strata and environments can be mapped with seismic data if used properly. Different targets demand different forms of the seismic reflection method. Examples of the types of reflection data, equipment, and practical uses will be shown, from analog systems of the past 30 years to state-of-the-art digital systems developed in the past year. Problems associated with these systems will be discussed.

ORCHARD, DAVID M., Energy Reserves Group, Inc., Denver, CO, and MICHAEL R. KIDWELL, Mull Drilling Co., Wichita, KS

Morrowan Stratigraphy, Depositional Systems, and Hydrocarbon Accumulation, Sorrento Field, Cheyenne County, Colorado

The Sorrento field, located on the western flank of the present-day Las Animas arch in western Cheyenne County, Colorado, has approximately 29 million bbl of oil and 12 bcf of gas in place in sandstones of the Lower Pennsylvanian Morrow units. The sandstones were deposited in a fluvially dominated deltaic system, and the trap for the hydrocarbon accumulation is formed by pinch-out of this deltaic system onto regional dip. The primary reservoirs are point-bar deposits.

At the Sorrento field, the basal Keyes limestone member of the Morrow formation rests unconformably on the Mississippian St. Louis Formation. Above the Keyes limestone, the Morrow shale is 180 to 214 ft (55 to 65 m) thick, and locally contains reservoir sands. The Morrow shale consists, in ascending order, of: (1) a lower marine shale averaging 40 ft (12 m) thick with minor limestone, siltstone, and sandstone; (2) a deltaic regressive sequence 10 to 65 ft (3 to 20 m) thick consisting of shoreline siltstone that grades laterally into channel-mouth siltstone and sandstone, flood-plain mudstone and coal, fluvial sandstone and conglomerate, levee deposits, and abandoned-channel mudstone; and (3) an upper marine shale averaging 105 ft (32 m) thick with minor limestone and siltstone.

The deltaic system prograded from northwest to southeast into a shallow, low-energy sea. The delta was inundated subsequently by regional transgression. The fluvial system of the delta was confined by levees to a meander belt; within this belt, the streams maintained a meandering character to the channel mouth. The major reservoir facies consists of fining-upward grain-size sequences of conglomerate and sandstone up to 55 ft (17 m) thick which are interpreted as point-bar deposits. Individual point bars within the field are characterized by sharp bases, lobate geometry formed by thinning toward the margins due to loss of section from the top, and diameters of 5,200 to 6,500 ft (1,600 to 2,000 m). The bases of the bars consist of very coarse sandstone and granular conglomerate with rip-up clasts of shale and coal. Where complete sequences are developed, the bars fine upward to fine-grained sandstone interbedded with shale at the tops. The point bars are overlain by marine shale with little reworking of the upper parts of the bars by marine energy. Channel-mouth bar deposits are developed only locally and are generally silty and tight. One well has encountered reservoir-quality channel-mouth bar sandstone which is distinguished from point-bar sandstone by better sorting, stratigraphic position, and finer grain size lacking the basal, very coarse sandstone and conglomerate.

Gas/oil and oil/water contacts are not uniform through the field owing to discontinuities between separate point bars. One such discontinuity is formed by an apparent mud plug of an abandoned channel separating two point bars on the southeastern end of the field.

In a well 7,000 ft (2,100 m) from the edge of the meander belt, the regressive sequence is represented by a shoreline siltstone unit 8 ft (2 m) thick with flaser bedding, graded bedding, load structures, and rare wave-ripple cross-bedding overlain by 3 ft (1 m) of flood-plain mudstone and coal with no indication of proximity to a nearby sand system.

PRATHER, BRADFORD E., Shell Oil Co., New Orleans, LA

Control on Reservoir Distribution and Quality in Regressive Member of an Upper Pennsylvanian Cyclothem

Isopach maps and diagenetic features may be used to predict the distribution of reservoir-quality rock in the D-zone cyclothem of the Lansing-Kansas City Groups in southwestern Nebraska. The D-zone cyclothem was deposited during one major oscillation of the epeiric sea in Late Pennsylvanian (Missourian). This cyclothem records a transgression of sea level followed by a major regression. During the regressive phase there was a brief sea level transgression.

The D-zone cyclothem consists of the four basic lithofacies common to most cyclic deposits of this age in northwestern Kansas and southwestern Nebraska: (1) a thin lower carbonate unit deposited in a shallow-marine environment; (2) a laterally extensive lower shale unit of marine origin resulting from a terrigenous influx from the north; (3) a complex upper carbonate unit deposited in shoaling water during waning terrigenous influx; and (4) an upper shale unit deposited in tidal flat to nonmarine environments.

Core data and an isopach map of the upper shale unit suggest that several shoal areas existed in Hitchcock County during part of the Missourian. Pellet, ooid grainstone deposition was localized on these bathymetric highs. The bathymetric highs may have been formed by (1) differential compaction of the upper shale unit of the underlying E-zone over erosional topography, or (2) movement on the ancestral Las Animas arch.

The presence of equant-calcite fringing cements in pores of the grain-supported rock indicate early diagenesis in a freshwater phreatic zone formed during initial subaerial exposure. Limpid dolomite rhombs intergrown with the early calcite cements and replacing the edges of some framework grains suggest cementation in a mixing zone. The highest stratigraphic occurrence of dolomite, if plotted on a cross section, forms a line which transects facies boundaries and may represent either the position of the mixing zone or an early paleowater table. The majority of the leached porosity in the grain-supported rock occurs above this line. Dolomitization of underlying carbonate facies probably occurred contemporaneously as the mixing zone migrated through the porous mud-supported sediments. Further enhancement of porosity may have occurred in a vadose zone above a later paleowater table. The position of this paleowater table is indicated by the distribution of skeletal fragments replaced by red silica, dissolution cracks infiltered with nonmarine clay, and authigenic gypsum. These features formed during a later stage of diagenesis which took place contemporaneously with soil formation and calichification in the upper shale in a semiarid or arid environment.

Conclusions: (1) paleobathymetery is reflected in an isopach map of the upper shale unit; (2) distribution of grain-supported rock is controlled in part by formation of bathymetric highs while underlying shales compacted around preexisting topographic highs; (3) enhancement of porosity by dissolution in the grain-supported rocks occurred in the freshwater phreatic and vadose zones; (4) recognition of diagenetic features associated with formation of paleowater tables may be used to predict the distribution of porosity in these grainstones.

RASMUSSEN, NOEL F., Borehole Exploration Corp., Tulsa, OK

Aeromagnetics in Exploration

Uses for aeromagnetic surveys include the evaluation of prospect leads and prospects that are controlled by basement fault movements. The identification of basement faults is based on the interpretation of the significance of magnetic edges. Magnetic edges are of two general types: (1) contacts between rock types within the basement, and (2) faults on top of the basement.

Traditionally, aeromagnetic surveys have undersampled so that magnetic-edge interpretations were not practicable. High resolution aeromagnetic surveys are designed so that basement faulting can be identified and interpreted. Interpretations must be made from magnetic records that have been processed adequately.

Many of the magnetic edges which are contacts between different basement lithologies are related to the paleostress fields and are caused by shearing. The identification of the components of the shear models help to explain the orientations of magnetic edges and help to identify the types of basement faults that can be expected. The interpretations are used as working hypotheses for establishing prospects and prospect leads in the overlying sediments.

ROBINSON, JOSEPH E., Syracuse Univ., Syracuse, NY

Computer Exploration in Graham County, Kansas

Oil production in Graham County, Kansas, is from the sands and carbonates of the Lansing-Kansas City Groups (Upper Pennsylvanian).

Accumulation generally is considered to be controlled by structure. However, the oil-to-structure relationship is difficult to discern in the original structure contour maps. Evaluation of the geologic maps can be aided by the application of computer enhancement techniques that display the component structures without the distorting effect of regional trends and conflicting small-scale features. A variety of computer techniques display potential prospects, and statistical tests are necessary to determine the optimum enhancement technique for each area. Spatial filtering of the Graham County maps indicates there is better than a 98% probability that the oil is pooled structurally and that the optimum filter displays features with untested locations that have a better than 40% chance of success.

SALGAT, BRENT, R. J. Walker Oil Co., Inc., Oklahoma City, OK

Scully Field—Marion County, Kansas

The Scully field is a multipay new-field discovery located in the southern end of Salina basin, Marion County, Kansas. Since discovery in November of 1981, R. J. Walker Oil Co., Inc., has drilled and completed successfully 15 wells within the field. Productive depths are < 3,300 ft (1,000 m) and production capabilities of individual wells can exceed 300 bbl of oil/day (24 hr gauges). Oil is trapped structurally within the Viola and Simpson units (Ordovician) and trapped by a combination of erosional truncation and structure in the Mississippian units.

The Scully field was discovered using a combination of satellite imagery and subsurface control. Structural lineaments recognized from satellite imagery in conjunction with an understanding of the structural timing and framework of the Salina basin enabled the definition of the structural unit which contains the Scully field. Subsurface control prior to discovery, although relatively sparse, was sufficient in light of these structural elements to define the prospective area of the Scully structure. Subsequent drilling has not altered significantly the potentially productive area.

The overall trapping mechanism at the Scully field is anticlinal closure. Infield drilling has demonstrated, however, that significant stratigraphic variations do exist within the productive area. The stratigraphic variations within the Ordovician reservoirs are controlled strongly by paleostructure.

The Simpson sands have been subdivided in five separate units which range from 4 to 12 ft (1 to 4 m) in thickness. Three of these are of economic importance in the field. In general, the sands with the most economic potential are distributed within relative Ordovician paleolows. Core analysis demonstrates that pay intervals have porosities of 14 to 18% and permeabilities of 200 to 500 md (air) (Whole Core Dean-Stark Analysis).

The Viola has four main lithologic divisions. The uppermost of these is a relatively thin dolomite cap which ranges from 2 to 15 ft (1 to 5 m). This upper dolomite is the primary Viola pay zone. Core analysis indicates that this interval has porosities of 6 to 12% and permeabilities of 30 to 140 md (air) (Whole Core Dean-Stark Analysis). In general, this dolomite is best developed on the Ordovician paleohighs.

The Mississippian section is eroded deeply over the Scully structure and demonstrates about 70 ft (20 m) of thinning. The potential pay interval is chert which has 25 to 30% porosity based on log analysis. The pay interval is absent over the portion of the field that is highest on present-day structure at the Ordovician level. The trapping mechanism is a combination of erosional truncation and structural closure.

In addition to the structural information obtained from satellite imagery, R. J. Walker Oil Co., Inc., evaluated the hydrocarbon potential of T18S, R1E, Marion County, Kansas, which contains the Scully field, using remote sensing technology developed by Earth Reference Systems of Long Beach, California. The technology involves direct detection of hydrocarbons in place, using satellite data, nonlinear mathematics, and the fundamental principles of molecular structure and electromagnetic wave propagation. This analysis was made several months after the discovery well had been drilled in the Scully field. The conformance of these data within the structural and geologic confines of the Scully field after 14 development wells drilled by R. J. Walker Oil Co., Inc., and two recent dry holes drilled by outside operators, provides an interesting glimpse at technology that may revolutionize the way the oil and gas industry searches for new reserves.

STARK, PHILLIP H., Petroleum Information Corp., Littleton, CO

Highlights of 1983 Industry Activity in Mid-Continent—Good Signs in Difficult Times

Drilling activity in the Mid-Continent has suffered from the industry slump. Mid-Continent industry activity, however, remains surprisingly strong when compared to the total United States. In 1982, four Mid-Continent basins ranked in the top ten based on total completions. Two provinces—Anadarko basin and Chautauqua platform—ranked in the top ten based on drilling and completion expenditures. Despite mature development of most Mid-Continent producing provinces, 1982 exploratory drilling continued strong and yielded good success. Seven Mid-Continent provinces ranked in the top ten based on density of wildcat drilling activity. Four provinces ranked in the top ten based on number of wildcats and best success ratios.

Coupled with active exploratory drilling both Oklahoma (+2.8%) and Kansas (+3.8%) increased their annual crude-oil production. Average 1982 oil well initial potentials increased by 30% to 30 bbl/day in Kansas and by 9% to 58 bbl/day in Oklahoma. The increased productive potential coupled with lower drilling costs indicates the potential for improved investment return for Mid-Continent wells.

The 1983 drilling and exploratory activity are reviewed to highlight positive factors and trends that support continued healthy industry activity in the Mid-Continent.

STEWART, HARRY E., Sun Exploration & Production Co., Dallas, TX

Integration of Remote Sensing Data into the Exploration Effort

Soon after the launch of the initial ERTS satellite in 1972 several facts became evident. (1) The multispectral scanner, which takes data and processes it in digital form, was a powerful new reconnaissance tool added to the geologist's list for evaluating prospective hydrocarbon and mineral producing areas. (2) Based on NASA laboratory and field experiments, if additional spatial resolution (from 80 to 30 m pixels) and additional spectral resolution (more bands in the near infrared and infrared) were added, the tool would be more valuable for the geologist. (3) There were inherent errors in the system affecting both geometric and radiometric accuracy.

During the 10 years following the 1972 initial launch, three more Landsat-type satellites were launched with the latest, Landsat 4, incorporating many of the changes requested by geologists. The new multispectral scanner has seven spectral bands covering portions of the visible, near infrared, and infrared. The ground resolution now is about 30 m (100 ft).

The purpose of this presentation is to introduce some processed images from the Landsat 4 thematic mapper, compare these images in terms of quality and information content to Landsat MSS, and to discuss methods of integrating these data into an exploration program. Methods of calibrating the images as well as methods of combining multiple diverse data sets also will be covered.

Examples of several geologic areas will be shown where multiple types of digital processing provide different types of information of the areas. Methods for extracting lithologic, structural, and vegetation cover information also are covered.

SUHM, RAYMOND W., Texas Gas Exploration Corp., Oklahoma City, OK

"Simpson" Reservoirs in Arkoma Basin and Ouachita Mountains, Oklahoma and Arkansas

The Simpson Group and its equivalents are shown to have reservoir potential in the Arkoma basin and Ouachita overthrust region of Oklahoma and Arkansas.

The Simpson in Oklahoma, the Everton/St. Peter in Arkansas, and the Crystal Mountain/Mazarn/Blakely of the Ouachitas were studied in outcrop, and from well cuttings and logs to derive an understanding of (1) their stratigraphic relationships, (2) the nature and distribution of "Simpson" reservoir sands, (3) depositional and source environments, and (4) geologic history.

It was determined that sandstones of the Calico Rock, Newton, and St. Peter of Arkansas are equivalent to the Oil Creek, McLish (Burgen), and Bromide sandstones of Oklahoma, respectively. Further, the Crystal