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.

NORMAN C. TALLIS, Phillips Australian Oil Co., Brisbane, Queensland, Australia

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.

GORDON E. TEBBUTT, Chevron Standard Ltd., Calgary, Alta.

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.

G. E. THOMAS, Central-Del Rio Oils Ltd., Calgary, Alta.

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.

ALLAN M. THOMPSON, Dept. Geology, Univ. Delaware, Newark, Del.

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 chlorite in red beds. Reduction and dissolution of hematite pigment in red beds may have supplied the necessary iron.

ALAN THOMSON, Shell Development Co., Houston, Tex.

SOFT-SEDIMENT FAULTS AS INDICATORS OF PALEOSLOPE ORIENTATION

The Tesnus Formation in the Marathon region, Texas, consists of interbedded sandstone turbidite and shale of a late geosynclinal filling phase. Deposition was on an unstable slope as indicated by the occurrence of deformational features of preconsolidation origin including rolled sandstone bodies (tens of feet long), sandstone dikes (up to 1 in. wide and 5 ft long), diapiric structures, and numerous normal faults of small displacement.

Throw on these microfaults is less than 1 in. and averages 0.25 in. The displacement is seen only on the undersides of sandstone beds and cannot be traced through the beds in which they occur. The faults intersect the base of beds at an average angle of 55° from the base, whereas most fractures of postconsolidation origin are oriented normal to the base. The measured intersections with the base of beds of 100 faults show that their mean orientation is 97° to the direction of paleoslope as indicated by flute casts. The standard deviation is 15°. Hence, the faults generally parallel paleoslope contours. Of hundreds of faults examined, more than 95% were downthrown down the paleoslope.

Each individual fault has a fault zone less than 1 mm wide. Petrographic evidence for a soft-sediment origin includes (1) boundaries between fault zones and country rock are not sharp, (2) fractured grains are not present in the fault zones, and (3) all healed fractures of postconsolidation origin cut the fault zones.

Soft-sediment faults have been found useful for providing current directions for sole markings, such as groove casts, which normally give only orientation. If used carefully, the faults also can provide paleoslope information where sole markings are absent.

DONALD C. THORSTENSON, Dept. Geology, Northwestern Univ., Evanston, Ill.

PORE-WATER CHEMISTRY OF CARBONATE SEDIMENTS FROM HARRINGTON SOUND, BERMUDA

The interstitial waters of some anaerobic carbonate mud from Harrington Sound, Bermuda, have been analyzed for several organic and inorganic chemical species. The pore-water chemistry is controlled by production of these species because of the action of anaerobic bacteria on organic matter in the sediment.

Interstitial waters from a series of shallow cores (approximately 1 m) were analyzed for the following aqueous species: pH, HCO_3^-, $SO_4^=$, NH_4^+, HS^-, CH_4, N_2, Ca^{+2}, Mg^{+2}, and SiO_2. The insoluble organic matter was analyzed for organic C and N. Some observed concentration ranges are NH_4^+:O to 1 meq/l; HS^-:O to 1 meq/l; HCO_3^-:2.7 to 8.0 meq/l. The decrease in $SO_4^=$ concentration varies from 0 to 2 meq/l. The abundance of all the dissolved organic species consistently increases with depth, with concurrent decreases in pH, $SO_4^=$, Ca^{+2}, and Mg^{+2}. The C:N ratio in the metabolized organic matter is approximately 8. The ratio of CO_2/H_2S introduced into the pore waters is 5. This cannot be explained solely by the action of sulfate-reducing bacteria.

The data are consistent with a theoretical model of organic decay in a closed chemical system, in which the components of the aqueous phase maintain near-equilibrium with the minerals present.

RODERICK W. TILLMAN, Sinclair Oil Corp., Tulsa, Okla.

CARBONATE FACIES AND PALEOGEOGRAPHY OF ROBINSON MEMBER, MINTURN FORMATION, EAGLE BASIN, COLORADO

The Robinson Limestone Member is one of eight carbonate members of the 5,000 ft thick, predominantly sandstone, Minturn Formation (Desmoinesian) in the study area west of the Gore Range in Central Colorado. The Robinson Limestone Member consists of three limestone units (lower, middle, and upper) interstratified with marine and nonmarine sandstone beds. Total thickness of the Robinson ranges from 200 to 400 ft.

The areal distribution and the thicknesses of four time-transgressive facies which make up each of the Robinson limestone units imply an asymmetrical deposition basin with a relatively deep marginal trough along the east side.

From east to west the facies are (1) an oölite facies composed of superficial oölites, pseudo-öolites and oncolites in micro-spar or micrite; it is interpreted to be a shallow-water, high-energy deposit on the east edge of the marginal trough; (2) a tubular foraminiferal facies composed mainly of tubular Foraminifera micrite; (3) a phylloid algae facies of biomicrite containing abundant *Archaeolithophyllum*, *Eugonophyllum*, fusulinids, and *Komia;* the phylloid algae facies is interpreted to be a deeper water deposit near the middle of the trough; (4) a stromatolite facies of stromatolites, laminated micrite, and vuggy ostracod-bearing intramicrudite, which indicate quiet-water deposition near the western margin of the trough. The overall patterns of the limestone facies and sandstone beds indicate intervals of rapid marine transgression followed by relatively slow depositional regression.

Bioherms as thick as 80 ft are in the areas of phylloid algae and stromatolite facies. Nonphylloid algae appear to be the major components of these bioherms. However, recrystallization and dolomitization make recognition of the algae types difficult.

ELAZAR UCHUPI, K. O. EMERY, S. T. KNOTT, C. O. BOWIN, JOSEPH PHILLIPS, K. E. PRADA, and E. T. BUNCE, Woods Hole Oceanographic Inst., Woods Hole, Mass.

CONTINENTAL RISE OFF EAST COAST OF NORTH AMERICA: SHALLOW STRUCTURE

The continental rise off the east coast of North America is a broad sedimentary apron 200–500 km wide, 1,200–5,200 m below sea level, with an average gradient of less than 1°. Continuous seismic-profiler recordings indicate that the rise is a prism of sediments lying on a strong and nearly level reflecting layer known as Horizon A. This horizon is believed to be the top of a turbidite sequence delineating an abyssal plain that covered most of the North American basin near the end of the Cretaceous Period. Progradation