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Carbonate Petrology of Arun Limestone, Arun Field, Sumatra, Indonesia

The Arun gas and gas distillate field (estimated 13.7 tcf hydrocarbon gas in place) is a large Miocene coral-algal reef complex located on an intrabasin high in the North Sumatra basin. It was discovered in 1971 by Pertamina/Mobil Oil Indonesia following definition of a reflection seismic anomaly. The field is a large, asymmetric stratigraphic trap 18.5 km (11 mi) long and 5 km (3 mi) wide. The Arun Limestone which forms the reservoir is overlain, underlain, and possibly surrounded by shale. The limestone ranges in thickness from zero west of the field to about 1,200 ft (365 m) in well A-10. Closure on the Arun Limestone is at least 1,200 ft (365 m).

The reservoir rock is made up of several carbonate rock types, including coral-algal boundstones, foraminiferal packstones and wackestones, mixed-skeletal wackestones and packstones, and dolomite. Interstitial fill of the reef consists of lime and reef detritus (i.e., skeletal wackestones and packstones); grainstone fabrics are notably absent in the Arun reef and related facies.

Diagenesis has had a strong effect on the original sediments; (1) the lower part of the reservoir is completely dolomitized; (2) patches of limestone throughout the Arun are recrystalized to sparry calcite; and (3) much, if not most, of the reservoir is strongly micritized. The most pronounced effect of diagenesis has been the formation of secondary moldic and vuggy porosity formed by the dissolution of aragonite fossils (mainly branching corals, mollusks, and foraminifera). Had there been no diagenesis of the original limestone, it is doubtful that a hydrocarbon reservoir would be present on the Arun structure.

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Estuarine and Fluvial Systems, Lower Mesaverde Group (Campanian), Northwestern Colorado

Stacked shoreline sandstones near the base of the Mesaverde Group are well exposed along the southern flank of Rangely dome, northwestern Colorado. Overlying these marine deposits is a thick sequence of carbonaceous siltstones that encase elongate lenticular sandstones. This sequence records the evolution from estuarine to fluvial channels formed along the western margin of the Cretaceous Western Interior seaway. Sections 180 to 250 m (590 to 820 ft) long, were measured along a trend perpendicular to paleoshoreline. Several individual sandstones were studied in detail to develop depositional models. Data from over 300 well logs provided information regarding regional distribution and stratigraphic relationships of the systems. Two major stratigraphic successions were recognized.

Thin (0.5 to 2 m, 20 in. to 6.6 ft) bioturbated and root-mottled fine sandstones, interbedded with pervasive siltstones occur immediately over the marine shoreline deposits in both sequences. The sandstones are interpreted as storm washover deposits. At Gillam Draw in the eastern portion of the outcrop study area, the washover sandstones are overlain by 50 to 60 m (165 to 195 ft) of bioturbated shales and siltstones. Ripple-stratified, upward-fining, fine to very fine sandstone lenses occur in this interval. These lenses are 4 to 8 m (13 to 26 ft) thick, have erosional bases, and have well-developed lateral-accretion bounding surfaces. *Ophiomorpha* and other trace fossils suggest an estuarine influence. The sandstone lenses are point bar deposits formed along meandering tidal creeks. Siltstones, coals, and 8 to 12 m (26 to 39 ft) thick lenticular sandstones overlie the tidally influenced interval. The sandstone lenses change significantly in geometry, bounding surface relationships, and textural trends within this succession.

Stratigraphically lower sandstones form broad (100 to 200 m, 330 to 660 ft wide) belts. Individual sandstone bodies within the lenses have erosional bases and prominent lateral-accretion surfaces. Trough cross-bedding near the base is overlain by ripple stratification. These broad, lenticular sandstones represent fluvial meander-belt deposits.

Sandstone lenses become narrower and lack accretionary surfaces higher in the section. These younger sandstones are multistoried, rather than multilateral, channel deposits and are flanked by extensive crevasse splay facies. They are interpreted as confined anastomosing fluvial channels. West of Gillam Draw, the anastomosing fluvial system directly overlies shoreface and storm washover deposits. The multistoried lenticular sandstones are thicker (20 to 30 m, 66 to 100 ft).

Sedimentation kept pace with subsidence in the eastern, basinward sections. Lower reaches of streams were tidally influenced even though the area was not inundated by marine waters. The western succession represents aggraded fluvial systems formed inland from the coast. Both sequences are characteristic of areas of rapid subsidence.

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Origin of Chert in Permian System in Southwestern Utah and Northwestern Arizona

Within the Permian System in southwestern Utah and northwestern Arizona, the Brady Canyon Member of the Toroweap Formation and the Fossil Mountain and Harrisburg Members of the Kaibab Formation contain five different forms of chert. These chert forms provide information about the origin and emplacement of chert in the Permian System. The forms present are: rounded chert nodules, ribbon chert, silicified burrows, disseminated chert, and massive chert that grades into limestone. Sources of chert are attributed to upwelling of deep bottom waters, silica-derived from freshwater mixing with saline water in deltaic complexes, and precipitation of silica through biological processes. Examination of fossiliferous rounded chert nodules, silicified burrows, ribbon chert, disseminated chert, and stringers of chert, indicate that deposition was the result of secondary solution moving through areas with greater porosity. Disseminated chert, found in the Fossil Mountain Member, was deposited in the areas where the porosity was greatest. Massive chert in the Harrisburg Member formed at the water table where dissolution of the limestone occurred. This chert layer was then exposed to erosion. Chert emplacement occurred following the partial dolomitization of the limestone early in the diagenetic history. Some chert appears to have been deposited as secondary cement in the carbonate rock following cementation and dolomitization. Chert horizons in the upper part of the Kaibab Formation suggest that chert may have developed much later during an erosional cycle. This is supported by colloform structures and gradation from a massive chert down to limestone.

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Evaluation of a Structurally Disturbed Portion of Wilcox Lignite Trend

Northwestern Resources Co.'s Jewett Project is located approximately 100 mi (160 km) south of Dallas. It is within the Wilcox Group and is bounded on the west by the Navasota River and the east by Interstate Highway 45.

The geology is generally typical of the upper Calvert Bluff Formation, with the exception of the project's west end. This area is abruptly separated from the rest of the project by a series of normal faults with displacements of up to 200 ft (66 m). The area is characterized by steeply dipping beds (15 to 20°), discontinuous lignite seams, anomalous lignite thicknesses (up to 35 ft, 11 m), stacked seams, and low-quality lignite. Core information reveals areas where pebble to cobble-sized angular lignite fragments are contained in a silty to sandy matrix.

On a more local scale, lignite elevations, and parting and lignite thicknesses have been observed to range as much as 15 to 20 ft (4.5 to 6 m) between pilot hole and core hole. Core sampling has revealed bedding planes oriented at 40° or horizontal in overburden material at one site and horizontal bedding in a 28-ft (8.5-m) lignite seam at another site.

Various exploration and evaluation methods have been used in an attempt to decipher this geologically complex area. Electric logs, geologic mapping, and cross sections show some of the anomalous features.

The paper presents the area in a regional framework with consideration given to the Elkhorn graben system to the northeast and the Marquez dome to the immediate south. Evaluation of the depositional environment and subsequent geologic history has assisted in determining the potential for mining in this area.

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Storm-Dominated Shoreface Deposits, Sego Sandstone (Campanian), Northwestern Colorado

Characteristics of progradational shoreface units have been described from several sandstones in the Cretaceous Western Interior seaway. Little work has been done to document the characteristics of shoreface deposits in a transgressive setting. Outcrop studies of the Sego Sandstone (Campanian), in Rio Blanco County, Colorado, indicate that an initial episode of progradation was followed by a stagnation of the system in which minor transgressions occurred. Transgression of the foundering coast is evidenced by landward movement and storm breaching of a thinned shoreface unit and by the aggradation of a thick associated tidal flat and lagoonal complex.

Three lithofacies are recognized in the shoreface deposits from 80 measured sections; each is composed of very fine-grained, laminated sandstone. (1) Stacked sequenced, 1 to 1.5 m (3.3 to 5 ft) thick, of interbedded sandstone and rippled sandy mudstone. The sandstone beds have 0.5 to 1 m (1.6 to 3.3. ft) thick, imbricated wedge-planar laminations that thin rapidly to the northwest into broad low-angle trough and antiform bedding before pinching out into the mudstone as rippled and burrowed beds. (2) Sandstone with low-angle trough cross-stratification and imbricated wedge-planar sets, but no associated mudstone. This facies ranges up to 5 m (16 ft) thick, but is most commonly 2 to 3 m (6 to 10 ft) thick. (3) Sandstone in superposed accretionary sets ranging from 0.5 to 3 m (1.6 to 10 ft) thick and 8 to 30 m (26 to 100 ft) wide.

Facies 1, which always forms the base of a sequence, is a stacked series of washover fans that thinned rapidly beyond the confined shoreface breach and spread landward into adjacent lagoonal lows. Facies 2 is a stabilized shoreface and is interrupted along strike by facies 3, the longshore-derived fill of storm channels. The stacking and lateral occurrence of filled channels indicates that active zones of weakness existed, and that net landward movement of the shoreface occurred as result of storm washovers.

A thick (80 m, 260 ft) sequence of tidal and paludal sediments is found above the shoreface. Facies include: (1) ripple-stratified, bioturbated humates, and very fine-grained sandstone, interbedded with thin (1 to 30 cm, 0.4 to 12 in.) continuous coals. (2) Thin-bedded fine-grained sandstone and mudstone with flaser bedding and starved current ripples. (3) Very fine-grained, laminated sandstone with low-angle through cross-stratification and accretionary sets; nearly identical to facies 2 and 3 of the shoreface but thinner (1 m, 3.3 ft). (4) Small to large scale, stacked accretionary sets of fine-grained sandstone ranging to 10 m (33 ft) thick (individual sets 0.1 to 3 m, 4 in. to 10 ft thick), containing rippled foresets and abundant *Ophiomorpha*. Mud clast conglomerates are found in some of the smaller channel forms.

Study of 30 measured sections indicates that lagoonal deposits (facies 1) become sandier upward and are overlain by sand tidal flats and mixed tidal flats (facies 2). A system of meandering tidal creeks eroded into the contemporaneous tidal flat and lagoon facies. These creeks coalesced to form a central tidal inlet (facies 4). A subsequent transgression reworked shoreface sandstones (facies 3). Influx of sediment by longshore currents reinitiated progradation of the system. Meander-belt and floodplain facies were deposited over the tidal flat-lagoon complex during this regressive phase.

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Role of Geophysical Logging in Coal Exploration and Discrimination

Geophysical logging has become an important phase of coal exploration. Electric logs that were run in wells drilled for oil and gas can be used to make preliminary studies of structure, coal thickness, depth, and sedimentological anomalies that affect coal continuity. They can be used to locate the best areas for local exploration coring.

Radioactivity logging has become standard procedure in most areas in exploration drilling and coring programs. Thickness (and therefore tops and bottoms of seams) can be determined with great precision on density and neutron logs. Interpretation of radioactivity logs allows the predictions of local geological, structural, stratigraphic, and sedimentological anomalies that will influence mining programs. Ash content calculations which compares favorably with core analyses can be made with the use of density logs. With the use of sonic logs in conjunction with density logs, calculations can be made which will give an indication to the strength of roof and floor rocks.

This paper presents case studies of the successful use of geophysical logs in regional and local phases of exploration and the discrimination of coal seams in several geographic locations.

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Subsidence and Heat Flow Across a Sedimentary Basin-Uplift Boundary: A Thermal-Mechanical Model

The northern coast of the Gulf of Mexico contains major depositional basins in east Texas, north Louisiana, and central Mississippi. They are separated by the Sabine and Monroe uplifts. Basin subsidence can be interpreted as resulting from extension by rifting related to opening of the Gulf of Mexico during Late Triassic to Early Jurassic times. Subsidence of the North Louisiana salt basin, determined from well data, is consistent with crustal extension by a factor of 1.5 to 2. Seismic surveys across