Oil and Gas Prospects of Southern Taranaki Bight, New Zealand[1]

Potentially petroliferous sediments of early Tertiary age are preserved in several subbasins and graben-synclines along the western parts of both islands of New Zealand. Collectively these constitute the now extensively disrupted, linear, and platformlike Cretaceous to Tertiary "West basin" or "geosyncline," which is separated from the more specifically volcanic "East geosyncline" by the geanticlinal backbone of the New Zealand continental block. The geanticlinal zone which is "geosuturelike" constitutes a major transcurrent fault system within the circum-Pacific tectonic belt.

Following a major break from the Jurassic to Cretaceous graywacke-breccia flysch-type deposition, Upper Cretaceous to Tertiary platformlike sedimentation in the newly forming West basin was regionally extensive and about 10,000–15,000 ft (3,050–4,600 m) thick. The basal unconformity is angular and sharp, whereas internal unconformities tend to be local and marginal. Facies changes are also important locally, but these are superimposed on regional sequences that are traceable through the full longitudinal extent of the platform.

Upper Cretaceous-lower Tertiary sediments are predominantly freshwater and coal bearing. Later sediments are dominantly marine, and include considerable thicknesses of mudstone and limestone.

Oil seeps along the West basin are associated almost entirely with the lower Tertiary coal measures. In the Taranaki basin a small oil field in Pliocene sandstone at New Plymouth has produced a total of 200,000 bbl of oil and 65 MM cu ft of gas (1.85 MM cu m). The Kapuni condensate-gas field in the Taranaki basin, discovered in 1959, is capable of producing 60 MM cu ft (1.70 MM cu m) of gas-condensate per day. Hydrocarbons are considered to be mainly indigenous to the coal measures, but some may be from overlying marine sediments.

Several geophysical surveys have outlined the broader structure of the southern Taranaki basin. Upper Cretaceous-lower Tertiary coal measures, together with a lower Tertiary limestone, provide the principal reflectors, except where masked by thicker Plio-Pleistocene section in the east (D'Urville trough). Sedimentary thicknesses in the area attain 10,000–15,000 ft (approx. 3,000–4,500 m), but thin considerably over conspicuous structural "highs." A variety of structural and stratigraphic traps is predicted.

Broad comparisons have been made with recently discovered major oil and gas fields of the Gippsland basin, Australia, directly across the Tasman Sea.

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Coarse Channelized Deposits and Other Indicators of Slope and Base-of-Slope Environments in Ancient Marine Basins

Submarine slopes are distinctive depositional environments because of their gradients and their position between sediment source locales at their upper level and areas more favorable for preservation on basin floors beyond. The model for slope sedimentation must incorporate such factors as gradient, dissection, type and rate of sediment input, and processes. Slopes are most often represented as inclined planes reflecting depositional instability, *i.e.*, relatively temporary resting places for sediments during their passage to depositional sites in more distal environments. Sediments are, however, preserved in a multiple set of slope subenvironments, and there are criteria for recognizing most of these.

Fine-grained pelagic deposits (some entirely reworked by benthonic organisms), hemipelagic materials influenced by bottom current activity, turbidites with mixed faunas and mineralogy, contorted slumped units, and allochthonous slabs which slid into deeper water generally are recognized as the dominant slope facies assemblage. However, the problem of distinguishing slope from basin-floor sediment remains because criteria for distinguishing facies are found in both environments, especially near their juncture. Marine geologic investigations have detailed the three-dimensional geometry, vertical-lateral relation, sedimentary properties, and have defined processes on modern slopes. These investigations and studies of paleoslope deposits in certain Tertiary flysch formations of the Alps and Carpathians, bring to light methods that permit more precise paleogeographic interpretations.

Channelized deposits, coarse units representing fills of submarine canyons and valleys and answering the description of *fluxoturbidites,* are important in this respect. They can be mapped regionally as shoestring bodies that migrate downslope and are incised in pelagic and bottom-current transported units and turbidite bundles. They are well developed on lower slopes, subsea fans, and rises, and can be traced well into basins; they are not necessarily proximal. Primary structures are generally indicative of traction processes. Their value in measuring primary dip and major slope trends, in pinpointing important source input along basin margins, and in serving as funnels in the transfer of sediments downslope can be demonstrated.

In association with these channels, wedges of pebbly mudstone are common at the base of slopes and, where concentrated, indicate the position of an important break (decrease) in gradient. Large, commonly rounded blocks and boulders enrobed in contorted mud suggest conditions of rapid sedimentation as off river mouths or along rapidly eroded coastlines, where materials are periodically moved across narrow shelves and then, *en masse,* on relatively steep slopes, perhaps between canyons.

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Evolution of Trilobite Populations, Late Cambrian Biomeres

New data from the southwestern United States on Late Cambrian trilobite biomeres suggest that the nonagnostid trilobite population of each biomere underwent four successive stages of evolution before becoming extinct. The first and stratigraphically lowest stage is characterized by species with considerable morphologic variability and short stratigraphic ranges. The second stage is characterized by species with longer stratigraphic ranges and less individual morphologic variability. The third stage is characterized by high species diversity and species with long stratigraphic ranges and increasingly less morphologic variation. The fourth, stratigraphically highest stage is characterized by low species diversity, coquinoid abundance of at

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least one species, and at least one species of olenid trilobites.

The bounding faunal discontinuities of trilobite biomeres probably resulted from repeated migrations onto the craton of a slowly evolving extracratonic basic stock, each migration replacing the major cratonic nonagnostid trilobites. Following each migration there was an initial burst of adaptive evolution (stage one) as the eugeosynclinal trilobites evolved rapidly under strong selection pressure imposed by their new cratonic environment. Stage two represents the attainment by a few genera of fairly complete adjustment to the environment. Stage three represents maximum adjustment to and utilization of the environment. The extinction of many long-ranging species near the end of stage three and the peculiar but characteristic composition of stage four suggest that stage four represents the last stand of the established trilobites of the biomere prior to their replacement by a new migration of extracratonic trilobites.

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MIDDLE GLEN ROSE (LOWER CRETACEOUS) DEPOSITS OF CENTRAL TEXAS: A DEPOSITIONAL MODEL OF SHALLOW-WATER CARBONATE SHELF

A 35–50-ft sequence of fine-grained middle Glen Rose carbonates, present in an extensive outcrop area (± 5,000 sq mi) south of the Llano uplift, contains a variety of sedimentary features resulting from relatively mild dynamic forces acting on a broad, low-relief shelf.

This distinctive rock sequence includes the following deposits in ascending order: (1) stromatolitic and rippled beds of probable intertidal origin, (2) very fossiliferous burrowed calcareous mudstone (*Salenia texana* beds), (3) an iron-stained *Corbula martinae* bed, and (4) collapse breccias resulting from vadose solution of two gypsum beds. Widespread sedimentary features confined to "key beds" include oscillation ripple marks, asymmetric current ripple marks, stromatolites, and pholad borings. Mudcracks and dinosaur tracks occur locally along diastems.

Current action was most intense on the San Marcos platform, a promontory extending from the Llano uplift, as indicated by thinner beds, the absence of one and perhaps both gypsum beds, and large asymmetric ripple marks on the *Corbula* bed. Southwesterly, the *Corbula* bed thickens and grades from shell grainstone to calcareous mudstone with indigenous *Corbula*. Within the basal beds, a consistent northwest-southwest alignment of oscillation ripple marks, present along 100 mi of outcrop, is a probable result of wind disturbance of very shallow water. The dominant currents flowed southwestward, as implied by the areal configuration of a sandstone-shale lens within the calcareous mudstone interval, and may have been driven by prevailing northeast winds.

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FACIES AND FAUNAL RELATIONS IN PENNSYLVANIAN MISSOURIAN ROCKS ALONG OKLAHOMA-KANSAS BOUNDARY

The transitional belt between Missourian rocks of Kansas and Oklahoma is characterized by complex facies and faunal relations and traditionally has been a subject of controversy. In contrast to the laterally persistent limestone beds of Kansas which terminate north of the state boundary as algal buildups, limestone beds of the transitional belt are local and consist of thin calcarenite and calcilutite, thick oölitic beds, and algal buildups. Where fossiliferous, intervening shale beds are dominated by crinoids and mollusks. Stratigraphic evidence indicates that the Hogshooter and Dewey Limestones of Oklahoma are not equivalent to the Dennis and Drum Limestones of Kansas. In Oklahoma the Iola Limestone disappears a few miles south of the state boundary. On the basis of crinoid evolution, the Iola interval farther south is considered to be above the Avant Limestone.

Lower Missourian *Apographiocrinus* typically has ornate surface markings which progressively disappear in evolution. *Apographiocrinus arcuatus* from the Avant Limestone retains some markings, whereas *A. typicalis* from slightly higher strata is essentially devoid of surface pustules. The latter species is from the Iola Limestone near the state line and the Wann Formation on the south. Two algal buildups are identified in the Avant. The Wann Formation consists of shale, sandstone, and several lenticular limestone beds. The limestone, previously referred to the Birch Creek Limestone, is known to occupy several stratigraphic positions. A Lansing unit, informally termed the "Tyro oölite," is present in southern Kansas and northern Oklahoma and bears *Cibolocrinus conicus, Apographiocrinus typicalis,* and other forms characteristic of Kansas Lansing limestones.

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CAROLINA CRETACEOUS: PETROGRAPHIC RECONNAISSANCE OF A GRADED SHELF

More than 140 samples were collected from the transgressive marine strata of the Carolina Cretaceous in order to assess the hypothesis that they were deposited on a size-graded shelf whose sediments were transported by storm-generated wind-drift currents. Calculations of size parameters revealed only a varying ratio of sand (tractive load) to silt and clay (suspensive load worked in by bioturbulation). However, examination of the shapes of the cumulative curves permitted classification of sediments into an evolutionary sequence of nearshore sand, proximal shelf sand, distal shelf sand, and shelf mud. A scatter of modal diameter *versus* distance from the Cretaceous shoreline has an upper limiting value of 3.5 ϕ, a spread of 1.0–3.5 ϕ at distance zero, but an essentially constant value of 3.5 ϕ for the seaward margin of the outcrop zone. The scatter appears to consist of nearshore and shelf segments, perhaps resulting from two distinct dispersal mechanisms. Detailed study of basal (nearshore), central, and upper (offshore) Peedee outcrops shows that the spread of values for nearshore modes corresponds to the presence in the nearshore outcrops of well-defined, size-graded strata of probable storm-current genesis. "Offshore" outcrops are fine grained, more homogeneous, and do not have well-defined meteorologic stratification.

A model is proposed whereby resuspension of bottom sediments by storms results in textural differentiation of nearshore sediment, and its movement seaward to replace sediment lost through deposition or bypass-