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 $\phi$, a spread of 1.0–3.5 $\phi$ at distance zero, but an essentially constant value of 3.5 $\phi$ 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-

ing over the shelf edge. Coarser sediment fractions are deposited preferentially nearshore, and the sediment becomes finer and more homogeneous offshore. The model conforms to the available data, but more detailed testing of the genesis of the strata is suggested in order to substantiate the hypothesis.

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DEVELOPMENT OF TERTIARY WEST PAPUAN BASIN

Marine-seismic studies and wildcat drilling in the Gulf of Papua have provided a comprehensive insight into the geology of the West Papuan basin. The basin is integrated closely in the west with a downwarped but structurally rigid segment of the Australian shield, and in the south with the Coral Sea hydrographic basin. It incorporates arcuate geosynclinal development eastward and northward beyond the continental margin.

The pre-Tertiary history is obscure. Middle Jurassic-Cretaceous clastic sediments overlie granite of the continental shield on the west. Eastward, the record is interrupted by a thick cover of Tertiary strata, and then possibly may be represented in outcrop by a metamorphic series of indeterminate age.

The Tertiary basin developed in three distinct phases, the first commencing in early Eocene. Marine seas transgressed a peneplaned and tilted Mesozoic land surface from east to west. A remarkably uniform wedge of shoal limestone and chert was deposited. Regression and erosion occurred in late Eocene time.

Late Oligocene oceanic crustal upwarp created an eastern volcanic rim to the basin. Typical orthogeosynclinal deposition followed in early Miocene time, with reef, shoal, and pelagic limestone formed marginal to the stable western (continental) shelf, and with prolific volcanism associated with the eastern (oceanic) flank. Mudstone-graywacke sediments were deposited in a narrow intermediate eugeosyncline.

Middle Miocene regional uplift and orogenesis of the Central Mountain geanticlinal belt resulted in the development of an inmmense southeasterly prograding system, which rapidly buried the early Miocene sequence. This phase probably still is actively prograding southward into the Coral Sea basin.

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DIAGENESIS OF PLEISTOCENE LIMESTONE ON AMBERGRIS CAY, BRITISH HONDURAS

The Pleistocene fauna in limestone on Ambergris Cay is homologous with the adjacent Holocene fauna enabling direct comparison between unaltered and diagenetic samples.

Four facies are recognizable in the limestone: a reef-crest facies (I); a backreef facies (II); a shelf-lagoon facies (III), composed of outer, middle, and inner shelf zones; and a mud-bank facies (IV). The Pleistocene middle shelf zone is oölitic, unlike any nearby Holocene deposits. Facies I and II are biomicrites, III is a biopelmicrite, and IV is dismicrite.

Aragonite persists in corals, mollusks, *Halimeda*, tunicate spicules, pellets, and oöliths, where not obviously replaced by calcite; magnesian calcite is retained in skeletons of encrusting algae and Foraminifera.

Skeletal materials show four categories of diagenetic alteration: (1) solution; (2) precipitation of carbonate as drusy rims, or coarse sparry mosaics of calcite, or syntaxial overgrowths; (3) replacement of aragonitic gastropods by calcite along a jagged "front," probably with solution and deposition on a minute scale; ghosts of primary structures remain in many places, indicating absence of a major intermediate void stage; replacement of *Halimeda* and corals such as *Montastrea annularis* occurs after occlusion of internal pores by sparry calcite; (4) recrystallization (*i.e.*, alteration of crystal form without change in mineralogy), evident in a few pelecypods where local patches of shell have altered to coarse, transverse blades of aragonite in which ghosts of primary structures may or may not persist.

Cementation of the limestone has been achieved through interstitial precipitation of drusy and sparry calcite and through recrystallization.

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TEXTURAL AND RESERVOIR VARIATIONS OF ORDOVICIAN MICRODOLOMITES, LAKE ALMA–BEAUBIER OIL-PRODUCING AREA, SOUTHERN SASKATCHEWAN

The stratigraphic accumulation of oil in the upper Red River Formation of the Lake Alma-Beaubier region of southern Saskatchewan, Canada, is controlled by textural variations in the medial "argillaceous or earthy" dolomite member which separates the underlying, mottled, extensively burrowed, skeletal micrograined, dolomitic limestone of the Yeoman beds from the overlying interior anhydrite-carbonate rhythms of the Herald beds.

Lenses of oil-saturated, coarse chalk to finely microgranular, calcareous dolomite (grain size 15–25 μ) pass vertically and laterally into micrograined (silt and clay intermixture) carbonate, and finally to cryptograined (less than 5 μ), commonly varved, dolomite.

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CLAY-MINERAL DIAGENESIS IN REDBED SEQUENCE, JUNIATA FORMATION, CENTRAL PENNSYLVANIA

The Bald Eagle and Juniata Formations are thick Upper Ordovician units which comprise much of the Taconic clastic wedge in central Pennsylvania. Large parts of these formations consist of a homogeneous subgraywacke-sandstone and conglomerate lithofacies of fluvial origin. The Bald Eagle (lower) part of this lithofacies is greenish gray (drab), whereas the Juniata (upper) part is dark red, with thin drab layers. Because drab and red parts of this lithofacies have identical sedimentologic histories, X-ray diffraction investigations of sandstone-matrix clay minerals were undertaken to establish possible differences in abundance and in octahedral-layer cation content of clay-mineral species between the drab and red beds.

The major clay phases present are illite and chlorite. Consistent variations in the ratios illite/chlorite (determined by peak area) and $Fe^{+2}/Mg$ in chlorite (determined by structure factors) occur between adjacent drab and red rocks. The illite/chlorite ratio is lower in drab than in red beds, and the Fe/Mg ratio is higher in drab-bed than in red-bed chlorite. Statistically, these ratios are inversely correlative, and suggest that the present clay-mineral distribution is not of depositional origin but is a result of diagenetic modifications of a detrital clay suite. Drab-bed chlorite commonly occurs as coatings between two generations of silica cement, which suggests diagenetic generation of chlorite in drab beds rather than secondary destruction of preexisting