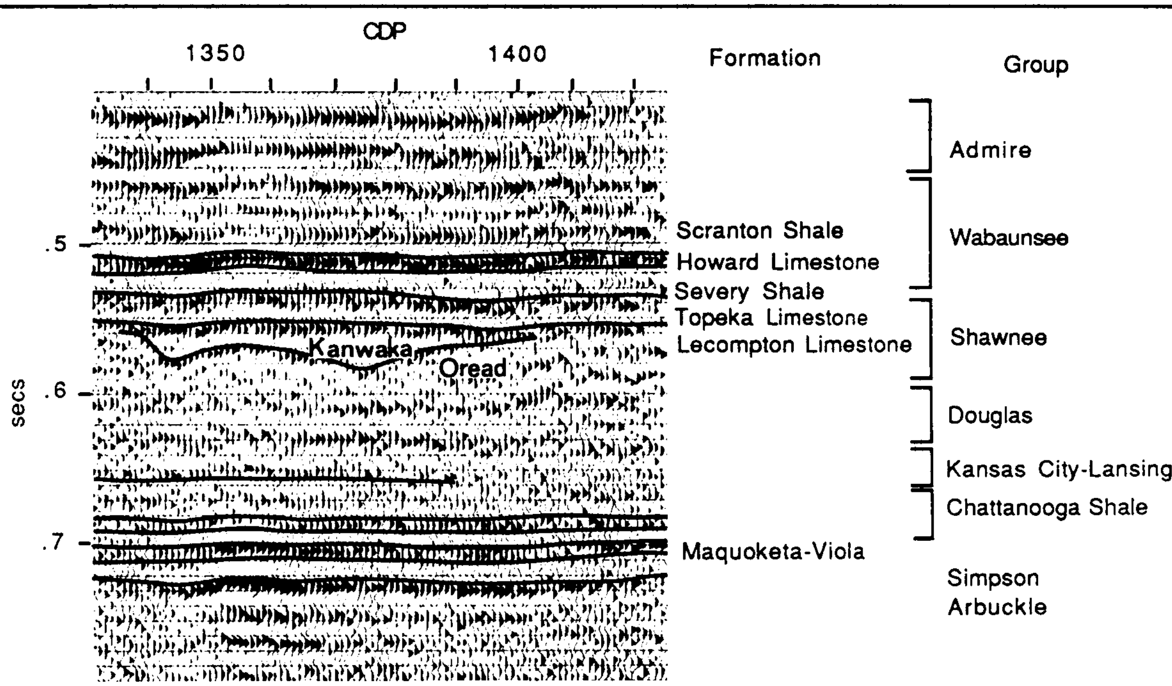

FIGURE 12. Large-scale detail of Rice County seismic section with interpretation. Stratigraphic relationships of Arbuckle through Wabaunsee groups are shown. Fading out of Chattanooga limestone reflector indicates a short interval in which it is replaced by siltstones or shales (CDP's 1350 to 1360). Channel sand of Kanwaka Shale formation shows erosion through several units down to the Oread Limestone.

Mississippian did it again become active (fig. 5). Abrupt termination of Arbuckle through Pennsylvanian basal conglomerate strata easily defines the fault plane and suggests a reverse sense of displacement along the fault between CDP's 610 and 620. Relative dating of the fault is Late Mississippian due to preservation of the upper Chattanooga Shale on the downthrown block. Evidence that the Pennsylvanian basal conglomerate is cut by the fault suggests renewed fault movement after development of the basal Pennsylvanian unconformity. Structure in the area of diffractions (CDP's 634 to 664, .600 to 1.0 sec) is undecipherable, although the diffractions may be caused by tight folding or faulting contemporaneous with the Late Mississippian to Early Pennsylvanian deformation.

Seismic expressions of the Pennsylvanian

The unconformity at the base of the Pennsylvanian is a low-amplitude discontinuous reflection which is most easily identified by the angular erosional truncations underneath. Except for the river valley in the small downfold of the Lyons anticline, the Middle Pennsylvanian land surface had been flattened and the reflection of the unconformity can be somewhat easily traced across the seismic section at approximately 650 msec (figs. 7 and 8). The Pennsylvanian basal conglomerate reflector fades between CDP's 185 and 250, probably due to thinning. The Chattanooga Shale thickens eastward below the basal conglomerate reflector. Silurian and Devonian rocks are absent probably because of pre-Chattanooga or pre-Pennsylvanian erosional episodes.

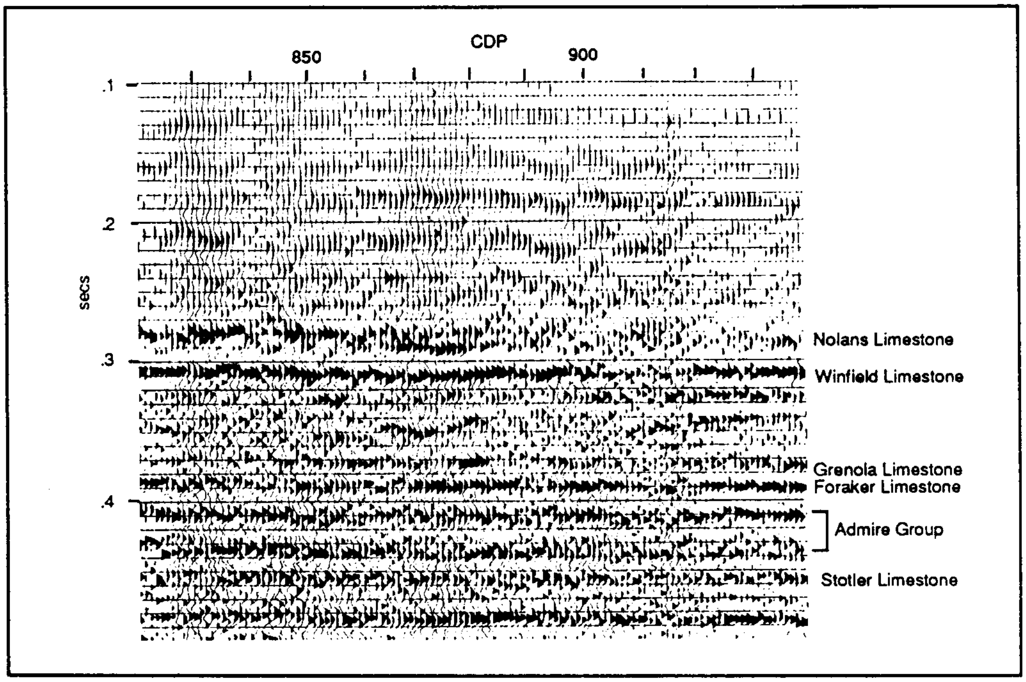

FIGURE 13. Large-scale detail of Rice County seismic section with interpretation. Stratigraphic relationships of Wabaunsee through Council Grove groups are shown. Interference patterns of thin shales and limestones create variable amplitude and character reflectors of the Admire Group and Foraker Limestone formation. The Nolans Limestone illustrates a stretched amplitude due to a transitional boundary.

Cyclothems of the Kansas City, Lansing, and Douglas groups display a similar reflection configuration of low continuity and amplitude, with parallel to slightly folded bedding (figs. 7 and 8). According to Brown and Fisher (1979), this indicates dominantly nonmarine clastic deposition by river currents and associated marginal-marine transport processes, which is in agreement with the known stratigraphy. Channel sands and shelf-margin limestone lenses and öolite shoals commonly occur within these lower cyclothem units (Merriam, 1963). Well-log data indicate the Kansas City and Lansing groups are composed predominantly of limestones with shales thin enough to be seismically undetectable. In contrast, the Douglas Group is made up almost entirely of shales and channel sands. Marine-limestone mounding, undetectable shales, and extensive erosional hiatuses combine to produce, in general, only nominal reflections for interpretation of the Kansas City, Lansing, and Douglas groups.

Two limestones in the Shawnee Group have significant seismic expressions—the Topeka at the top of the group and the Lecompton near the middle (fig. 12). The thickness of the intervening Calhoun Shale varies across the section, indicating moderate erosion during the hiatus before its deposition. One area of interest and high data quality within the Shawnee Group between CDP's 1330 and 1410 is a stream-channel fill of Kanwaka Shale (fig. 12). Although the Heebner Shale Member at the base of the Shawnee is highly visible in well logs and cores, its 6-ft thickness is only .03 of a wavelength, making its seismic expression virtually invisible.

Within the Wabaunsee, two limestone formations exhibit high-amplitude continuous reflections. The Howard near the base (fig. 12) and the Stotler near the top (fig. 13) both possess abrupt lithologic boundaries that produce high reflection coefficients. These reflections are the most continuous of the cyclothem sequence and were used as a guide for much of the statics correction "flattening." The Severy Shale immediately below the Howard shows the greatest thickness variation of all units, suggesting an undulating erosional surface on top of the Topeka Limestone. Between the Stotler and the Howard are several reflections of laterally varying character and amplitude. These reflections are due to several thin limestone and shale units which constructively interfere to appear as a single reflection. These beds are known to be discontinuous, resulting in variable reflection character. In other areas, such as the Shawnee Group in the area of the Heebner, interference is destructive and produces cancellation of unresolvable beds.

Seismic expressions of the Permian

The Admire, Council Grove, and Chase groups of the Lower Permian produce reflection configurations that are similar to the high-amplitude, continuous reflections of the Wabaunsee (fig. 13). Reflections are often the result of interference of laterally constant but individually unresolvable thin beds, which maintain a continuous reflection across the seismic section. Within the Chase Group, individual shale units between the Grenola and Foraker apparently thicken locally and have minimal velocity variations, which is characteristic of homogeneous units. As a result, this interval may be reflection-free in places and seem to be a more or less homogeneous unit. The Nolans Formation also varies laterally and, in places, shows a gradational transition from limestone to shale which results in a stretched-out pulse. The Sumner and Nippewalla groups are not seen in this particular seismic-reflection section.

Conclusions

The Rice County seismic-reflection profile generally confirms the straight-line interpolations of well geology. However, by virtue of seeing beyond and below the first dimension of the borehole, the seismic line has added the following contributions which greatly improve knowledge of area stratigraphy and structural history.

1) Layered reflections of the Precambrian Rice Formation are present and possibly thin onto the Lyons anticline. The reflection character of the anticline at depth differs from the layered reflections in the Rice Formation, implying a different rock type, possibly the granites of the terrane-transition zone.

2) Arbuckle and lower reflectors show divergence both westward and eastward away from the crest of the Lyons anticline. This contrasts with all the subsequent Simpson through Shawnee Group reflectors which generally diverge (thicken) eastward. The eastward and westward divergence in the Arbuckle and Precambrian indicates uplift of the anticline and subsidence in the area of the Central Kansas uplift during Proterozoic and Cambrian–Ordovician time. The anticline during this time was a much larger feature, possessing a broad west-dipping flank, rather than a terminating fault as in the Early Pennsylvanian.

3) The growth history and geometry of the Lyons anticline can be accurately defined by reflection seismology. The anticline during the Cambrian–Ordovician, and possibly the late Precambrian, was a large symmetric positive feature. It was eroded prior to deposition of the Simpson and reactivated during the Late Mississippian to Early Pennsylvanian as a smaller, asymmetrical, highly folded and faulted, positive feature. The valley near the crest of the anticline developed on the erosional surface associated with the basal Pennsylvanian unconformity. The location of the valley is controlled by a small synclinal fold and is terminated on the west by a fault scarp. Diffractions to the west of the river valley imply tight folding or faulting and are associated with a major reverse fault with over 200 m (650 ft) of vertical displacement. The subcrop limits of the sub-Pennsylvanian strata on the east flank of the anticline can be precisely located using the seismic line.

4) Within the areas of good data quality, the Chattanooga limestone unit is continuous across the seismic profile. Gradual thinning develops from west to east, and partial replacement by lower velocity lithologies (siltstone or shale) occurs between CDP's 1350 and 1360. Further seismic studies extending east of the present seismic section would determine where complete replacement occurs.

5) Most resolvable Pennsylvanian and Permian cyclothems display consistent reflection character throughout the seismic section, although bed thickness can be highly variable due to intercyclic erosion. In particular, the thickness between the Lecompton Limestone and the Calhoun Shale, and the interval between the Topeka Limestone and Severy Shale, is variable. These thickness variations cannot be detected with present well control.

6) The channel observed in the Kanwaka Shale formation is a potential stratigraphic trap. Without the seismic line, detecting by wells alone would have been very difficult. The utility of seismic lines in defining features such as this is thereby demonstrated.

7) Detailed correlation of the local stratigraphic section and the reflectors on the seismic section is achieved. Reflectors from the Precambrian into the Lower Permian have distinguishable characteristics and can be used to determine geologic structure and local stratigraphic continuity.

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gk abstracts

These abstracts are from technical papers or presentations on Kansas Geology or by Survey staff members. They represent current or recent research projects.

Paleobathymetry from Pennsylvanian chonetid brachiopods from eastern Kansas (Published in the *Transactions of the Kansas Academy of Science*, 92(3-4), 1989, pp. 184-191)

by R. S. Spencer, Department of Geological Sciences, Old Dominion University, and D. F. Merriam, Department of Geology, Wichita State University

Chonetid brachiopods are used to interpret paleobathymetry of two nonmarine/marginal marine shale sections (Severy Shale and Kanwaka Shale) in the Virgilian (Pennsylvanian) of eastern Kansas. Results indicate that in both instances the water conditions were shallowing in the Pennsylvanian Kansas sea as the basin infilled with sediments, prior to a new marine transgression. Detailed studies should provide additional information on transgressive/regressive conditions in the development of the classical megacyclothem of the Mid-continent.

Stratigraphy of Mid-Continent Rift System in Kansas as revealed by recent exploration wells

Presented at the1989 Amercian Association of Petroleum Geologists annual convention, April, 23-26, 1989, San Antonio, Texas.

by K. David Newell, Peter Berendsen, W. Lynn Watney, John H. Doveton, and Don Steeples, Kansas Geological Survey

The Texaco 1 Poersch well in Kansas (11,300 ft TD) was the first significant exploration test of the Mid-Continent Rift System (MRS). An upper succession of rift-related rocks (2,847-7,429 ft) contains approximately 90% mafic igneous rocks with minor pegmatites and 10% oxidized siltstone and arkose. Arkose and subarkose with minor siltstone and shale make up 90% of a lower succession (7,429 ft. to TD). The remaining lower succession is composed of mafic igneous rocks.

Mafic rocks are typically alkali basalts. Individual flows (detected by presence of amygdules, interflow sediments, compositional differences, and oxidized zones) range in thickness from 20 to 250 ft.

Sedimentary rocks in the lower succession are divided into three sequences, each 1,000 to 2,000 ft thick. The sequences overlie relatively thin mafic flows or intrusives. Each sequence is generally composed of fining-upward units (50-150 ft thick) attributed to episodic movement and erosion of fault blocks in alluvial fan-dominated sedimentary environments. Shales and siltstones are too oxidized to be viable petroleum source rocks, but gray shale with approximately 0.5% total organic carbon was found in the MRS by the 1-4 Finn well, 21 mi to the northeast.

Geologic examination of several shallower Precambrian test holes near 1 Poersch shows considerable variability in sedimentary and tectonic settings along the MRS. Correlation between wells in Kansas and exposed areas of the MRS is still problematic. Additional wells will be necessary to better understand its hydrocarbon potential.

Estimating potential for small fields in mature petroleum province (published in The *American Association of Petroleum Geologists Bulletin*, v. 73, No. 8 (August 1989), P. 967-976

by John C. Davis and Ted Chang, Kansas Geological Survey

A histogram of the number of fields discovered in a basin, plotted in categories of increasing volumes of fields, is called a field-size distribution. Its shape reflects the parent size distribution of oil pool that exist in the basin, the efficiency of the discovery process, and economic constraints that limit the development of extremely small pools. Typically, field-size distributions are approximately lognormal in form, with a pronounced tail extending to the larger field sizes on the right. In a maturely explored basin, the right tail of the field-size distribution will closely correspond to the shape of the underlying distribution of pools originally in place because almost all larger fields will have been discovered. The shape of the left tail, however, reflects economic truncation. Increases in crude oil prices may shift the point of economic truncation to the left, so previously submarginal discoveries may be placed into production. Most of the remaining undiscovered economic potential of mature basins may lie in these submarginal pools.

The size distribution of pools originally in place in a basin is not directly observable, but attempts have been made to infer its form from discovery process models applied to maturely explored basins. Models that postulate that the original pool-size distribution is J-shaped forecast that extremely large numbers of submarginal-size pools await discovery. These optimistic predictions have been cited in state and national petroleum policy statements. Statistical analyses of distributions of discovered fields in two mature areas indicate that J-shaped models of the pool-size distribution cannot be justified from available data. Information contained in the size distribution of discovered fields is not adequate to predict the number of submarginal pools remaining in the basin.

Lead and Zinc Mining in Kansas

Past Successes, Present Problems

At one time, the Tri-State mining district of southwest Missouri southeast Kansas, and northeast Oklahoma was one of the major mining areas of the world. Between 1850 and 1950 the district produced 50 percent of the zinc and 10 percent of the lead in the United States. The first commercial ore discovery in the district was made in southwest Missouri around 1838, and the first first major discovery in Kansas was in 1870 at Galena. However, sometime earlier, lead and zinc were discovered along mine creek in Crawford County, an area just north of the Tri-State district boundaries. Indians told early settlers about the presence of lead ore and, and the settlers found evidence of an old mine dump. Early French explorers or Indians may have opened this mine, and several mining ventures have since operated at this site, known as Big Jumbo. One operation in 1901 produced 15 tons of high-grade lead ore, which was shipped to a refinery in the Argentine district of Kansas City, Kansas.

But most of the lead and zinc mining in Kansas occurred farther south in Cherokee County, where production peaked in the early 1900s. By 1920, the Tri-State mining area was the world's leading producer of zinc. During the life of the district. more that 4,000 shaft mines—up to 480 feet deep—produced 23 million tons of zinc concentrates and 4 million tons of lead concentrates from Mississippian -age rock. At peak production in the 1920s, more than 11,000 underground miners were employed in the area with perhaps three times that many workers in support jobs and related industries. In addition to the lead and zinc produced in the Tri-State district, cadmium and germanium were produced as by-products of the lead/zinc smelting process. But by mid-century, production began to decline and in 1970, the last lead and zinc mine in the Tri-State district—the Swalley Mine just west of Baxter Springs—closed.

By Lawrence Brady, James McCauley, Larry Knoche, and Rex Buchanan

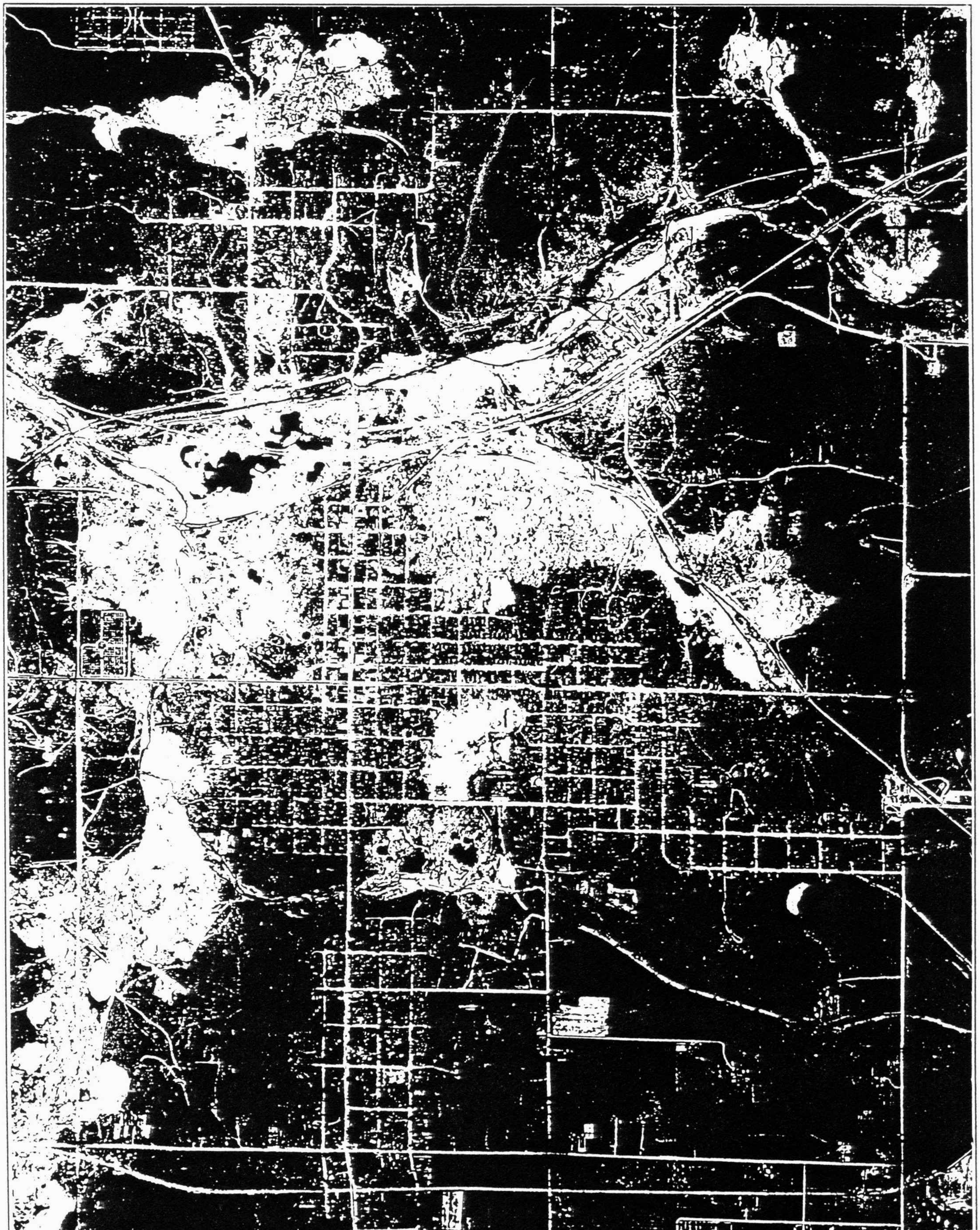


FIGURE 1. Aerial photograph showing mine tailing piles around Galena, Kansas. (Courtesy of the U.S. Dept. of Agriculture)

Mines and piles of waste, created by excavating and milling nearly 500 million tons of ore and rock, are still conspicuous in this area. In the early 1980s, the U.S. Bureau of Mines became interested in determining the physical hazards associated with the old mining areas. The Bureau of Mines, in cooperation with the state geological surveys, conducted detailed studies in each state. These studies showed that there are more than 1,500 open mine shafts and nearly 500 subsidence collapse features in the Tri-State. Problems of heavy metal metals in water and open shafts and large subsidence areas have put the area around the towns of Treece and Galena in Kansas and Pitcher in Oklahoma on the EPA Superfund list.

Hazards in the Treece Area

A total of 97 mine hazards were found in the Treece area. Seventy-nine are open shaft mines. Although only 17 are surface collapses, some are quite large. The largest collapse in the Treece area is along Tar Creek and is 230 feet by 430 feet and is about 60 feet deep. Another large collapse is about 180 feet in diameter and is filled with water to within 40 feet of the surface. Its total depth is unknown, but the mine workings are about 300 feet deep. Shallow subsidence just to the southeast of this large collapse might indicate its direction of growth.

The remainder of the 97 hazards found in the Treece area are hazardous shafts. Sixty-two of these hazardous shafts are collapsed. Some of them appear to have been filled at one time, but further collapse and settlement of the fill has again made them hazards. These shafts are generally less than 30 feet deep and are thimble-shaped. However, a large number of the shafts are still growing outward. Most of these shaft openings are surrounded by brush and trees that conceal the potential hazard until it is closely approached. Eighteen of the shafts are open but not collapsed, reaching depths up to 200 feet. These shafts are usually rectangular in cross-section with wood cribbing and often have concrete collars.

Mines depths in the Treece area range from 170 feet to 480 feet in depth. Many of the mines are more than 300 feet deep.

Hazards in the Galena area

A total of 599 mine hazards were found in the Galena area. This represents nearly two-thirds of all the mine hazards found in the Kansas study. Most of the mine hazards in the Galena area are located within three or four miles of each other, including six open adits (nearly horizontal shafts), seven open pits, 209 surface collapses, and 377 hazardous shafts. Many are within the Galena city limits.

One particularly bad spot in Galena is known as "Hell's Half Acre" by local residents. This area is a "moonscape" of rubble piles, collapsed mines, and open mine shafts. One of the largest of the 209 surface collapse features in the Galena area is a combination of two collapses that form an opening about 600 feet long and 60 feet deep.

In some cases cave-ins have occurred where either an underground room was close to the surface or the spalling of the roof rock has brought the room close to the surface. In either case, part of the underground workings are exposed at the surface. Survey geologist Jim McCauley entered two such cave-ins in the Southside Mine area in 1983, accompanied by Ralph Cure, a life-long Galena resident familiar with its many mine hazards. One mine was entered through surface collapse. This mine opening lead downward and then eastward. From underground, the penetrations of three mine shafts could be seen through the ceiling. Another mine was entered through a surface collapse. This mine claimed the life of a boyhood friend of Cure's about 20 years ago. At that time, the mine, according to Mr. Cure, was deeper, having since worked its way to the surface through a succession of roof falls. When McCauley and Cure entered this mine in the late summer of 1981, three mine shafts could be seen penetrating what appeared from below to be a very thin roof. Cure expressed surprise at how much higher the floor of this mine was in comparison to his last visit. It appeared that a large part of the ceiling had fallen in fairly recently. Cure and McCauley vacated the mine at that point and no other mines were entered. If deterioration and spalling of room ceilings is occurring in this mine room, similar conditions are probably occurring in other mine rooms as well. Despite the age of the Galena mine workings, they have probably not reached stability and further mine cave-ins are a possibility.

Whereas most of the surface collapses

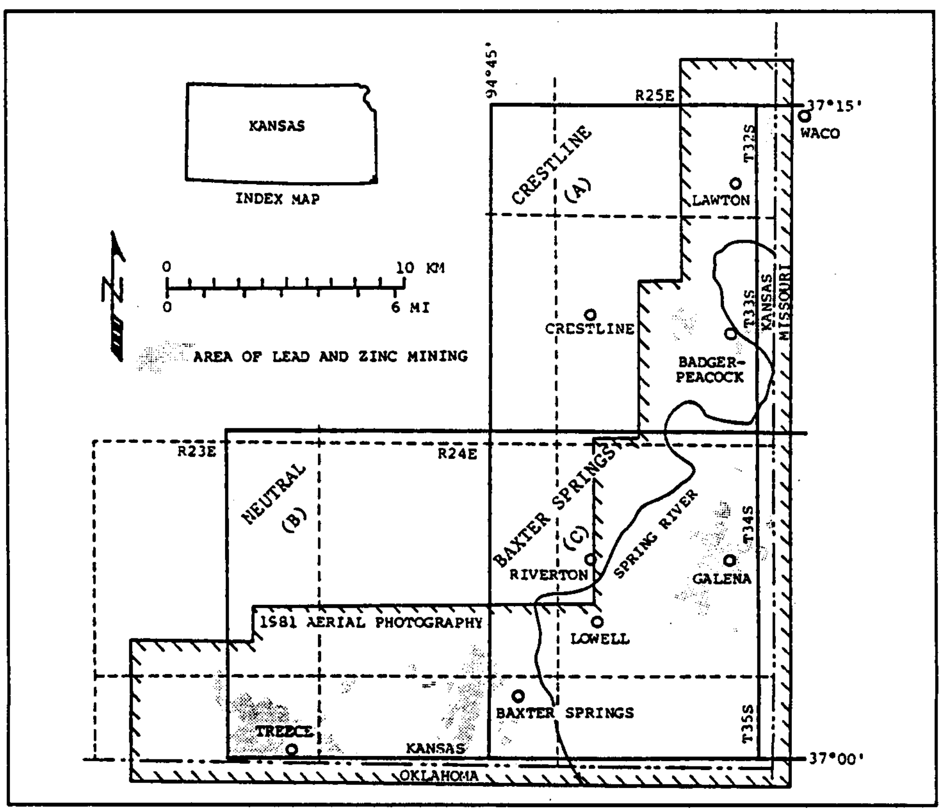
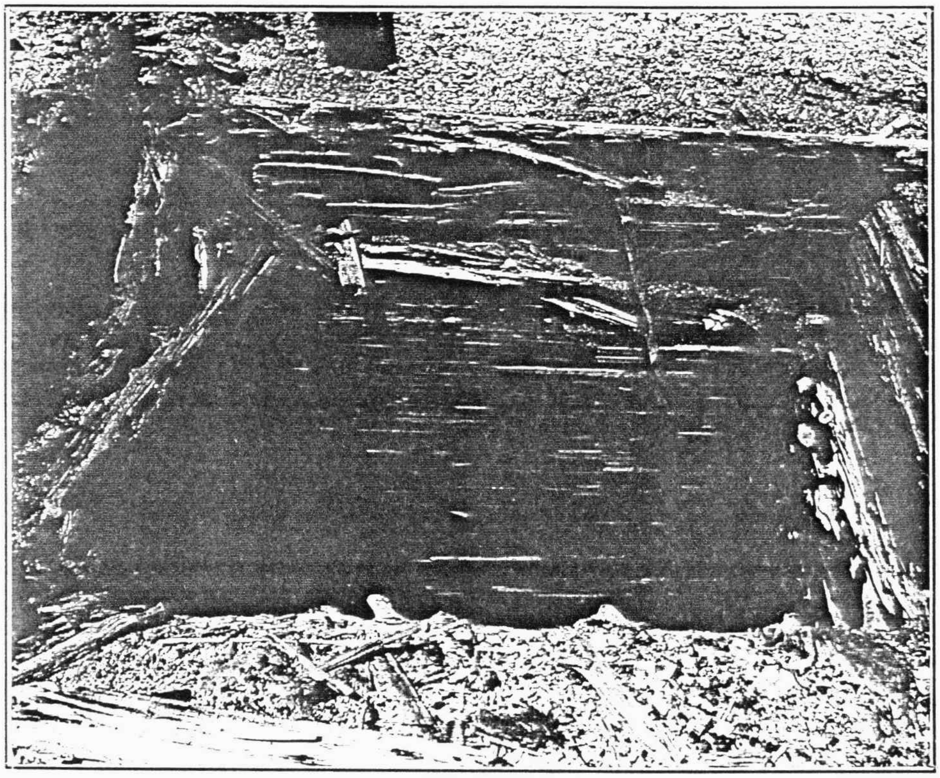
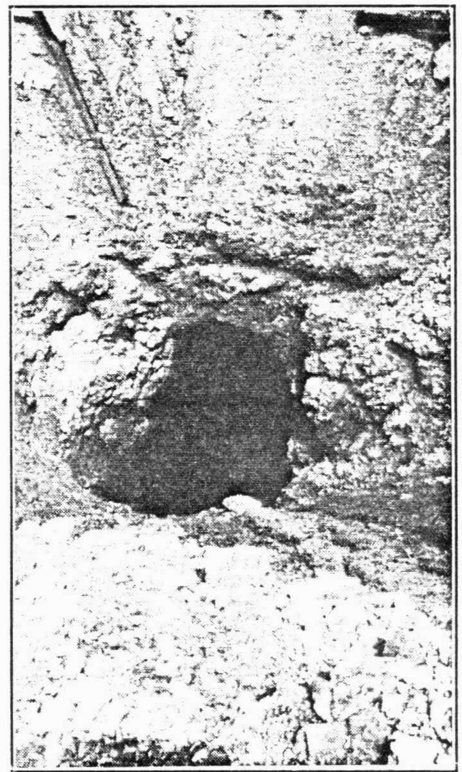


FIGURE 2. The tri-state mining district extends into the southeast corner of Kansas in Cherokee County.





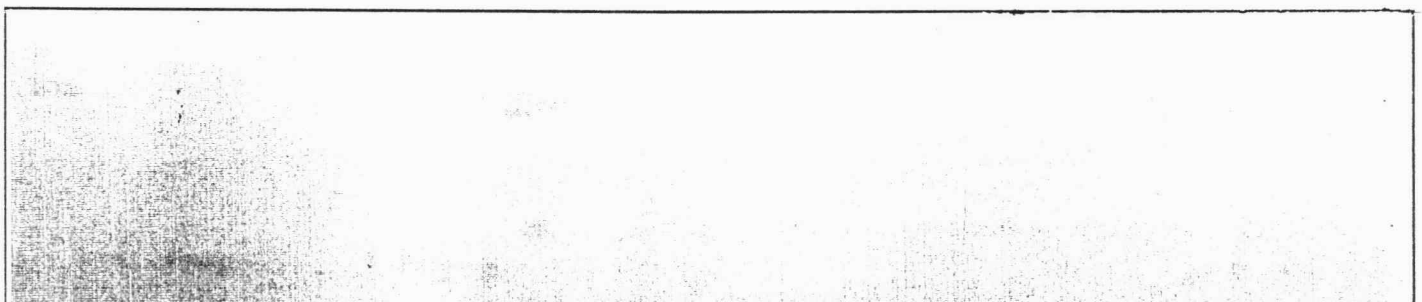


FIGURE 3. (Upper left) Open uncollapsed shaft north of Treece. FIGURE 4. (Upper right)—Collapsed shaft and shallow mine room in Galena. FIGURE 5. (Bottom) The southside mine area, known locally as "Hell's Half Acre." in Galena.

in the Southside Mine area are dry and are generally less than 60 feet deep, surface collapses in the Short Creek valley usually contain water. Three of the largest water bodies in the area, however, are actually open-pit mines. Most of the open-pit mining was conducted in the 1940s. One open-pit mine resulted in a a 250-feet by 300-feet pond that appears to be quite deep. It is know locally as the "Blue Hole" because of the vivid color of its water. Few of the other surface collapses in the Galena area contain water.

Of the 599 hazards in the Galena area, 377 are hazardous shafts and all but 11 are collapsed to some extent. The paucity of uncollapsed shafts in this area can be explained by the age of the shafts, the rotting away of cripping over the years, and the widespread occurrence of unconsolidated cherty gravels that mantle most of the outcrops. As a result, the 366 collapsed shafts in and around Galena have the characteristic appearance of inverted cones of loose cherty rubble at or near the angle of repose. These cones narrow down to small, square, craggy shafts cut through cherty limestone bedrock. The loose rubble slopes surrounding these shaft-openings make them very hazardous. Because the material above the shaft is at or near the angle of repose, people walking along this slope may set off a small landslide of which they might inadvertently become a part.

Working levels of most of the mines in the Galena area were shallow, generally less than 100 feet in depth. However two mines reached depths of 185 feet. The hazardous nature of many mine shafts and surface collapses around Galena is tempered somewhat by the lack of heavy vegetation in the mining areas. The cherty rubble that blankets area of former intense mining creates a substrate that is too sterile for most types of native vegetation. However, tall grasses may grow where the mine waste is thin or absent and can conceal open mine shafts.

Following the study of mine stability in the three states, the U.S. Bureau of Mines conducted a project to demonstrate a new approach to closing abandoned mine shafts in the Galena area. The Bureau of Mines constructed eleven pyramid-shaped steel forms that have bases eight to 12 feet square. The forms were placed pyramid point down into the shaft opening and filled with concrete. After two years, there was no settlement in the concrete plugs.

Surface and Ground-water Problems

Both the Cherokee County area in Kansas and the Tar Creek area in Oklahoma were placed on the Environmental Protection Agency's Priorities List or "Superfund" list because water in the areas contained heavy metals from old mine workings that could contaminate drinking water supplies. There was concern that the metal-laden water would enter shallow private water supplies and public water

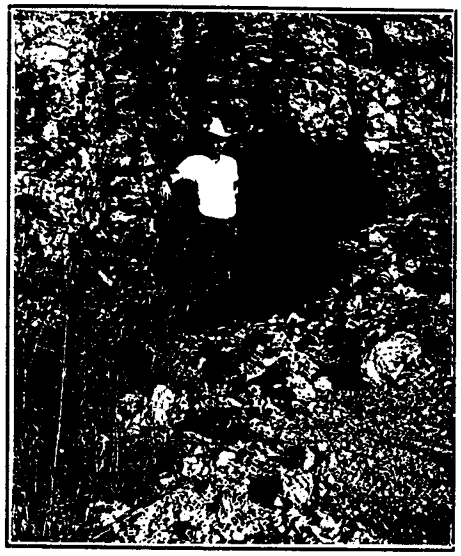


FIGURE 6. Entrance to an adit (a near-horizontal mine shaft) near Galena.

supples that come from deeper Ordovician Roubidoux Formation. Contamination of this deeper aquifer could be by deeper abandoned deep water wells, open exploratory holes, and wells with faulty casings. Remediation of the problems was the location and plugging of deep wells into the Roubidoux Formation and the diversion of surface water along Tar Creek drainages away from mine collapse area where the surface water was captured.

In 1983, the EPA added a 110-square mile area of Cherokee County to the National Priorities List. EPA divided the Cherokee County area into six sites. The Galena site is the largest, covering approximately 18 square miles. At this site, the EPA has determined that metallic compounds containing lead, cadmium, zinc, and other contaminants were being released into surface streams and shallow ground water. Sources of the metals or old mine workings and the chat and waste rock piles on the surface that resulted from the mining and milling operations. The level of metal content in the water could cause deterioration of the environment and present a health hazard to those people who use shallow water wells in the area.

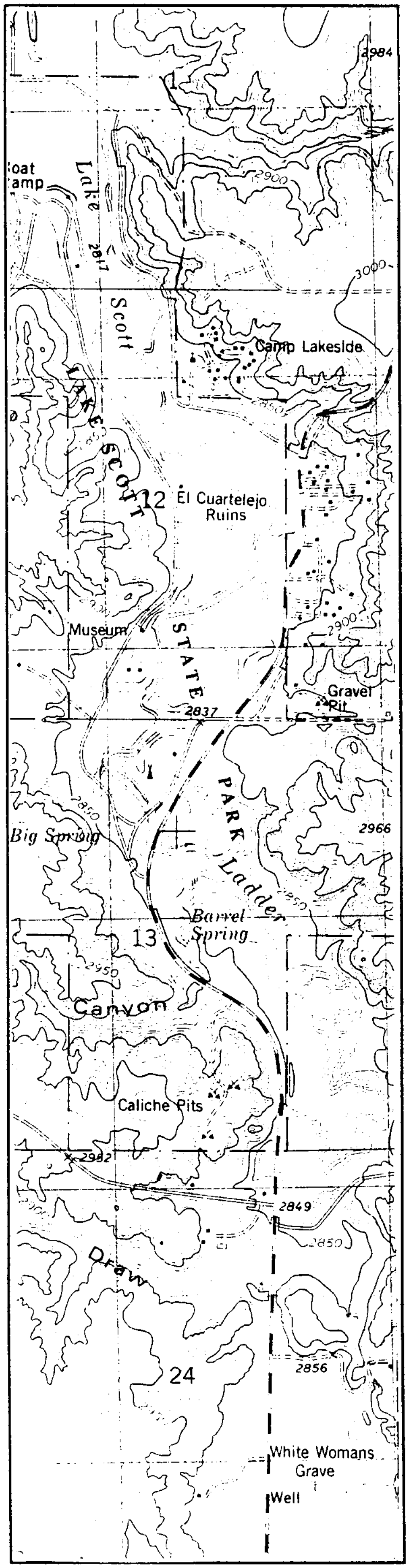
Cleanup

In response to the problems the EPA and the Kansas Department of Health and Environment (KDHE) have developed a preferred remedial action plan for the Galena area. The plan consists of four parts. First, surface-mine waste will be removed and treated, through milling and flotation, to remove lead and zinc. This will reduce human exposure to the contaminants in the surface wastes and the migration of those contaminants to ground water and streams. The metal removed from the wastes will be sold to help defray a portion of the costs. The tailings remaining after the removal of the metals will be disposed of in the mine voids.

Second, surface drainage will be diverted around specific areas to prevent stream capture by mine shafts and subsidence. The planned diversions include reestablishing the Tributary A stream bed through Hell's Half Acre via a lined channel and channelizing Owl Branch in the Blue Hole area. Lined channels will eliminate surface water recharge to the groundwater system. A portion of Owl Branch will be diverted to Tributary C to reduce surface water flow through the mined areas. This basin is a primary contributor to the metals loading in Short Creek.

Third, to reduce surface water ponding and infiltration to the subsurface mineral zones, the surface will be recontoured. The EPA is exploring the use of vegetation to stabilize the soils and control erosion of the recontoured surface. Fourth, wells penetrating the Roubidoux aquifer will be examined. Abandoned wells will be plugged. Operating wells will be lined if remediation is necessary. This action will be taken to protect the Roubidoux aquifer from contaminant migration from the shallow aquifer.

The cost of this plan is estimated by EPA to be $5,800,000 with an annual maintenance cost of $10,000. ■



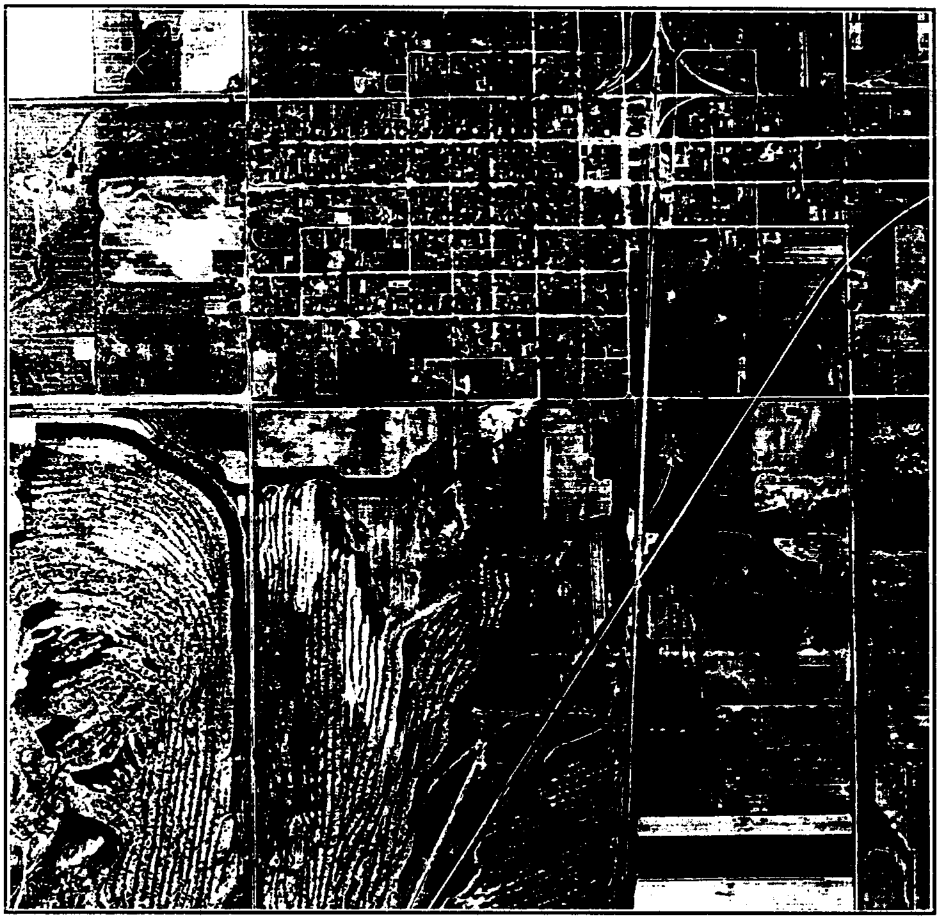
Multi-use topographic maps

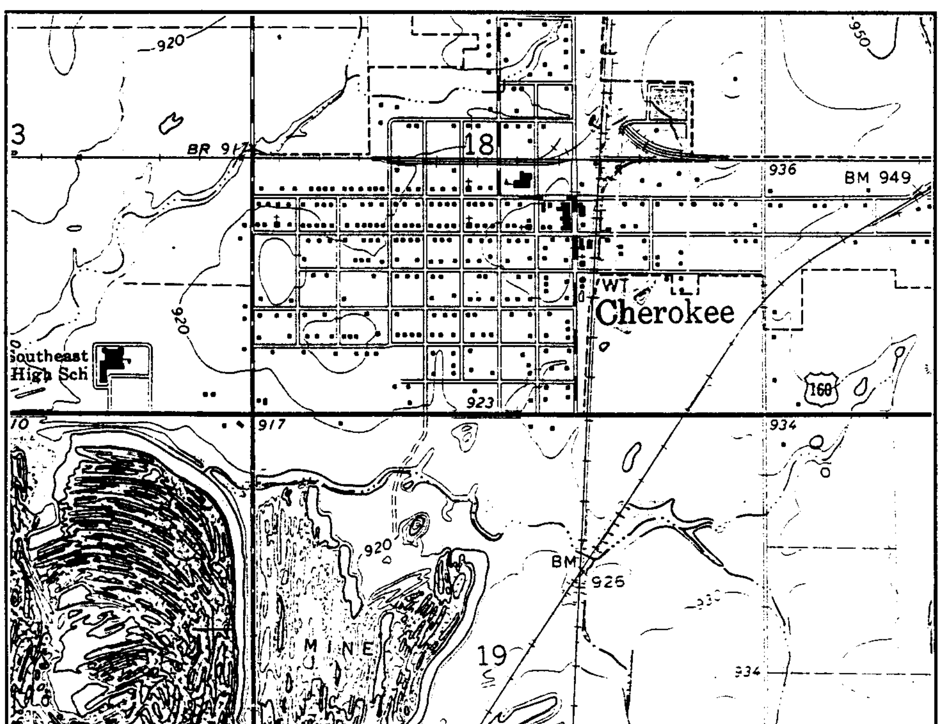
By Catherine S. Evans

Many maps are multi-purpose, but one of the most versatile maps around is the topographic map. Produced by the U.S. Geological Survey, a variety of topographic maps are available for the United States. For Kansas alone several series of topographic maps, which come in different scales, are available. Topographic maps have contour lines that represent the shape and elevation of the terrain. Most of them also contain other information, such as the location of roads, cities, rivers, and lakes.

The U.S.G.S., the federal equivalent of the Kansas Geological Survey, is a prolific map maker, producing maps that are are useful to a much wider spectrum of people than its name implies. Topographic maps produced by the U.S.G.S. are useful for hikers, bicyclists and photographers wanting to locate features such as roads and paths, hills, mountains, and forests. History and genealogy buffs can also use these maps to identify places, such as cemeteries, ghost towns, and old schools and churches.

Natural and man-made features, including hills, valleys, mountains, and other landforms, are represented on the maps by contour lines connecting points of equal elevation. Cities, towns, rivers, creeks, ponds, vegetated areas, roads, railroads, quarries, airports, national and state parks, and forests and wildlife areas are also shown on many of the maps. The detailed 1:24,000-scale series includes major city streets and rural buildings as well.





Topographic maps of Kansas are available in a variety of scales, from the most detailed 1:24,000-scale maps to a generalized map of the entire state.

1:24,000-scale (7.5-minute) series

Each 1:24,000-scale map covers approximately 6.5 x 8.5 miles or 7.5 by 7.5 minutes of longitude and latitude. These maps show towns, lakes, rivers, creeks, ponds, roads, railroads, quarries, pipelines, radio towers, airports and landing strips, townships, vegetation, cemeteries, and rural buildings. Most of the maps have 10-foot contour intervals. The 1:24,000-scale maps are available for the entire state. About 1,500 maps provide full coverage of Kansas. Dates on these maps vary, depending on when they were completed or updated.

1:50,000—scale series

Produced for the Defense Mapping Agency, these maps have a 1,000-square meter grid and are red-light readable. Each map covers an area of approximately 13 by 17 miles or 15 by minutes of longitude and latitude. These maps show towns, lakes, rivers, creeks, ponds, roads, railroads, quarries, pipelines, radio towers, airports and landing strips, political townships, vegetation, cemeteries, and rural buildings. Elevation contours are in meters, with 10-meter contour intervals. 1:50,000-scale maps are available for limited areas in northeast and north-central Kansas. Dates on these maps vary.

1:100,000-scale series

Each 1:100,000-scale map covers approximately 34 x 55 miles or 30 x 60 minutes of latitude and longitude. These maps show towns, lakes, ponds, rivers, creeks, roads, railroads, airports, and landing strips, quarries, vegetation, and radio towers. Elevations and contours are in meters, with 10-meter contour intervals. Among the newer U.S.G.S maps, these are not available for the entire state but number of published maps grows each year.

FIGURE 1-A. An aerial photograph (top) shows stripped mined land around Treece, Kansas. (Photo courtesy of the U.S. Department of Agriculture) 1-B. The same area (left) as depicted on a 1:24,000-scale topographic map (actual map in color). (Used with permission of the U.S.G.S.)

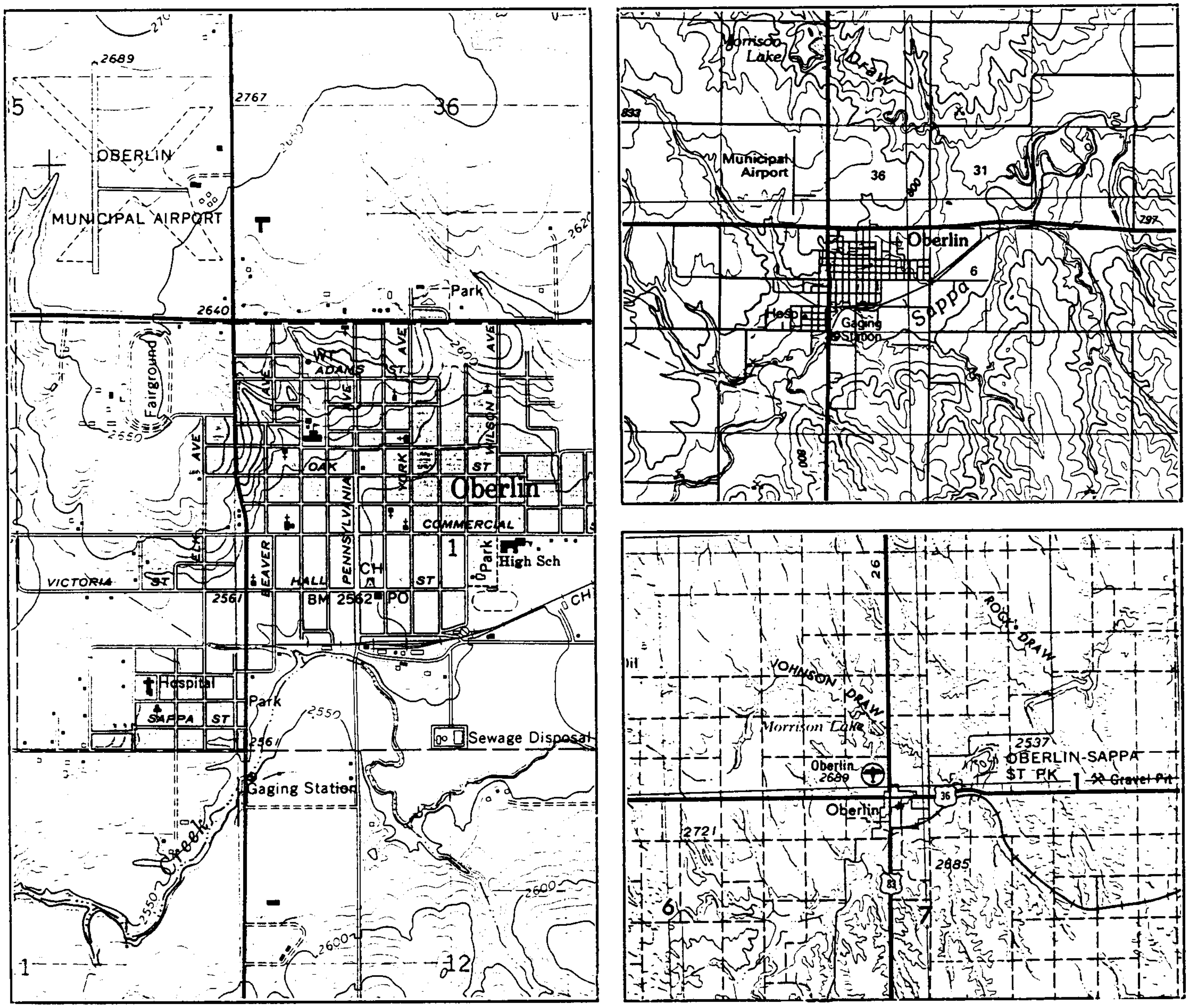


FIGURE 2. THE AREA AROUND OBERLIN, KANSAS AS DEPICTED ON MAPS OF VARYING SCALE AND DETAIL. THE MAPS SCALES ARE 1:24,000 (ABOVE), 1:100,000 (TOP RIGHT), AND 1:250,000 (RIGHT).

County series

Also at a scale of 1:100,000, the maps in this series are available for more than 50 counties in Kansas. Maps of other counties will be produced in the future. These maps show towns, lakes, ponds, rivers, creeks, roads, railroads, airports, and landing strips, quarries, vegetation, and radio towers. Elevations and contours are in meters, with 10-meter contour intervals

1:250,000-scale series

Each map covers approximately 68 by 110 miles or 1 x 2 degrees latitude and longitude. These maps show towns, lakes, rivers, creeks, roads, railroads, airports, and landing strips, quarries, and radio towers. Unlike the 100,000-scale series, these maps do not show areas of vegetation. Elevations and contours are in feet, with 100-foot contour intervals. Dates vary, but most of these maps for Kansas were produced in the 1970s.

1:500,000-scale state map

This map, compiled in 1961 and updated in 1984, covers the entire state. Towns, county lines, lakes, rivers, creeks, railroads, highways, and paved rural roads are shown. Elevations and contours are in feet, with 200-foot contour intervals.

Topographic maps for all states are available for a fee from the U.S.G.S. All Kansas maps are also available at the Kansas Geological Survey. For more information and a free map index of maps, contact:

Kansas Geological Survey
1930 Constant Ave., Campus West
University of Kansas
Lawrence, KS 66047
(913) 864-3965

or,

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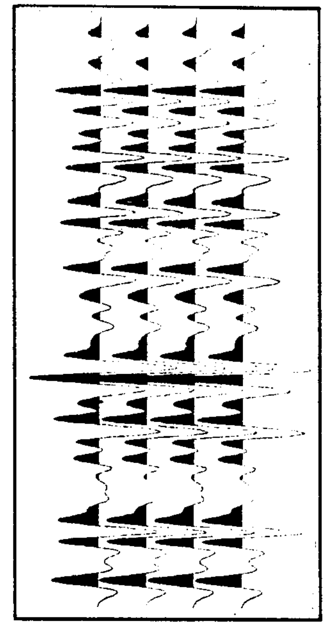
Geophysical prospecting

Hands-off exploration

By Don W. Steeples



There are several means of exploring the Earth by geophysical methods. Each of these techniques exploits fundamental physical aspects of Earth materials such as electrical, magnetic, acoustical, or gravitational properties. While these techniques do not allow detailed examination of the rocks beneath us, they often enable geologists and geophysicists to infer the most likely properties of large volumes of rocks. The physical fundamentals of various geophysical exploration techniques are discussed in the following paragraphs.

Gravity methods

The Earth's gravitational attraction varies slightly from one place to another on the Earth's surface. Some of this variation occurs because the Earth is not a perfect sphere, and some is related to differences in elevation on the Earth's surface. While these variations in gravity, such as those caused by unknown geologic features are not predictable.

For example, in north-central Kansas, there is an anomaly known as the Mid-continent Gravity High where the Earth's gravity is about 0.006 percent greater than normal. In other words, it would be slightly more difficult for a track and field athlete to high jump or pole vault in north-central Kansas than in other parts of the state.

Gravity measurements are made with an instrument known as a gravity meter, and maps can be produced that show differences in the pull of gravity across the state. These variations are useful in locating geologic faults and ancient volcanoes, for example. They can also indicate the presence of geologic basins that are filled with unusually large thicknesses of sedimentary rocks.

Magnetic methods

The Earth's magnetism varies from place to place, much as the gravity varies. The variation in strength of the magnetism is caused primarily by concentrations in rocks of a magnetic mineral called magnetite. Rocks such as granite and sandstone have a high magnetite content relative to such rocks as limestone and shale.

These variations in magnetism have been measured for the state of Kansas by towing an instrument known as a magnetometer behind an airplane. The resulting magnetic maps are useful in finding geologic faults and geologic basins that are filled with unusually large thicknesses of sedimentary rocks or buried mountains that are covered with unusually thin sediments.

Electrical methods

Variations in the electrical properties of Earth materials can be measured at the Earth's surface and within drill holes. These measurements are very often made in holes at the time of drilling, but are not often made at the Earth's surface in Kansas. The presence of oil and gas in rocks in a drill hole is indicated by unusually high electrical resistance.

Prospecting with seismic reflection

Seismic reflection, a powerful technique for underground exploration, has been used for more than 60 years. Seismic waves are essentially sound waves that travel underground at velocities of two to four miles per second (three to six km per second), depending upon the type of rock through which they pass.

Seismic-reflection techniques depend on the existence of distinct and abrupt seismic-velocity and/or mass-density changes in the subsurface. These changes in either density or velocity are known as acoustical contrasts. The measure of acoustical contrast (formally known as acoustic impedance) is the product of mass density and the speed of seismic waves traveling within a material. In many cases, the acoustical contrasts occur at boundaries between geologic layers or formations, although manmade boundaries such as tunnels and mines also represent contrasts.

The simplest case of seismic reflection is shown in Fig. 1. A source of seismic waves emits energy into the ground, commonly by explosion, truck-mounted vibrators, mass drop, or projectile impact. Energy is radiated spherically away from the source. One ray path originating at the source will pass energy to the subsurface layer and return an echo to the receiver at the surface first. In the case of a single flat-lying layer and a flat topographic surface, the path of least time will be from a reflecting point midway between the source and the receiver with the angle of incidence on the reflecting layer.

The sound receivers at the surface are called geophones and are essentially low-frequency microphones. Signals from the geophones are transmitted by seismic cables to a recording truck, which contains a seismograph. The seismograph contains amplifiers that are very much like those on a stereo music system. The sound returning from the Earth are amplified and then recorded on digital computer tape for later processing and analysis. The purpose of computer processing is to separate echoes from other sounds, to enhance the echoes,

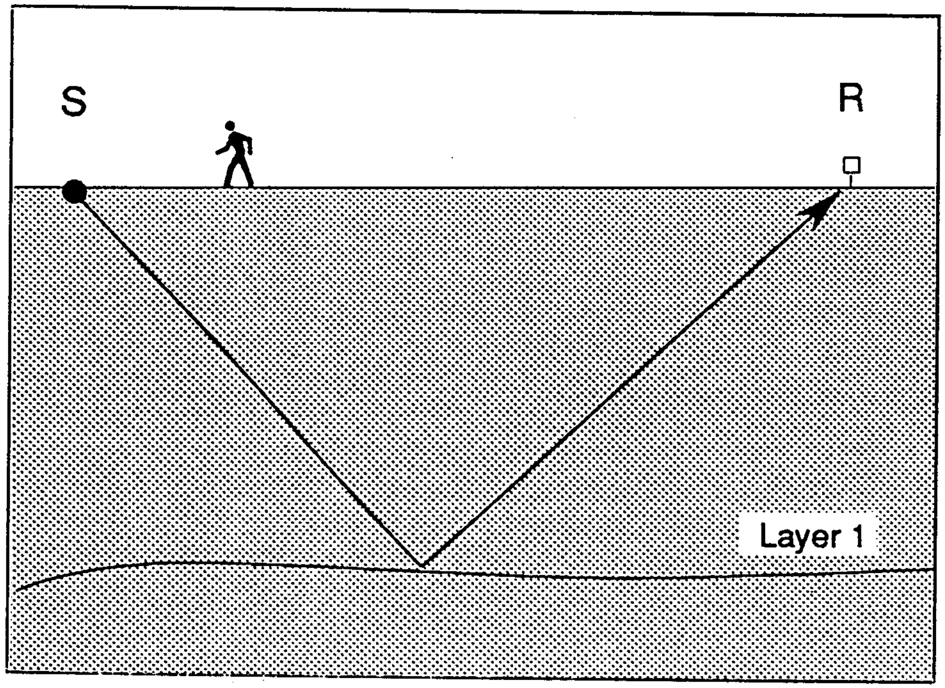


FIGURE 1. REFLECTION FROM ONE LAYER

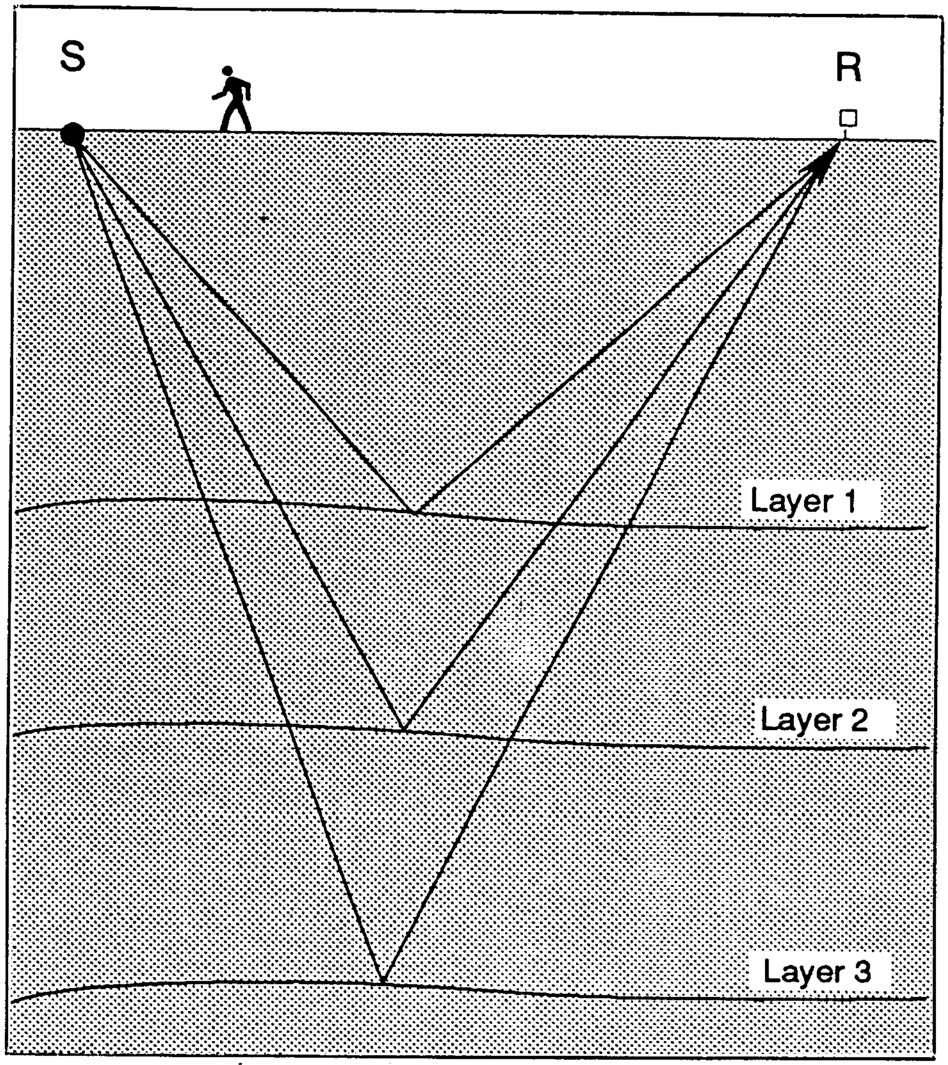


FIGURE 2. REFLECTION FROM THREE LAYERS

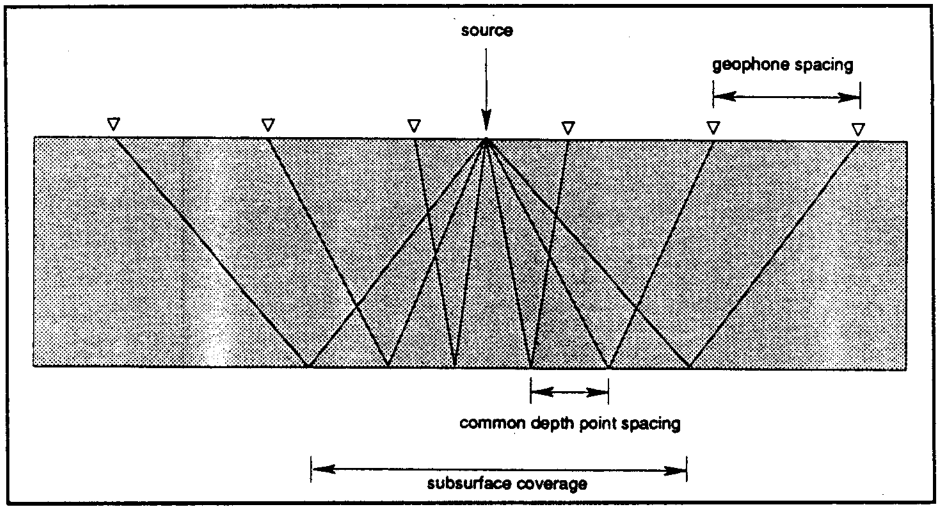


FIGURE 3. SCHEMATIC DRAWING OF SEISMIC-RAY PATHS FOR A SINGLE SHOT WITH A SIX-CHANNEL REFLECTION SEISMOGRAPH.

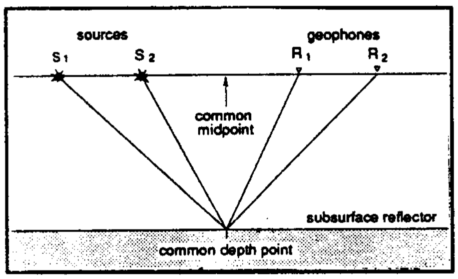


FIGURE 4. THE CONCEPT OF COMMON DEPTH (CDP). NOTE THAT RAY PATHS FROM TWO DIFFERENT SHOTS (S1 AND S2) REFLECT FROM A COMMON POINT IN THE SUBSURFACE.

and to display them graphically.

In the real world, several layers beneath the Earth's surface are usually within reach of the seismic-reflection technique. Fig. 2 illustrates that concept. Note that echoes from the various layers arrive at the geophone at different times. The deeper the layer, the longer it takes for the echo to arrive at the geophone. Because several layers often contribute echoes to seismograms, the seismic data become more complex.

In the case of a multi-channel seismograph, several geophones detect sound waves almost simultaneously. Each channel has one or more geophones connected to it. Reflections from different points in the subsurface are recorded by various geophones. Note in Fig. 3 that the subsurface coverage of the reflection data is exactly half the surface distance across the geophone spread. Hence, the subsurface-sampling interval is exactly half the geophone interval at the surface. For example, if geophones are spaced at 16 m (52 ft) intervals at the Earth's surface, the subsurface reflections will come from locations on the reflector that are centered 8 m (26 ft) apart.

In Fig. 4, source and receiver locations have been placed in such a way that path S1-R2 reflects from the same location in the subsurface as path S2-R1. This is variously called a common-reflection point (CPR) or a common-depth point (CDP). The power of the CDP method is in the multiplicity of data that come from a particular subsurface location. By gathering common midpoint data together and then adding the traces in a computer, the reflection signal is enhanced. Before this addition can take place, however, the data must be corrected for differences in travel time for the reflected waves caused by the differences in source-to-geophone distance. The degree of multiplicity is called CDP fold. A seismograph with 24 channels, for example, commonly is used to record 12-fold CDP data.

The seismic-reflection method is used to determine the spatial configuration of underground geological formations (Fig. 5). Note that the peaks of the seismic reflections have been blackened to assist in the interpretation. This example is a very simple version of typical near-surface geology that depicts a buried sand lens in a river valley. The deeper the sand lens below the surface, the more difficult it is to detect, but the physical principles remain the same.

Earlier in this discussion, we touched on the analogy between a seismograph and a stereo music system. A stereo music system has control knobs to enhance high frequencies (like a flute) or low frequencies (like a bass drum). A seismograph has similar capabilities in choosing the sound frequencies that are recorded. A seismologist selects the frequencies to be enhanced depending on the depth and size of underground geologic features of interest.

To detect small geologic features, it is necessary to use a seismograph that can record and enhance high-frequency sound waves. The use of high-frequency seismic waves in reflection seismology is known as "high-resolution" seismic exploration. As research and instrumentation develop-

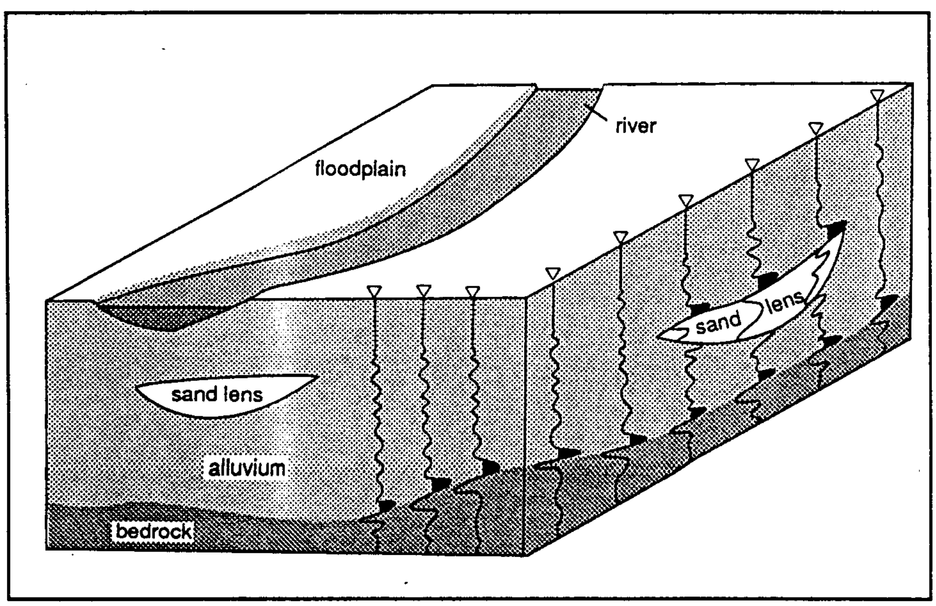


FIGURE 5. SCHEMATIC SHOWING A SEISMIC SECTION RELATING TO REAL-WORLD GEOLOGY.

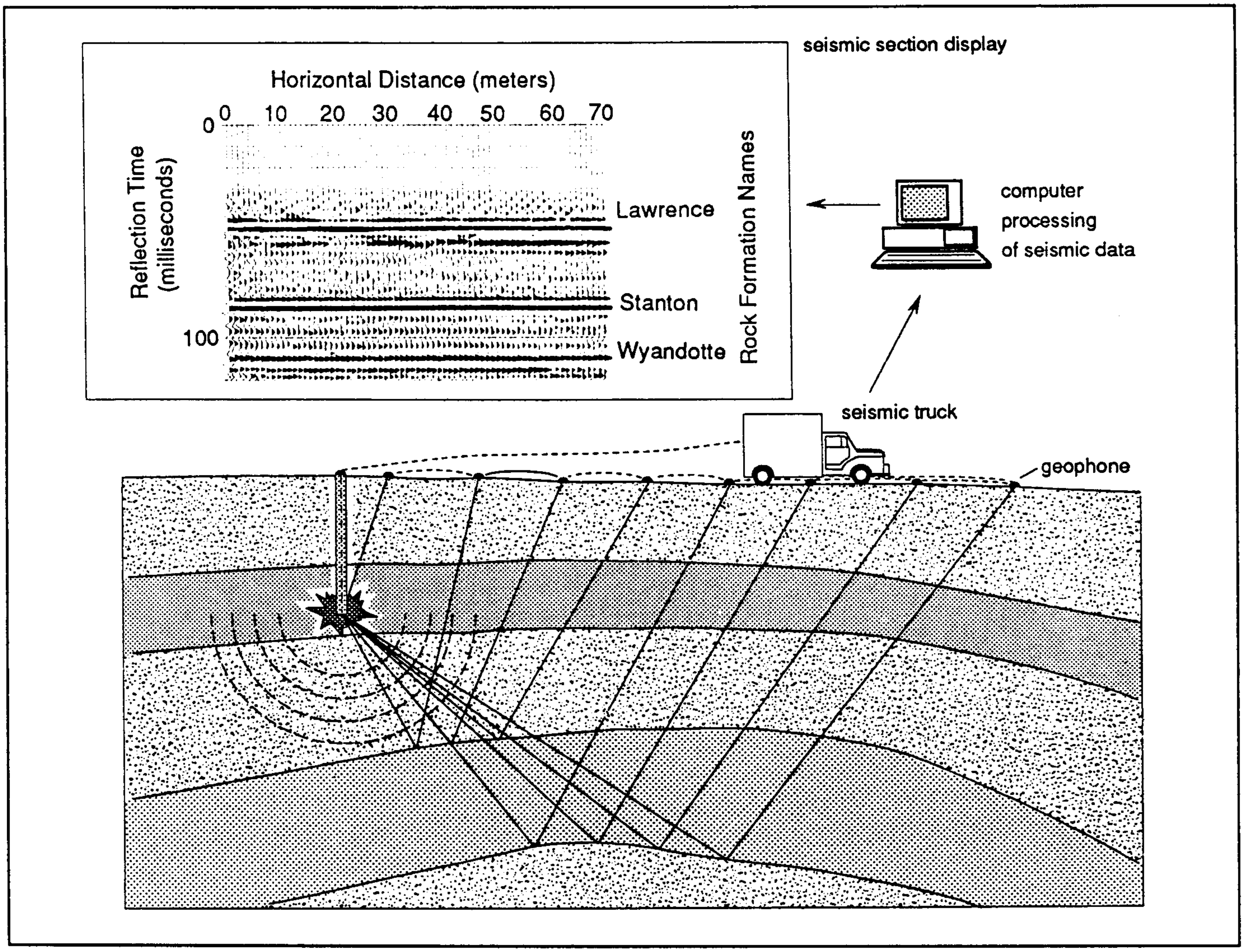


FIGURE 6. SCHEMATIC CROSS SECTION OF GEOLOGY, SEISMIC-RAY PATHS, AND PROCESSED SEISMIC DATA.

ments allow recording higher and higher seismic frequencies, it is becoming possible to prospect for progressively smaller geologic targets.

Compressional waves, or P-waves, are the most common type of seismic wave used for reflection prospecting. P-waves propagating through the Earth behave similarly to sound waves propagating in air. P-waves generate echoes (reflections) when they come in contact with an acoustical contrast in the air or under the ground. In the underground environment, however, the situation is more complex because energy that comes in contact with a solid acoustical interface can be transmitted across the interface or converted into refractions and/or shear waves as well as reflected waves.

Seismic reflection is sensitive to the physical properties of Earth materials and is relatively insensitive to chemical makeup of both Earth materials and their contained fluids. The seismic-reflection technique involves no assumptions about layering or seismic velocity. However, no seismic energy will be reflected back for analysis unless acoustic impedance contrasts are present within the depth range of the equipment and procedures used. This is identical to the observation that sound waves in air do not echo back to an observer unless the sound wave hits something solid that causes an echo. The classic use of seismic reflections involves identifying the boundaries of layered geologic units. It is important to note that the technique can also be used to search for anomalies such as isolated sand or clay lenses and cavities.

Fig. 6 depicts a single explosive charge fired in a drilled hole to provide a source of seismic waves for a seismic-reflection survey. The seismic waves, which are really sound waves, echo from underground rock layers. These echoes are then detected at the Earth's surface by geophones, which are really low-frequency microphones. The signals are transmitted to the recording truck by way of cables. The seismograph in the recording truck is much like a multichannel stereo music system. The seismograph's amplifiers condition and amplify the data and send them to a digital tape recorder. After the data are placed on computer tape by the recorder, they are ready for processing. The signals are processed in computer to produce a final display called a seismic section. The seismic section in Fig. 6 shows echoes from rock units—the Lawrence, Stanton, and Wyandotte formations—a few hundred feet below the Earth's surface.

gk new and related publications

New releases

"To bring together, correlate, and preserve": a history of the Kansas Geological Survey, 1894-1989

Rex Buchanan

Over the past 100 years, Survey researchers have collected, analyzed, and interpreted geologic information. This book describes the people, research, and politicking that led to increased geologic knowledge about Kansas and the development and growth of the Survey. It covers the history of geological exploration in Kansas from the pre-Survey days of early European and American explorers, through the first Survey years when staff and funds were spars, up to the near-present as the Survey expanded in size and scope to include computer technology and research on environmental issues, such as waste disposal and ground-water pollution. 96 p. Price: $7.50

Geophysics in Kansas

Edited by Don Steeples

This book is a collection of articles by geophysicists from industry, the Survey, and other institutions. Topics include seismic explorationcase histories, seismic-reflection surveys of central Kansas sinkholes, gravity and magnetic studies, and heat flow and geothermal investigations. 316 p. Price: $15

Publications related to articles in this issue

Arachnida (p. 2)

Regional geology and paleontology of upper Paleonzoic Hamilton quarry area in southeastern Kansas, ed. by Gene Mapes and Royal H. Mapes (Guidebook series 6), 280 p., 1989. Price: $25

Kansas cyclothems (p. 4)

Sedimentary Modeling: Computer Simulation of Depositional Sequences, edited, by Evan K. Franseen and W. Lynn Watney, 84 p., 1989. Price: $7.50

Lead and zinc mining (p. 16)

"Guide to mined-land problems and reclamation in southeast Kansas," by Lawrence Brady et al., (Open-file report 89-19), 21 p., 1989. Price: $2.10 (photocopy)

Towns and minerals in southeastern Kansas, a study of regional industrialization, 1890-1930, by John G. Clark, (Special distribution series 52), 148 p., 1970. Price: $3

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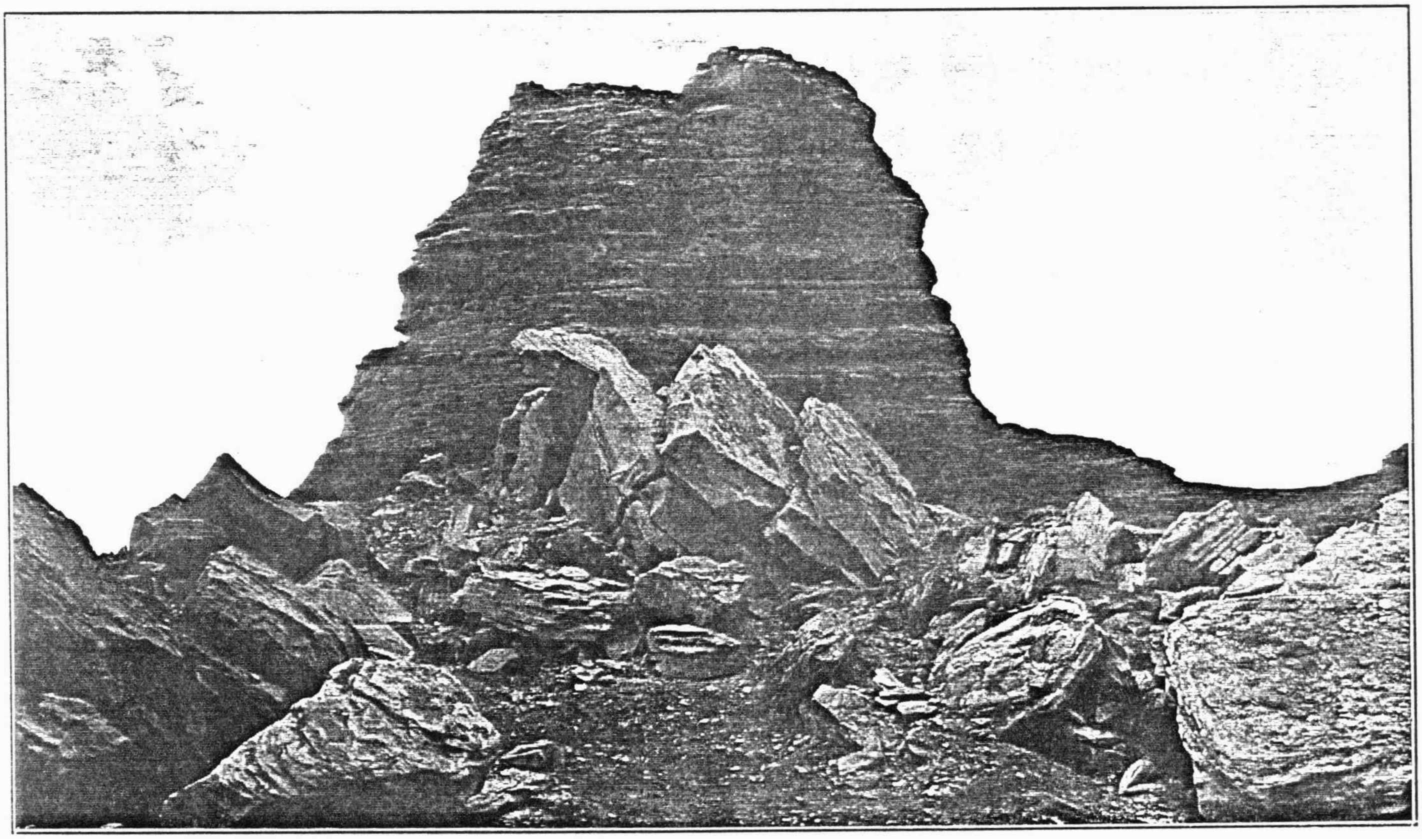

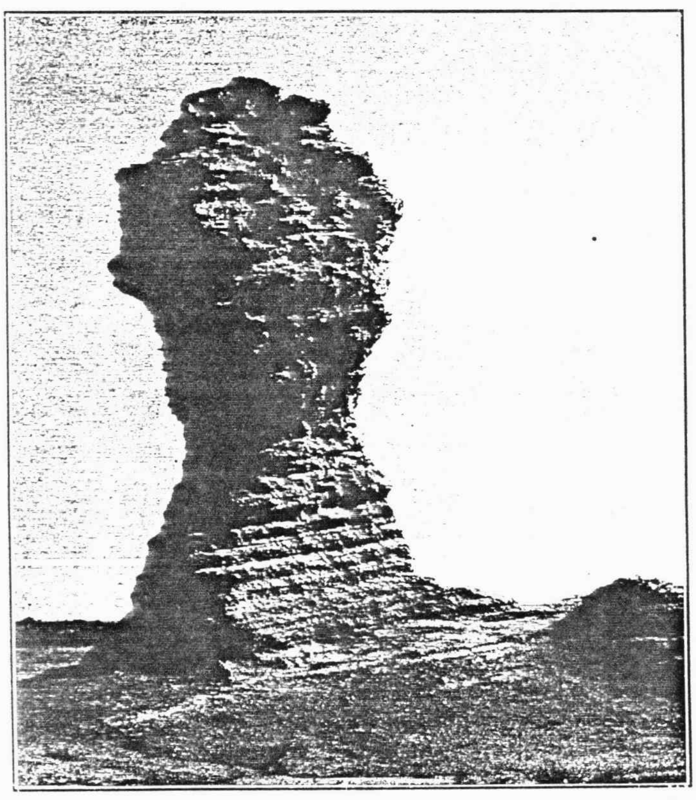

The Sphynx (Gove County)

Chalk formations in western Kansas do not erode quickly, but millions of years of erosion sometimes cause catostrophic overnight changes. The Sphynx, a chalk pillar north of Monument Rocks in western Gove County, withstood the forces of erosion and gravity until 1986 when the formation suddenly toppled. In the photo at left, taken only three or four years before the Sphynx's demise, the formation appears fairly solid. But once the head toppled, it shattered into rock fragments shown above.

The Sphynx is just one of several chalk formations in western Kansas that were left behind when the chalk around them eroded. Monument Rocks, a national natural landmark, is about a quarter mile south of the Sphynx. Fossils are common in the chalk beds of western Kansas, among the most extensive chalk beds in the world. However, around Monument Rocks they are rare because of easy access and a relatively high number of visitors.

Monument Rocks and the Sphynx are about half-way between Oakley and Scott City just east of US 83. Although the main section of the rock formations are part of the Monument Rocks National Natural Landmark, they are on private property and the landowner's rights should be respected.

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