One or more major gravity-slide thrusts have been documented in the Eola, Southeast Hoover, and Southwest Davis oil fields, and in the western Arbuckle Mountains, Garvin and Murray Counties, Oklahoma. The gravity-slide area initially covered portions of at least nine townships; it was more than 30 mi (50 km) long and 5-6 mi (8-10 km) wide. It involved a stratigraphic sequence greater than 5,000 ft (1,500 m), extending from the lower Springer Formation into the upper portion of the Arbuckle Limestone. The major slides moved to the northeast and northwest, probably in the Middle Pennsylvanian. Slides and faults were subsequently isoclinally folded in the Late Pennsylvanian. The tensional updip segment of the major folded slide fault now coincides with the trace of the Washita Valley fault. The compressional end of the slide coincides with the Reagan fault in the east and the frontal Eola fault in the west. In the Lake Classen area the latest folding has turned all formations involved in the slide—and the associated faults—to a near-vertical position. Thus, the slide is exposed in a "profile view" on the south limb of the overturned Washita Valley syncline. On the north normal limb of the Washita Valley syncline, the slide is exposed in "plan view," with the Dougherty anticline and related folds representing compressional folding at the toe of the slide. Several tectonic breccias near the top of the Kindblade Formation of the Arbuckle Group probably mark the orogenic event.

PULLING, DAVID M., Independent, Oklahoma City, OK

Clinton Gas Field: A Significant Stratigraphic Discovery

Clinton gas field has developed into one of the most significant stratigraphic discoveries in Oklahoma. This field is important not only for the magnitude of its hydrocarbon reserves, but also for the model it provides for finding similar fields.

The Clinton field is part of the Clinton-Geary trend, which is productive from upper Red Fork sandstones of Desmoinesian age. This trend is a 65-mi long, 0.5-2-mi wide incised fluvial channel that runs through Blaine, Caddo, Canadian, and Custer Counties. The Geary field at the northeastern end of the channel was discovered and subsequently developed in the 1970s. In 1979, the Clinton field was discovered, and since that time no less than 50 productive wells have been drilled. Development of the field is still continuing at a rapid pace.

The Clinton-Geary channel developed on a pre-Pink limestone erosional surface and eroded a 200-ft deep valley, which was subsequently filled by stream deposits, predominantly sands, silts, and clays. Sandstones in the channel range from a few feet in thickness to almost 200 ft.

Individual wells in the Clinton field have had flow rates exceeding 10 MMCFGD, with calculated open flow in excess of 40 MMCFGD. Estimated reserves are 30-40 bcf of gas and 0.6-0.8 million bbl of oil for the best wells in the field. Ultimate recoveries for the field are estimated to be 0.75 tcf of gas and 15 million bbl of oil.

The Clinton field is the most prolific Red Fork gas field in Oklahoma. A thorough understanding of its depositional history may help us discover similar significant fields.

RASMUSSEN, NOEL F., BOREXCO, Tulsa, OK

Use of Airborne Magnetics in Overthrust Areas

Detailed airborne magnetic surveys have been useful in exploring overthrusts containing magnetic, igneous rocks. The structural configuration of these rocks can be closely approximated. The most important information is the thickness of igneous material overlying sediments and the dip of the overthrust base. Thicknesses and dips of magnetic rocks in overthrusts can be highly variable. Thickness variations of 20,000 ft have been found to occur over the course of 5 mi parallel with the toe of the thrust. The igneous to sedimentary rock contact can range from vertical to horizontal in the same distance.

Interpretations can be used to guide the exploration program in overthrust areas. Seismic surveys can be located in areas of thin granite cover so prospective structures in the underlying sediments might be located at shallower depths.

The Arbuckle Mountain Range is an example of an overthrust that can be explored in this fashion. This overthrust covers a large surface area; in places it is very thin and in others, very thick, being in contact with the basement. The thrust covers a large surface area in an intensely drilled basin. The sediments below the thrust cover an area large enough to "hide" several major oil fields.

Undrilled areas large enough to contain major oil reserves are becoming increasingly scarce. The use of magnetics to detect and map igneous overthrusts can find undrilled sedimentary areas large enough to contain major reserve prospects.

ROGERS, JAMES P., B. R. STINSON, and G. E. MORGAN, Independents, Denver, CO

Dry Creek Field, Nebraska: Subsurface Methods Case History

Dry Creek field produces oil from thin Lansing (Pennsylvanian) limestone beds at a depth of about 4,000 ft (1,200 m) in central Hitchcock County, Nebraska. This subtle oil accumulation was discovered in 1963 by good fortune and weakly quantified subsurface geology; it remains geologically ill-defined. Conventional subsurface studies have been of little value in explaining the oil accumulation at Dry Creek field.

We have developed a method for evaluating thin Lansing reservoir beds that incorporates careful analysis of cuttings and logs of early vintage. This method facilitates mapping Lansing reservoir distribution, thereby permitting a better understanding of the subtle trap at Dry Creek. We believe this method can be used as an additional subsurface exploration tool in the northern Mid-Continent.

Subsequent to original publication of the methods described in this study, additional wells have been drilled at Dry Creek field. Some of these wells supported our original interpretation of reservoir distribution at Dry Creek, while others did not. Recently, the geologic techniques developed at Dry Creek field have been used successfully in exploration drilling in Decatur County, Kansas.

SONNENBERG, STEPHEN A., Bass Enterprises, Denver, CO

Tectonic and Sedimentation Model for Morrow Sandstone Deposition, Sorrento Field Area, Denver Basin, Colorado

Pennsylvanian Morrow sandstones are oil and gas productive throughout a large area in southeast Colorado. The Sorrento field is a recent major Morrow discovery with recoverable reserves estimated at over 10 million bbl of oil from an area of 3,200 ac (1,295 ha.) at depths of 5,400 to 5,600 ft (1,646 to 1,707 m). Minor production also occurs from the Mississippian Spergen and Saint Louis, and the Pennsylvanian Marmaton.

Productive Morrow sandstones are interpreted on the basis of subsurface mapping to be fluvial valley-fill deposits, consisting mainly of channel sandstone. These deposits are encased in marine shale and range in thickness from 5 to 55 ft (1.5 to 16.7 m); net pay ranges from 5 to 30 ft (1.5 to 9.1 m). Porosities average 19%, and permeabilities range from 1 to 4,000 md.

Isopach maps of the Morrow and associated stratigraphic intervals indicate that paleostructure influenced Morrow depositional patterns. Morrow channel sandstones accumulated in paleostructural low areas created by movements on basement fault blocks. Structural nosing is present in the same location and trend as the Morrow channels, indicating structural inversion. Analyses of stratigraphic intervals above the Morrow indicate that the structural inversion occurred during the Early and Middle Pennsylvanian. The field is regarded as a combination structural-stratigraphic trap.

Knowledge of paleostructural control on reservoir facies provides a new idea for exploration for Morrow reservoirs in southeast Colorado.

STOUTAMIRE, P. STEVE, Essex Exploration Co., Tulsa, OK

Furgerson Field: A Lesson in Serendipity

Serendipity is the aptitude for making desirable discoveries by accident. The development of the Arkoma basin's Furgerson field in Pope County, Arkansas, is an excellent example of this.

Although it was discovered in 1965, little development occurred in this field until 1981 when Texas Oil & Gas drilled the 1 Beard (Sec. 32, T9N, R20W). This well encountered two pay sands within the Pennsylvanian Atoka and one within the Pennsylvanian Morrow for total reserves of 4-5 bcf of gas. The TXO 1 Forehand (Sec. 33, T9N, R20W) was then drilled as an offset, supposedly aimed at encountering the same sands. Unfortunately, the Atoka pays present in the 1 Beard were faulted out, and the

Morrow pay was tight. Instead, the 1 Forehand encountered three new Atoka pays and one new Morrow pay. When completed, the well sold in excess of 13 MMCFGD until pipeline takes were curtailed. Subsequent drilling in this section yielded two more producers and one new pay, which resulted in establishing proven reserves of approximately 25 bcf of gas in this section.

All production from the Furgerson field is dry gas from 11 different Pennsylvanian sands at depths less than 6,500 ft. Cumulative production for the field is 16 bcf of gas, and remaining reserves are approximately 44 bcf. At the time of this writing, the field contains 22 producers and 5 dry holes. Field boundaries are not fully defined, and development drilling continues to result in economically attractive wells. Few, however, could be as pleasant a surprise as 1 Beard and 1 Forehand.

STURM, DAVID M., KEITH L. TALLEY, and ALAN R. CARROLL, Sohio Petroleum Co., Dallas, TX

Recognition and Correlation of Morrowan-Age Wash Reservoirs in Roger Mills and Beckham Counties, Oklahoma

Upper Morrowan-age "washes" in Roger Mills and Beckham Counties, Oklahoma, are prolific yet elusive targets for exploration and production geologists. Hydrocarbon reserves can average 14 bcf of gas/well from net reservoir sand thicknesses of less than 20 ft; however, precise sand trends are difficult to predict consistently. This unpredictability is directly related to the complex depositional history of the wash sediments. Upper Morrowan-age washes represent the initial sedimentary response to uplifting, overthrusting, and erosional unroofing of the ancestral Wichita Mountains. Prograding fan deltas largely overwhelmed normal basin sediments close to the mountain front. Farther basinward, interfingering of the two systems led to rapid vertical and lateral facies changes within the wash sequence.

Successful exploration in this sequence depends on recognition of reservoir facies and physical distribution, along with an understanding of the evolutionary nature of the wash sedimentary environment. Detailed correlation of individual sand bodies within the wash is essential. Core and cuttings data may then be integrated with log response to determine sand facies and reservoir characteristics. Reservoir quality is highly dependent on diagenetic history. High-resolution stratigraphic seismic control is useful in delineating sand trends. All available information should be integrated in an overall sedimentary response model for the area that reflects the structural and depositional evolution of the wash sedimentary wedge from its mountain front source to its distal basinward margin.

WALKER, JAMES R., Dyco Petroleum Corp., Tulsa, OK

Development and Economic Significance of Springer-Britt Sandstone, Eakly Field, Caddo, Custer, and Washita Counties, Oklahoma

In the fall of 1981, Lear Petroleum commenced drilling a seismic wildcat prospect in the deep Anadarko basin. The well was located in an area previously thought to be a poor prospect because of the small number of tests in the proximity and the low success ratio of drilled wells. The Lear wildcat discovered the Eakly field of the Pennsylvanian Springer-Britt sandstone at a depth of 15,450 ft. Because their leasehold in the offsets was expiring, four additional wells were drilled immediately, resulting in only one dry hole. During this period, Amoco also found production from the Britt sandstone along depositional strike approximately 10 mi southeast of the Lear discovery.

By the fall of 1982, it was evident that the trend had enough areal extent to potentially become one of the Anadarko basin's giant fields. With a market value of about $4.00/mcf, initial flow potentials from 2.5 to 12 MMCFGD at 7,000 to 9,000 psig, and depths under 16,000 ft, the Eakly trend became one of the most attractive exploration targets in the Mid-Continent region. Representative wells in the Eakly field today produce at rates up to 18 MMCFGD, and ultimate recoveries are estimated at 5-30 bcf of gas/well. The trend is still being developed and extends approximately 30 mi. Reserves estimated at 910 bcf of gas from 50 wells make the Eakly Springer trend one of the Anadarko basin's true giants.

WEBSTER, ROBERT E., Consultant, Irving, TX

Relation of Lower Morrow Sandstone and Porosity Trends to Chester Paleogeomorphology, Persimmon Creek Field Area, Woodward County, Oklahoma

Thickness and porosity trends of several lower Morrow sandstone units were strongly influenced by the paleogeomorphology of the subjacent Mississippian Chester limestone in a study area near Persimmon Creek field in T20N, R22W, southwestern Woodward County, Oklahoma. Pre-Pennsylvanian streams flowing south-southwest across the Anadarko basin shelf had created a dendritic drainage pattern with paleogradients of about 40 ft/mi (7.5 m/km), and intervening stream divides were 50-100 ft (15-30 m) above the valley floors. As the sea transgressed the area in the Early Pennsylvanian, cyclic transgressions and regressions led to deposition of four prominent lower Morrow sandstone members separated by shale units that are approximately parallel lithologic time markers.

The two lower members—a prograding beach complex and a delta front complex—experienced thicker sand deposition above the paleovalleys. In the overlying member (Brown sandstone), also a delta-front complex, thickest sand accumulation and best porosity development occur above the Chester paleodivides. The uppermost member shows little relationship to Chester paleotopography.

Persimmon Creek field is a small stratigraphic trap accumulation that occurs above a prominent southward-plunging nose or paleotopographic high on the Chester limestone surface. Four wells produce from two Brown sandstone units, a stream-mouth bar and an overlying channel sand that has prograded across the bar. Although the geometry of individual sandstone bodies such as these is almost impossible to predict prior to field development, Morrow sandstone prospects can be defined by locating the most likely sites of thick, porous sand accumulation controlled by Chester paleotopography.

WILLINGHAM, DANIEL L., El Paso Exploration Co., Amarillo, TX

Geology of Puryear Member of Upper Morrow Formation at Cheyenne Field, Roger Mills County, Oklahoma

The Puryear member of the Pennsylvanian upper Morrow formation is the most prolific gas-producing unit in the deep Anadarko basin. The Puryear sandstone, a quartz sandstone and chert conglomerate, is the major depositional cycle in an overall regressive upper Morrow sandstone-shale sequence.

At Cheyenne field, the Puryear trends northwest-southeast, subparallel to the Amarillo-Wichita uplift, which is about 25 mi to the southwest. The unit pinches out to the north and northeast and is water-bearing to the south and southwest in the local area. Productive sandstone thickness ranges from 10 to 45 ft, with porosities of 14 to 18% and permeabilities averaging 0.5 to 1.5 md at drilling depths of 14,800 to 16,000 ft. Textural interpretations of the cored Puryear sandstone at El Paso's 1-6 Berry (Sec. 6, T13N, R24W) show a coarsening-upward, poorly sorted, matrix-supported conglomerate consisting of fine to coarse-grained quartz sandstone with pebble to cobble-sized, angular and subrounded chert clasts.

The Puryear member at Cheyenne field is interpreted as a delta-front deposit associated with a fan-delta system sourced from the Amarillo-Wichita uplift.