13. ALONZO D. JACKA, Texas Technical College, Lubbock

Depositional Dynamics of Almond Formation, Rock Springs Uplift, Wyoming

In the Rock Springs uplift of Wyoming, the late Cretaceous Almond formation consists of a lower alluvial unit and an upper transitional and marine unit which exhibits cyclic deposits. Typical cycles display the following sequence of units from the base upward: (1) marine and/or lagoonal shale, (2) barrier island sandstone unit, (3) marsh or mud flat deposits, and (4) lagoonal or bay deposits. These rhythms reflect the lateral shifting of three contemporaneously existing depositional entities: (1) marine environment—in which surfzone and infra-surfzone sands, and offshore muds accumulated; (2) barrier island environment—consisting of foreshore beach, backshore beach, and fringing marsh or mud flat deposits; (3) lagoonal environment—in which predominantly fine-grained sediment, carbonaceous material, and oyster reefs accumulated.

The barrier island sandstone units display a characteristic sequence of sedimentary structures that reveals their origin. This succession of primary features records the building-up of the sea floor until it emerged and a beach was formed.

Evidence indicates that seaward growth of barrier islands was accompanied by an expansion of the lagoons which resulted in a progressive flooding of the landward margins of the barriers. Thus positions previously occupied by a barrier island were successively blanketed with lagoonal deposits. As the distance between a seaward-advancing barrier island and the mainland increased, a threshold limit was approached beyond which the amount of sand supplied to the seaward face was insufficient to permit further seaward growth. The operation of negative processes (subsidence, compaction, erosion, and perhaps an independent rise in sea-level) soon brought about the submergence or "drowning" of an abandoned barrier.

The effects of a rapid transgression were mimicked as lagoons merged with the open sea and marine conditions were rapidly extended to the edge of the mainland. Emergence of a new chain of barrier islands near the mainland shore initiated another cycle. Thus rhythmic seaward migration, progressive isolation, cessation of growth, and submergence of barrier islands simulated the effects of slow regressions and rapid transgressions and produced the cyclic deposits.

Similar ancient barrier island units are present in other Cretaceous formations both in the Rock Springs uplift and in numerous other localities.

14. JOHN L. STOUT, California Oil Company, Denver, Colorado

Pore Geometry as Related to Carbonate Stratigraphic Traps

The increase of oil exploration in carbonate provinces requires a better understanding of stratigraphic entrapment. Photomicrographs of reservoir and trap rock from a Nesson anticline field in North Dakota illustrate this problem. The pore geometry and petrology of rocks with a similar relation would be beneficial to the exploration geologist.

A schematic diagram illustrates the interstices of a reservoir rock. The total porosity is a ratio of the rock's void space to its bulk volume. Under subsurface reservoir conditions, this porosity is occupied by fluid of two phases. The non-wetting oil phase occupies this porosity according to the size and distribution of the rock's pore system. The displacement of interstitial water by oil depends on the size of pore throats. What is not effectively displaced by oil remains as irreducible water saturation within the reservoir.

In the laboratory, the mercury injection method of capillary pressure measurement simulates these reservoir properties and pore size and equivalent reservoir characteristics can be calculated. The capillary pressure curves may be investigated by the same statistical methods used on cumulative curves from sieve analysis of unconsolidated sands. The hysteresis of the capillary pressure curve depends on the vuggy makeup of the rock.

Seven distinctive petrophysical characteristics were evident from two hundred samples of Williston basin carbonate rocks studied. These characteristics may be classified by displacement pressure, effective porosity, and pore distribution. Examples of typical rocks show good and intermediate reservoir rock and a specific reservoir-trap rock. A photomicrograph of reservoir rock with low effective porosity gives an insight into the reason for expecting highly water-cut production from carbonate reservoirs. This petrophysics is independent of the porosity and permeability routinely measured on reservoir rock.

Stratigraphic entrapment of oil in a field example is explained by petrophysics of the reservoir and trap rock. These petrophysical distinctions can be observed from sample examination without extensive laboratory measurements.

15. GARY S. SANDLIN, Pubco Petroleum Corporation, Denver, Colorado

Sleepy Hollow Field of Red Willow County, Nebraska

The Sleepy Hollow field, on the southwest flank of the Cambridge arch, is a recently discovered oil field of major importance which produces from multiple pay zones at a relatively shallow depth.

The oil accumulation is partly controlled by a structural nose, trending south-southwest across the field. A large area of limited reversal may be mapped near the center of the field.

Good porosities across the southern half of the field are responsible for production from the Lansing-Kansas City limestones. The principal producing limestone of this group is the C zone. The build-up of porosity in the C zone is a part of a porosity trend which can be traced for a considerable distance east and west of the field.

Production from the basal sand is controlled by an oil-water contact on the flanks of the structure and by a pinch-out or truncation of the sand at the northeast end of the field.

Cumulative production from the Sleepy Hollow field exceeds 10 million barrels. The Lansing-Kansas City has contributed approximately 3 million barrels and the basal sand has produced approximately 7 million barrels.

The wells in the field average 3,500 feet in depth and can be completed for less than $40,000.

16. JAMES A. BARLOW, JR., D. N. MILLER, JR., AND JOHN D. HAUN, Barlow & Haun, Inc., Casper

Stratigraphy and Petroleum Potential of Latest Cretaceous Rocks, Big Horn Basin, Wyoming

Approximately 2,500 feet of Upper Cretaceous post-Cody non-marine sediments in the southwestern part of the Big Horn basin interfinger toward the north and east with marine shale. In the eastern part of the basin four formations are readily distinguishable; they are, in ascending order, the Eagle Sandstone, Claggett Shale, Judith River Formation, and Bearpaw Shale. In the western part of the basin the equivalent stratigraphic section includes the Mesaverde (Gebo Formation of Hewitt), and the Meeteetse Formation. Non-marine deposits of the Lance Formation, including locally the Fox Hills Sandstone, overlie the Meeteetse-Bearpaw section.

Major transgressions are evidenced by the Claggett and Bearpaw shales and regressions by the nearshore and non-marine sediments of the Eagle, Judith River, and Lance formations. Minor transgressions and regressions produced a complex interfingering of sand and shale that complicates formational boundaries.

Isopachous maps, utilizing all available well information as well as fourteen partial surface sections, were compiled to show the distribution of each of the formations. The stratigraphic interval containing the Eagle Sandstone thickens from 200 feet near the Wyoming-Montana line to 800 feet along the south margin of the basin, but the sandstone content decreases southward as the over-all interval increases. Eagle sands are particularly well developed in the area between Worland and Coon Creek. The Claggett Shale is recognizable throughout the east half of the basin and reaches a maximum thickness of 275 feet along the eastern margin. The Judith River and Mesaverde formations thin northward and eastward throughout the basin while the overlying Bearpaw Shale displays a reciprocal relationship ranging in thickness from zero in the southwestern part to 1,000 feet in the north end. In the south part of the basin the Judith River is divisable into three mappable units: upper sandstones, middle continental deposits, and lower sandstones.

Marine and transitional beach environments, that have produced sandstone reservoirs and petroleum accumulations in several other basins in the Rocky Mountains are well represented in the Eagle, Judith River, and Bearpaw of the Big Horn basin. Numerous littoral and neritic sandstones provide a variety of trapping conditions in conjunction with both old and present-day structural features. Embryonic development of Laramide structures during late Cretaceous resulted in (1) thinning of sediments over some of the major structural features and (2) the accumulation of thicker and more porous sandstones along the flanks and over the crests. Examples of depositional thinning of the Claggett Shale may be observed in the vicinity of Five Mile, Worland, Slick Creek, and Sand Creek fields. Local thinning of the Judith River interval occurs at Worland and Slick Creek fields. Similar Laramide structural growth patterns have been mapped in association with oil and gas production in the Patrick Draw-Table Rock area of the Great Divide basin in southern Wyoming.

In approximately 60 per cent of the basin the top of the Judith River and Mesaverde is at a depth of 8,000 feet or less. There is no petroleum production from Upper Cretaceous rocks of the Big Horn basin at the present time. Significant shows have been found at (1) Neiber anticline where a well blew out and burned from gas in the Eagle, (2) Golden Eagle field where three cable-tool wells produced gas from the lower Mesaverde during the early stages of the field's development (1918–1923), (3) Golden Dome and Dry Creek fields in Montana where gas was produced from a zone in the lower Mesaverde, and (4) at the Berwin area northwest of Badger basin where oil was recovered on drill-stem tests of the lower Mesaverde. Smaller shows of oil and gas have been encountered in several other wells.

17. EDWARD L. REID, Murphy Corporation, Casper

Oil and Gas Occurrences in Disturbed Belt of Southern Alberta and Northern Montana

Several of the most important "disturbed belt" hydrocarbon occurrences are briefly summarized in order of discovery and development.

The hydrocarbon trap at Turner Valley is primarily structural; however, there are some indications of pre-structural stratigraphic control of accumulation. The Highwood structure, 2 miles west of Turner Valley, has tested only water from the Mississippian. Producing porous zones at Turner Valley can not be easily correlated with porous units at Highwood, indicating that there may never have been a direct connection between the two reservoirs. In addition, some wells drilled east of Turner Valley have encountered tight Turner Valley producing zones. Gas reserves originally in place at Turner Valley were 1.74 trillion cubic feet.

Hydrocarbons at Jumpingpound are structurally trapped in the updip edges of a thrust-faulted Rundle slice. Jumpingpound will eventually produce about 700 billion cubic feet of gas.

Surface geology in the Pincher Creek area does not suggest the presence of an anticlinal fold or large thrust sheet at depth. In contrast to steep west-dipping surface beds, the Mississippian rocks of the reservoir block at Pincher Creek dip southwest at only 4°–8°. Pincher Creek accumulation is structurally controlled. Current estimates give Pincher Creek 2.29 trillion cubic feet of gas reserves. During the past 5 years, four more important discoveries have been made in the Waterton and Castle River areas near Pincher Creek. Structurally these blocks lie above and west of the Pincher Creek block.

Total in place Mississippian gas reserves in Southern Alberta "disturbed belt" fields currently stand at 8 to 8.5 trillion cubic feet.

Early and recent oil and gas occurrences in the Montana part of the "disturbed belt" are briefly reviewed. Wildcat density, time of structural movement, degree of crustal shortening, and Mississippian stratigraphy are suggested as possible reasons for lack of economic success in the Montana part of the disturbed belt. Mississippian stratigraphy and its influence on hydrocarbon accumulations near the disturbed belt are illustrated with the suggestion that the combination of proper stratigraphic and structural conditions have not yet been found in the Montana disturbed belt.

18. SIDNEY B. ANDERSON, North Dakota Geological Survey, Grand Forks

Selected Devonian Possibilities in North Dakota

The Devonian System of North Dakota consists of rocks of Middle and Upper Devonian age. The Middle Devonian is represented in ascending order by the Winnipegosis, Prairie, and Dawson Bay Formations and the lower part of the Souris River Formation. The Upper Devonian is represented by the upper part of the Souris River Formation, the Duperow, and Three Forks Formations. These formations represent a total Devonian thickness of about 650 feet in south-central North Dakota, approximately 1,400 feet in the north-central North Dakota and about 800 feet in the southwestern part of the state. These units are dominantly carbonate rocks, the principal exceptions being the Three Forks shale and the evaporites of the Prairie Formation.

Though there is no Devonian production in these