diagenesis is nearly isochemical.

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Relation of Lithofacies and Diagenesis to Porosity Development, Mission Canyon Formation (Mississippian), Eastern Montana and Western North Dakota

The ability to map lithofacies trends suitable for hydrocarbon reservoirs is critical for a successful exploration program. In exploring basins with carbonate reservoirs, diagenetic alterations must also be understood in relation to porosity development. The Mission Canyon Formation (Mississippian) of the Williston basin provides an excellent example of the need to understand the lithofacies/diagenesis relation.

During the Mississippian, the Williston basin was the site of subtidal to supratidal carbonate deposition. In general, depositional environments became more restricted from Montana, eastward into North Dakota. Subsurface mapping suggests a strong relation between the degree of marine restriction and diagenesis and porosity development in carbonate sediments. Two fields that produce from the Mission Canyon interval illustrate this relation.

MonDak field, situated on the Montana-North Dakota border, lies west of the limit of massive Mission Canyon anhydrite, in a sequence of normal marine sediments. Reservoir porosity is due to fracturing of tight, fine-grained limestones. Low matrix porosity and sparse, erratic fracturing are responsible for low daily production rates.

The Billings Nose–Little Knife trend (Billings, Dunn, and McKenzie Counties, North Dakota) lies well within the limit of massive anhydrite. Reservoir porosity in this case consists of a thick sequence of intertidal-supratidal sucrosic dolomites which are sealed by 20 to 25 m of massive anhydrite. Reflux of Mg-rich brines is believed to be the process leading to dolomitization.

Good matrix porosity and permeability allow for higher daily production rates. Regional mapping indicates that the presence or absence of anhydrite is in direct correlation with the development of good matrix porosity.

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Regional Assessment and Interregional Comparison of Oil Exploration Potential—Breaking the Time Barrier

At any time, the degree of exploration may vary widely within a region or between regions. Regional assessments or interregional comparisons based on projections of field-size distributions in time-series discovery data are therefore dependent upon non-uniform evaluation of oil potentials. In this study, drilling history data from wells in Kansas are used to identify the various times at which all locations within regions of the state achieve selected exploration levels. Maps of the regional variation in time associated with a uniform level of exploration demonstrate the historical step-out pattern of the industry.

Known oil fields in Kansas are ranked in relation to prior exploration in the vicinity of discovery wells, with low-rank values corresponding to low density of prior exploration. All known fields within a region are classified into sets. Each set consists of fields discovered at various times, but at a uniform exploration level. Probabilities of discovering fields at different levels of exploration are developed in relation to field size. Projections of the ultimate number of fields in each size class expected within a region are then obtained through analysis of field-size distributions within each of the uniform exploration sets. By subtracting known fields from the ultimate number expected in each size class, a measure of future regional potential for continued exploration is obtained. Measurements of the success of exploration by the petroleum industry relative to the potential success from random drilling are also obtained.

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Arumbera Sandstone: A Possible Late Proterozoic-Early Cambrian Deltaic Complex, Central Australia

A detailed investigation of the Arumbera Sandstone was undertaken in the northeastern Amadeus basin, central Australia, where the unit forms distinctive strike ridges with orange-white cliffs and dark reddish slopes. The Arumbera is divisible into four informal, readily mappable units.

Approximately 80% of the "average" stratigraphic section is composed of recessive, pale-red, thin to medium-bedded, fine to medium-grained arkose with major proportions of siltstone and mudstone. These sediments are interpreted as a complex assemblage of coastal and nearshore marine environments including tidal flats, tidal channels, estuaries, and beaches. Evidence includes: (1) predominance of alpha, beta, and xi cross-stratification with common herringbone laminae, hummocky cross-strata, planar foreshore stratification, and flaser bedding; (2) bimodal paleocurrents; (3) records of intermittent subaerial exposure; and (4) rare to abundant marine trace fossils.

The remaining 20% of the Arumbera is composed of cliff-forming orange-white thick-bedded, fine to medium-grained arkose and lithic arkose with pebble to cobble conglomerate. This facies probably is a fluvial sheet sandstone. It is characterized by: (1) pi and omicron cross-stratification; (2) general paucity of mudrocks, but abundant shale pebbles; (3) unimodal, northeast-oriented paleocurrents; (4) wedging channel-sand bodies; (5) absence or extreme rarity of trace fossils; (6) sheet-like geometry; and (7) decrease in maximum grain size to the northeast.

The Arumbera probably was deposited in a coastal environment unrestricted by vascular land plants, but perhaps analogous in other ways to the delta of the modern Godavari River of India. Evidence includes: (1) a pronounced depocenter for the unit in the central part of the study area (thickness northeasterly from 216 to 1,123 m in 80 km); (2) unidirectional paleocurrents from fluvial sheet sands that radiate to the north, northeast, east, and southeast; (3) fluvial and coastal deposits in vertical, repetitive succession; and (4) east and northeast-trending zones of thicker deposits within fluvial sheet sands which may be distributary lobes.

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Diagenesis of Lime Mud, Mississippian-Age Bioherms, Sacramento Mountains, New Mexico

Samples from six Waulsortian bioherms were examined from the Mississippian Lake Valley Formation, Sacramento Mountains, New Mexico, to determine the timing and mechanisms of lime-mud cementation and to evaluate the role of this cementation in biohermal stabilization and growth.

Petrography and cathodoluminescence of bioherm and inter-bioherm muds defined distinct diagenetic mud types. Each mud type is characterized by a distinct grain size, mud color, and cathodoluminescence. Bioherm *type 1* mud is dark gray, fine-grained, ($\overline{Y}$ = 3.7 μm) and has a dull luminescence. *Type 2* mud, which coexists with type 1 mud, is coarse grained ($\overline{Y}$ = 5.7 μm), lighter gray, and has a brighter luminescence. *Type 3* mud is darker gray, coarser-grained ($\overline{Y}$ = 6.7 μm), and is nonluminescent. *Type 4* mud is gray brown, and is the coarsest grained ($\overline{Y}$ = 8.8 μm) and most brightly luminescent of all bioherm mud. For comparison, interbioherm mud has the finest mean grain size ($\overline{Y}$ = 3.36 μm and the brightest luminescence of all mud types examined.

It is proposed that synsedimentary marine cementation of biohermal muds and within synsedimentary stomatactis is the causative factor for bioherm stabilization and growth. Dark gray nonluminescent bioherm muds reflect a significant component of synsedimentary marine cements while lighter gray luminescent bioherm muds reflect a higher proportion of post-burial intergranular cements. This interpretation is supported by the oxygen and carbon isotopic composition of the lime-mud types. For example, synsedimentary stromatactis cavities lined by fibrous marine cements are constructed from nonluminescent type 3 muds which possess the heaviest isotopic signatures (−1.8 to −2.7 ‰δ^{18}O; + 4.81 to +4.1 ‰δ^{13}C). In contrast, cavities infilled by post-burial granular cements are associated with luminescent mud types 1, 2, and 4, which possess lighter isotopic signatures (−2.3 to 14.4 ‰δ^{18}O; +2.0 to +4.2 ‰δ^{18}O). Interbioherm muds, interpreted to have lithified at a later stage than bioherm muds, possess lighter isotopic signatures (−3.8 to −6.7 ‰δ^{18}O; +2.3 to +2.5 ‰δ^{13}C).

Because of the heterogeneous distribution of synsedimentary cemented muds within the bioherms, the formation of the stromatactis cavities characteristic of Waulsortian bioherms is interpreted to occur from the slumping and subsequent removal of uncemented grains from beneath patches of early marine cemented mud. As such, this study emphasizes the role of early marine cements in fine-grained sediments as an active process which merits careful consideration in determining original porosities and diagenetic histories in ancient fine-grained carbonate facies.

CRANE, DAVID C., D. C. Crane, Inc., Dallas, TX

Interactive Video Digitization of Well Logs

An interactive microprocessor-based system is under development which converts the curve data on paper well logs to a computer-usable digital format. The system can be adapted to convert log curves from microfiche. The system is expected to reduce the cost, time, and drudgery associated with current hand-tracing and editing techniques, without sacrifice of quality.

The initial system consists of a 64K (64,000 character) memory, a Zilog Z-80B microprocessor, a TV camera, a color monitor, a video digitizer with 256K of raster-refresh buffer, and almost 30 million bytes of on-line magnetic storage.

The hardware semiautomatically captures log images in raster form. Software converts the raster imagery to an X-Y coordinate model. The operator then makes model corrections interactively by using a small digitizer tablet as a pointing device and with pattern-recognition assistance from the system.

The author hopes to add software to allow "slipping" digital logs on the same equipment. The next logical development would be a plotter, a floating-point processor, and software to add contouring capability to the system.

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Distribution of Carbonate and Evaporite Facies of Mississippian Mission Canyon Formation

Thirty-five oil fields have been developed in the Mission Canyon Formation in northern Bottineau and Renville Counties, North Dakota. Six cyclic sedimentary units have been defined in the Mission Canyon in that area. They are, in ascending intervals: Landa, Wayne, Glenburn, Mohall, Sherwood, and Bluell. These intervals or sequences were deposited during marine regressions in the intracratonic Williston basin. A brief but widespread transgression at the initiation of each cycle resulted in deposition of a thin argillaceous marker which can be correlated over large areas.

The depositional setting during Mission Canyon time was similar to that of shallow epeiric seas. Limited circulation resulted in hypersaline conditions and widespread evaporite deposition. A shelf-to-basin configuration probably never existed; rather, deposition occurred on a shallow ramp with little topographic relief. Exposure and the resultant vadose leaching caused occurrence of porosity on depositional highs such as oolite shoals and organic banks. Anhydrite plugging of this porosity is common where evaporite environments migrated basinward over the porous facies.

Three types of stratigraphic traps have been recognized, these are: (1) a carbonate-evaporite facies change where porous carbonates are sealed by the overlying evaporite facies; (2) porous carbonates sealed by nonporous carbonates; (3) porous carbonates subcrop beneath the Triassic Spearfish shale which serves as the updip seal. An understanding of the distribution of porous facies is essential to determining areas of future exploration.

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Paleoenvironmental Factors Affecting Mine Planning of Pocahontas No. 3 Coal Seam in Southwestern Virginia

The Pocahontas Formation (Carboniferous) in southwestern Virginia and West Virginia ranges in thickness from 600 to 750 ft (183 to 229 m). A major mineable coal seam known as the Pocahontas No. 3 (P3) is a laterally continuous, low-sulfur coal extending throughout Russell, Tazewell, and Buchanan Counties. It lies within 1,500 to 2,000 ft (457 to 610 m) below the surface and ranges in seam height from 0 to 72 in. (0 to 1.8 m).

Identification of potential roof hazards in the preliminary drilling stages of mine development is possible by reconstructing the depositional setting of the P3. Rock types overlying the P3 coal primarily consist of coarsening-upward shales and sandy shales, and thin-bedded graywacke sandstones deposited in the central and northwest parts of the study area. In addition, thin coals overlying clay partings and massive, fining-upward, cross-bedded graywacke sandstones are present in the east and southeast. Thus, the depositional setting is interpreted as an upper delta front system of distributary channels, splays, and adjoining interdistributary bays which prograded from the southeast over the transitional environment of the P3 seam.

Knowledge of this setting, integrated with previous in-mine research, revealed potentially hazardous areas with respect to continuous and longwall mining practices. Also, preliminary evaluation techniques developed in this study make it possible to initiate a more effective secondary drilling program resulting in the definition of stable areas for the driving of mine entries.

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