

and a small percentage of planktonic Foraminifera. *Globorotalia fohsi*, *G. mayeri*, *G. menardii*, and other planktonic species are sinistrally coiled. The change from random to predominantly sinistral coiling coincides approximately with the inception of Harang deposition ( $\pm 12-14$  m.y. B.P.). The faunal assemblages indicate a muddy-water, outer neritic to bathyal environment, and suggest a cool water mass. The apparent anomaly of a cold-water fauna in this stratigraphic position in this area might be explained by upwelling, paleogeographic changes, and/or significant Miocene refrigeration.

During the time span that includes Harang deposition, continental glaciation in Antarctica, cold-water invertebrate faunas, cool-climate floras, and other evidences of cool climate in many parts of the world indicate mid-Miocene refrigeration. Although some conflicting evidence also exists, we conclude that the distinctive characteristics of the Harang biofacies are related to a cool water mass which was part of a worldwide cooling phenomenon.

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Recent work in the Canadian Cordillera has led to the formulation of several models for its tectonic evolution. These models can be tested by relating the structural evolution of the crystalline core zones and fold belts to the depositional record of the orogenic foredeeps and successor basins. They require a comprehensive understanding of paleodrainage. The arcuate geometry of orogenic belts places the principal structural constraint on the evolution of late orogenic drainage patterns. Like other mountain belts, the two orogens of the Canadian Cordillera (Pacific orogen in the west, Columbian orogen in the east) consist of a chain of structural salients and reentrants. During the growth of folds and thrust faults, the structural reentrants constituted the shortest connection between the rising core zones and the subsiding foredeeps and successor basins. Streams issuing through the reentrants, therefore, were the first to capture the longitudinal drainage which evolved during the growth of the fold belts and became the most important suppliers of clastics to the late-orogenic basins. This "reentrant principle" can be illustrated on a regional tectonic scale with the Peace, Liard, Eagle Plain, and Chukachida reentrants of the Columbian orogen. Local examples are used from near Crossnest Pass, the Spatsizi Plateau, and the Fraser River. From the structural salients, predominantly small, though locally vigorous, streams issued directly into the late orogenic basins. Therefore, simple straight drainage lines connecting source areas and clastic basins were probably valid only for the earliest stages of uplift in the Canadian Cordillera. Later growth of folds and thrust faults produced curved or even U-shaped river systems, which merged near reentrants and effected thorough mixing of compositionally diverse sediment loads.

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#### RELATION OF INVERTEBRATE DEATH ASSEMBLAGES TO LIVING BENTHIC COMMUNITIES IN RECENT CARBONATE SEDIMENTS ALONG EASTERN YUCATAN COAST

The fidelity of the fossil record for paleoecological studies often is questioned. This investigation attempted to determine how well communities of living benthic organisms are represented by the assemblages of dead remains accumulating in the sediment, i.e., future fossil assemblages.

Fifty quantitative samples were collected with a diver-operated suction dredge from various shallow-marine environments near Isla Cancun and Isla Contoy, Quintana Roo, Mexico. Virtually all the geologically preservable megafaunal remains in the sediment consisted of mollusks, and 290 molluscan species were identified in the samples. Although nearly three fourths of

the species were collected only as dead shells, almost all live individuals were represented by dead shells of their species in the same sample.

A series of Q-mode and R-mode cluster analyses, utilizing 5 different similarity coefficients and data based on the presence or absence and relative abundances of species, demonstrates that the same general associations of samples and organisms occur, whether living animals or dead remains only are considered. Chi-square association tests between pairs of samples collected 5 m apart reveal that the death assemblages in both samples of each pair are similar, whereas the living communities are not.

The death assemblages apparently reflect the in-place accumulation of remains of living benthic communities during sedimentation as patchily distributed populations of organisms migrate across the bottom, leaving a record of their mortality behind them in the sediment.

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#### CHANNELIZED SUBMARINE CARBONATE-DEBRIS FLOW, CRETACEOUS, MEXICO

Carbonate platforms, fringed by rudistid reefs, rose to more than 1,000 m above contemporaneous basinal carbonates in the middle Cretaceous of central Mexico. The platforms are surrounded by halos of debris forming wedges which extend as much as 5-15 km from the platform margin. An exception to the wedge morphology is a breccia-filled channel exposed in section perpendicular to the paleoslope, 1 km from the marginal escarpment of the El Doctor platform, Querétaro, Mexico.

The main part of the channel deposit is 225 m wide and 16 m thick. Breccia clasts are 75% basinal components (pelagic limestone and chert) and 25% platform derived. The bedded clasts form flat plates up to several meters in maximum dimension. A few clasts are deformed, indicating that they were at most slightly lithified and presumably of low density; nevertheless, most are neatly stacked with little distortion. Unstable clast postures, with long axes approaching normal to bedding, and imbrication are common. Content of dolomitized muddy matrix is low; the deposit is grain supported.

The morphology of the breccia deposit and truncation of pelagic limestone at the channel edge demonstrate erosional competence of the depositional mechanism. Locally in the channel base an incipient slump of slightly folded pelagic limestone and chert indicates slope instability and suggests a mechanism for incorporating basinal carbonates in the breccias. In the top few meters of the deposit, breccia grades upward into fine-grained, skeletal-fragment packstone, which extends several hundred meters beyond the channel limits as thin, graded bed. At least 3 episodes of channel fill are suggested by internal structure.

This evidence places the following constraints on the depositional process—high competence (large clasts, erosion), high viscosity (unstable clast postures), low turbulence (slight deformation and platy form of unconsolidated clasts), high clast concentration (grain support, clast interaction) and channelization (form of deposit, multiple episodes). A high velocity submarine debris flow is suggested. The nonchannelized part of the last depositional episode is a typical turbidite.

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#### DISCOVERY AND DEVELOPMENT OF SAWTELLE OIL FIELD, CALIFORNIA

No abstract available.

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#### QUANTITATIVE PETROLOGY AND DEPOSITIONAL ENVIRONMENTS WITHIN ESSENTIALLY ISOCHRO-