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.

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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.

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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.

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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.

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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).