of the Cuchumatanes Mountains of northwestern Guatemala and the once adjacent region in central Guatemala. By moving the blocks back to their pre-slip positions and examining the union of modern topographies, several interesting correlations are noted. In the pre-slip position the present drainage divide of the Cuchumatanes Mountains on the northern block closely matches the present drainage divide between the Polochic and Chixoy Rivers on the southern block. Ridge and drainage trends extend across the fault so that, in the reconstructed position, a missing part is restored to the annular drainage pattern of the Cuchumatanes domal uplift. The Chixoy and Polochic Rivers on the southern block probably flowed into the present Selegua and Cotzal Rivers respectively. Before slip, the region south of the fault drained northward around the highest elevations of the Cuchumatanes Mountains, but after slip the drainage of rivers on the southern block was shunted into the new, fault-controlled Cuilco and eastern Polochic River channels, vastly reducing the discharge across, and erosion of, the northern block. Significantly lower terrane on the southern block is probably due in large part to this erosional factor.

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Bank-Barrier Reef Morphogenesis, St. Croix, United States Virgin Islands

Bank barriers are the major structural reef type in the eastern Caribbean, yet their internal structure and formation process are poorly understood. Twenty-six core holes drilled along the northern St. Croix barrier and on a transect combined with a ship-channel section through the southern bank barrier have shown that this is a bar-type structure which consists of a series of patch reefs within a carbonate sand and rubble matrix capped by reef-crest and fore-reef facies. Locally, reef linearity and location are controlled by a 4-m limestone step of Pleistocene age.

These bank reefs apparently were initiated by shelf-current deposition of carbonate traction load in a bar configuration. Scattered corals—*Porites porites, Diploria* spp., *Acropora cervicornis,* and dominantly *Montastrea annularis*—acted to stabilize the bank. Framework-dominated patch reefs developed at scattered locations and depths as the bank grew upward. As the reefs built into shallow water, carbonate production increased, eventually coalescing them into a continuous reef crest.

Core return shows that the structure is characterized by little cementation. Cement occurs in localized lenses within the structure just as it does along the present reef surface. Framework construction is concentrated in patch-reef, reef-crest, and fore-reef facies. This type of construction produces highly permeable structures with extremely high local porosity. Extensively cemented caps occur only in areas having low accumulation rates and in areas of high energy.

Bank-barrier reefs are probably also important in the Indo-Pacific in exposed non-atoll situations, but their occurrence is generally not recognized. Descriptions of Mesozoic and Cenozoic reefs suggest that the bank reef is an extremely important but little understood type in the fossil record also.

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Oil Exploration in Pre-Salt and Post-Salt Sequence of West Africa—Results in Cabinda

The Aptian evaporites separate two different oil habitats in the offshore of Cabinda: the pre-salt and the post-salt sedimentary sequence, with three-quarters and one-quarter of the oil production, respectively. In the pre-salt sequence, three oil fields are being produced: Malongo North, Malongo West, and the Block 121 trap. In the post-salt, three shallow accumulations are present, in the Malongo North area.

The pre-salt sequence is extremely variable in thickness, and its sedimentary environment is strictly connected with the initial rifting between Africa and South America. In the earliest Cretaceous, a basement peneplane was flooded by a few fluviatile streams along which the thick Lucula sands were accumulated. Production from Malongo North and part of Malongo West fields comes from two of these independent sandstone bodies.

Subsequent subsidence of the basin resulted in the deposition of the Bucomazi black shales in a lacustrine environment. These shales may grade laterally into the Toca carbonate rocks, mainly as a function of the water depth of the lake, every shallowing being accompanied by an increase in carbonate deposition. The Toca carbonate rocks around the Malongo West basement high are the second important reservoir of the field. They are largely dolomitized rocks derived from algal biostromes or pelecypod coquinas.

After the Aptian salt deposition and the definitive opening of the Atlantic Ocean, the basin was tilted to the west, its original trough shape being modified into a monocline. During the Albian, the eastern part of Cabinda offshore was covered by continental red sandstones of the Vermelha Formation. Seaward of this, a definite shallow marine environment existed where the Pinda carbonate beds were deposited, frequently substituted by sandstones and siltstones. These are the reservoir rock of GCO and Mibale fields in Zaire. After a brief marine transgression during the Cenomanian, the heterogeneous Senonian sediments of the Iabe Formation form the reservoir rock of the shallow Malongo fields.

It seems that the proximity of a growth fault may enhance the quality of the post-salt reservoirs: silt and clay accumulated along the downthrown sides of the faults, while salt flowage created localized highs where clean carbonate rocks were deposited in a high-energy environment.

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Deformational Structures in Pliocene Bouse Formation Near Vidal, Southeastern California

Ball-and-pillow, flamelike, and load structures accompanied by convolute laminations in the Pliocene Bouse Formation are thought to be caused by slumping of water-saturated sediments. New structural data suggest that these structures formed by foundering and by lateral movement of unconsolidated sand into hydroplastic mud and silt. Asymmetric ball-and-pillow structures and overturned flamelike structures suggest that movement was toward the southeast. Deformation probably was initiated by earthquake shock.

The deformational structures are restricted to the basal member of the Bouse Formation 13 km northeast of Vidal, California. The basal member is divided into a lower unit of mudstone that grades upward to siltstone. The lower unit is conformably overlain by a well-bedded calcareous sandstone.

Ball-and-pillow structures, 5 cm to 4.5 m across, consist of mudstone, siltstone, and sandstone. The curvilinear long axes of these structures trend at oblique angles to tectonic strike and plunge at angles steeper than the dip. Overturned flamelike structures of mudstone and siltstone separate the ball-and-pillow structures.

Sandstone bedding planes conform to the outline of the ball-and-pillow structures but are undeformed a few centimeters above these structures; hence the ball-and-pillow structures are contemporaneous with deposition of the overlying sandstone. Saclike load casts and elliptical sandstone balls formed concurrently with the ball-and-pillow structures. Sandstone beds are buckled but not displaced by faults that stop within the sandstone unit.

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Comparison of Carbonate Chemistry of Brines from Orca Basin and Dead Sea

The Orca basin is an anoxic, brine-filled intraslope depression (2,250 m deep) located on the Louisiana continental slope in the Gulf of Mexico. The Dead Sea, also brine filled, is only 40 m deep. Both pH (6.83) and ΣCO_2 (5.04 mM) in the Orca brine are higher than in the Dead Sea brine (pH = 5.9–6.5, ΣCO_2 = 2.53 to 2.59 mM). These comparisons and our laboratory experiments on carbonate dissociation constants indicate that Orca basin brine and Dead Sea brine have quite different carbonate chemistries. Carbonate interactions in the Dead Sea brine are strongly influenced by its bulk ion composition, especially the magnesium and calcium enrichments, which are 2.8 and 3.7 times, respectively, relative to normal seawater. These enrichments cause a decrease in the second dissociation constant of carbonic acid. The Orca basin is depleted in magnesium and calcium and has a carbonate system that resembles a NaCl-saturated seawater.

Sass and Ben-Yaakov have attributed the low pH in the Dead Sea to ion pairing of $Mg\ CO_3^{o}$. Carbonate interactions in the Orca basin can be explained by the increased NaCl effect on the dissociation constants, with pH being largely controlled by an input of biogenic CO_2 from the sediments. This addition of CO_2 is significant and accounts for the higher ΣCO_2 levels that were found. These differences in the carbonate system between these two hypersaline bodies may result from differences in their origin.

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Geologic Distribution of Oil

A model for the worldwide distribution of oil can be constructed using only geologic variables. Three joint probabilities are required to explain the known distribution of giant oil fields in time. These probability functions are (1) that an adequate source has been deposited, (2) that oil has been generated and entrapped, and (3) that accumulations have not been destroyed nor the accumulation process aborted. The tectonic setting strongly affects the probability values.

For cratonic areas, the probability of adequate source can be modeled by the published curves for changes in sea level, because times of maximum transgression are most favorable for deposition of source sequences. Adequate thermal maturation varies with the geothermal gradient and is, therefore, extremely dependent on tectonic setting. Generally, Tertiary fields are in tectonically active areas whereas pre-Tertiary fields are in more passive areas. Oil fields in tectonically active areas are destroyed rapidly, whereas older fields which are in generally passive areas are destroyed more slowly.

This model predicts the large concentration of Cretaceous and Jurassic oil as the result of (1) maximum source availability because of extensive transgression, (2) adequate thermal maturity, and (3) very little destruction.

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Organic Acid Anions in Oil-Field Waters and Origin of Natural Gas

The concentrations of short-chain aliphatic acid anions (acetate, propionate, butyrate, and valerate) in 120 formation-water samples from 25 oil and gas fields in Alaska, California, Louisiana, and Texas were determined to study the formation of natural gas from decarboxylation of these anions. The reservoir rocks consist of sandstones ranging in age from Triassic through Miocene.

The samples from Tertiary rocks depict three temperature zones. The aliphatic acid anions of formation waters in zone 1 (subsurface temperatures $<80°C$) are characterized by concentrations less than 60 mg/L and consist predominantly of propionate. The concentrations of acid anions in zone 2 (temperatures 80 to 200°C) are much higher (up to 4,900 mg/L) than in zone 1 and decrease with increasing subsurface temperatures and age of their reservoir rocks; acetate forms more than 90% of the total anions. No acid anions are present in zone 3 (temperatures $<200°C$) or in formation waters from Triassic rocks. Microbiologic degradation of acetate and dilution by mixing with meteoric water most likely explains the composition and concentration of acid anions in zone 1. The trend in zone 2 and the absence of acid anions in zone 3 and Triassic rocks are explained by thermal decarboxylation of these anions as in the reaction: $CH_3COO^- + H_2O \rightarrow CH_4 + HCO_3^-$.

The aliphatic acid anions mainly result from the thermocatalytic degradation of kerogen. We believe that these anions, which are highly soluble, are produced