allite patterns as "fabricational noise" while ignoring any possible phylogenetic constraints. This study rephrases the question of the adaptational significance of fossil corallite patterns.

The set of all possible two-dimensional mosaics of regular, identical polyhedra consists of triangular, square, and hexagonal nets, and thus represents a simple *constructional* constraint on pattern in a developing or evolving colony of anthozoan polyps. A regular hexagonal pattern of corallites possesses the utmost possible reduction of surfaces in contact by way of equal-angle triple junctions. This makes a regular hexagonal array to be ideally most efficient. However, most polygonal patterns of corallites deviate from this ideal with a particular pattern often being characteristic of a taxon. For example, a less efficient, irregular pattern may be common for one particular group (e.g., *Eridophyllum*) but a regular hexagonal array for another (e.g., *Hexagonaria*). This deviation from ideal form leads to the recognition of a second, *phylogenetic* constraint on corallite pattern.

The significance, constructional versus phylogenetic, of pattern development can be better understood by also considering the ontogeny of individual corallites in a colony which shows a hexagonal array. Within the continuum of varieties of colony patterns, polygonality first appears in cerioid forms. Transitional phaceloid/cerioid colonies of the Lithostrotionidae demonstrate that corallite centers do not closely approach one another until their margins are actually in apposition. It is at this stage of margin contact that hexagonality is achieved, not at the onset of close packing.

Hexagonality in fossil anthozoans is concluded to have probably first arisen in cerioid colonies as an adaptation to maintain and further a higher level of colony integration.

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Economics of Scale Versus Completion Risks, Cottonwood Wash Oil Shale Project, Uinta Basin, Utah

The major problem plaguing the synfuels industry is the financing of large capital requirements in a technologically unproven field. This is exemplified by the two to three billion dollar investment required by oil shale development. Despite an unquestionable resource which is well characterized and a wealth of information from processes which have undergone extensive pilot development work, financing of a project is difficult because of the risk.

In recent studies on a worldwide basis as a background for evaluating the Cottonwood Wash Project in the Uinta basin, Utah, we have shown that the concept of small scale or modular development of this type of resource can lead to acceptable economics with a substantially higher probability of actual completion. This small scale or modular system approach may be applied to other synfuel developments.

This paper discusses Uinta basin oil shale resources and current developments and evaluates the economics of small scale or modular development for the Cottonwood Wash Project processes. This evaluation shows the effects of such a development in reducing the project's economic and technical risks.

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Countess Oil Field, South-Central Alberta, Canada: Case History in Finding a Stratigraphic Trap

The Countess field produces oil and gas from zones in eight geological formations from the Upper Cretaceous Belly River to the Mississippian Pekisko. The principal producing zones are the Lower Cretaceous Glauconitic and Ostracod (Mannville) Sandstones, at an average depth of 1,097 m (3,600 ft). These zones were deposited as offshore sandstone bars on submarine topographic highs, caused by underlying Pekisko cuestas. The bars are encased in marine Mannville shales. The sandstones are gray to brown, fair to well-sorted and subrounded to rounded. Porosities average 22%; permeabilities average 580 md. Reservoir thickness averages 9.75 m (32 ft). The productive sandstones cover approximately 4,243 hectares (10,500 acres). The reservoir contained approximately 34,136,000 cu m of oil (215,000,000 bbl) of which approximately 12,288,000 cu m (77,300,000 bbl) or 36% will be recoverable. In addition, the reservoir contained 3,826,000,000 cu m of gas of which 60% or 2,295,000,000 cu m (81,500,000,000 cu ft) will be recoverable. Other formations will produce 32,980,000,000 cu m of gas. Twelve dry holes, drilled prior to November 1965, a drilling density of 1.7 wells per township, indicated the probable presence of this stratigraphic trap. A wildcat drilling program of 34 wells was designed to explore the seven townships. Three of the first four exploratory wells were dry. One was a discovery. Finally, seventeen of the exploratory wells were successful and seventeen were dry. The statistical exploration method, an adequate number of wildcat tests, for this large geographical area resulted in the ultimate exploratory success.

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Gulf of Alaska: A Cold Bath

The Gulf of Alaska continental shelf has proven to be one of industry's major disappointments in hydrocarbon exploration during the last decade. Eight of the nine major structures leased for 560 million dollars in the 1976 OCS Sale 39 have been drilled without finding commercial hydrocarbons. Thermal immaturity of the potential source rock, extreme depth of as yet untested potential reservoirs, and problems caused by overpressured shales have all contributed to the lack of success.

Stratigraphy and structure are the result of the northwestward movement of the Gulf of Alaska microplate. Movement is primarily in conjunction with the Pacific plate although there is minor oblique subduction beneath it. Progressive deformation from the northwest toward the southeast is the result of collision with the North America plate. OCS Sale 39 was located in the area of growing anticlines and active deformation. OCS Sale 55, held in 1980, and the subsequent reoffering sale in 1981 were on the relatively undeformed southeastern part of the plate. Prospective horizons in this area lie at much shallower depths, but the lack of significant structures and unknown thermal maturity of the source rocks tend to downgrade prospects in the area which is untested to date.

MCCRACKEN, WILLARD A., Texaco USA, Bellaire, TX

Recognition of High Gradient Braided Stream Deposits, Sespe Formation (Tertiary), Ventura Basin, California

Lower Sespe arkosic sandstones and petromictic conglomerates of late Eocene and Oligocene age rim the Ventura basin in California and are interpreted as high-gradient, braided river deposits. Lower Sespe deposits contain a high ratio (over 20/1) of bedload/suspended load. Lenticular, poorly sorted, imbricated, bar-shaped conglomerate units interbedded with graded to parallel-laminated sandstone beds are typical of lower Sespe deposits. Graded and reverse graded conglomerate units, graded sets of avalanche cross-stratification, cuspate cut-and-fill structures, and antidune cross-stratification also characterize the lower Sespe conglomerate facies. These features all indicate a braided stream model for lower Sespe deposits.

Steep gradients during lower Sespe deposition are suggested by: (1) clast size data (average maximum clast size = 41 cm), (2) a predominance of upper flow regime structures (85% of all structures measured), and (3) high consistency ratios (mean consistency ratio = 0.78) of paleocurrent data.

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Eustatic Sea-Level Control of Silurian (Niagaran) Reefs, Michigan Basin

Eustatic sea-level changes controlled Niagaran reef and off-reef facies and eogenesis both in the Michigan basin and on the adjacent platform, as shown by surface (Thornton, northeast Illinois; Pipe Creek Jr., central Indiana) and subsurface reef studies (Onandaga, south Michigan). We recognize four stages of development defined by alternating highstands and lowstands of sea level. (1) During Llandoverian-Wenlockian time, a highstand resulted in growth of reefs with 10s to 100 m depositional relief with a basal stromatactis mudstone facies capped by volumetrically dominant crinoidal wackestone to grainstone-coral boundstone facies. Reef growth was below wave base and was characterized by extensive submarine cementation. (2) A relative fall of sea level in the late Wenlockian caused a saline brine to develop in the restricted Michigan basin, halting pinnacle reef growth and resulting in A-1 Evaporite deposition and anhydrite replacement of reef fossils and sediment. This fall of sea level did not expose the shelf or bring reef tops above wave base. It may be expressed in the surface reefs as distal megabreccias containing normal marine stromatoporoid-coral-*Renalcis* fauna and in the subsurface reefs (basin) by a hiatal break. (3) A Ludlovian-Pridolian highstand resulted in basinal reef rejuvenation (stromatoporoid-algal boundstone facies and followed by the stromatolite facies) and dissolution of replacement anhydrite. The deep-water basinal A-1 Carbonate was deposited at this time. (4) A subsequent lowstand (Pridolian?) resulted in basinal hypersalinity, cessation of pinnacle reef growth, and A-2 Evaporite deposition.

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Canadian "Deep-Water" Carbonate Deposits: Distinction from "Analogous" Siliciclastic Deposits and Their Hydrocarbon Potential

"Deep-water" carbonates accumulate by gravitational processes which have many similarities to, but important differences from, those responsible for "analogous" siliciclastic deposits. For example, recently there has been much emphasis on the accumulation of "deep-water" siliciclastics in submarine channel-fan complexes. In contrast to this type of point source origin, carbonate basin slopes are mainly the result of processes from shelf and slope-centered linear sources, and processes from basin water-mass-centered area sources. The resulting carbonate slope accumulation is most commonly a debris apron which has a geometry and petroleum potential that is distinct from a fan.

Much of the worldwide petroleum interest in deep-water carbonates is in chalks which in the last 100 million years have become the major type of deep-water carbonate accumulation. However, in Canada almost all of our major deep-water carbonates are Paleozoic or older and, therefore, we are confronted with mainly hemipelagic slope deposits and peri-platform talus. There will be no new advances in understanding the process of accumulation of these latter types of basinal carbonate deposits until the premise that the processes and their resultant deposits are identical to those responsible for similar siliciclastic deposits is examined critically. An understanding of the obvious differences, combined with recognition of interactions between carbonate processes and process sets and of the factors that modulate carbonate process systems, leads to a more realistic understanding of the resulting "deep-water" facies and the physical and chemical controls on diagenesis.

The spectrum of Canadian deep-water carbonate basinal slope deposits which will be discussed cannot be integrated into one single model. Four major depositional facies models will be presented which are dependent on the nature of the adjacent margins (by-pass versus depositional) and type of margin sediment (reef versus lime sands). These models can be distinguished as separate seismic facies. Still other models are possible, underlining both the complexity of this type of carbonate accumulation and the challenge involved in its exploration, especially in the frontier areas.

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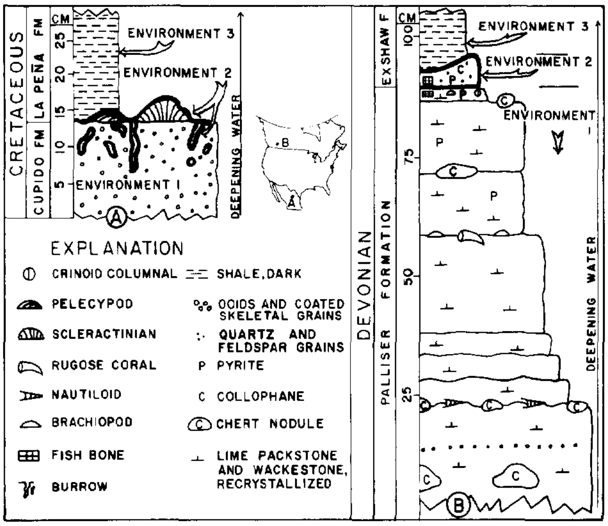
Comparison of Two Enigmatic Contacts: Palliser-Exshaw, Devonian, Southwestern Canada, and Cupido-La Pena (Cretaceous), Northeastern Mexico

In both the Palliser-Exshaw and Cupido-La Pena sequences, uncommonly sharp contacts separate carbonate bank deposits from overlying dark shales. Three environments discernible in each sequence may be attributed to gradual deepening of water during detrital influx.



At Potrero de la Mula, Coahuila, the uppermost Cupido consists of poorly sorted, oolith lime grainstones (environment 1). Abundant filled scolecoid burrows 1 to 2 mm in diameter extend 8 cm down into the Cupido from the iron-stained upper surface on which occur gastropods, pelecypods, and unabraded, hemispherical scleractinian colonies (environment 2). Dark shales of the La Pena Formation (environment 3) rest on this surface. Environment 1 was an active shoal with a shifting substratum which may have been stabilized as a result of deepening water (environment 2) permitting occupancy by corals and small burrowers. Bypassing prevented sedimentary accumulation except for