the stratigraphic column as a thin sheet sand with local variation in internal physical and biogenic sedimentary structures. Overall bed-form orientation would be slightly flood dominant, and the flood-tidal delta sands would be sealed on top and bottom with fine-grained, organic-rich sediments. Modern flood-tidal deltas are excellent sources for beach nourishment projects and, given sufficient burial, ancient flood-tidal deltas could make good petroleum reservoirs.

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Sedimentology of Quartzose Sandstones of Lower Mannville and Associated Units, Medicine River Area, Central Alberta

Quartzose sandstones of the lower part of the Mannville Group in east-central Alberta are generally referred to as the Ellerslie Formation (Member). They are considered to be the deposits of a Lower Cretaceous fluvio-deltaic complex which overlies the "Pre-Cretaceous" unconformity in western Canada. In west-central Alberta, other quartzose sandstone units can be present beneath the Ellerslie. Some workers have included these units within the Mannville, others have attempted to map them separately. The result has been general confusion.

The trend and origin of different sandstone bodies can be compared in the Medicine River area. Here, two unconformity-bounded units—the UJ2 and UJ3 of Ter Berg (1966)—fill a deep valley cut into Lower Jurassic and Mississippian strata, and are overlain by the Ellerslie.

Ellerslie sediments blanket the area and are productive from quartzarenites in a number of isolated pools. Productive sandstone bodies encompass a variety of small estuarine, shoreline, and tidal ridge deposits, none of whose trends relate to the configuration of that old favorite, the eroded surface of underlying Mississippian strata.

Comparison of quartzose sandstone units in the Medicine River area with similar sandstone units elsewhere in Alberta, Saskatchewan, and Montana, indicates that the Ellerslie was deposited in a vast inland sea into which several large deltas prograded. UJ2 and UJ3 sandstones are similar to those of the Success and Morrison formations of Saskatchewan and Montana, respectively.

Similar sandstone deposits can be anticipated along the eastern margin of the Alberta trough, in south and central Alberta. Where quartzarenites are present, they will have resisted diagenetic porosity destruction, and will form attractive reservoirs.

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Niton Field: An Estuarine Sandstone Reservoir

The Niton field is a classic stratigraphic trap caused by the updip migration of hydrocarbons along a gentle southwesterly regional tilt (50 ft/mi, 9.5 m/km) into reservoir sandstones of the Basal Quartz Formation. These reservoir sandstones were deposited during the Late Jurassic to Early Cretaceous transgression over an unconformable surface on Jurassic sediments. As sea level rose, the topography on the unconformity gave rise to a number of tide-dominant estuarine valleys, 3 to 5 mi (5 to 8 km) wide at their mouths.

Two major factors related to this depositional setting exerted the greatest control on the distribution of Basal Quartz reservoir potential sandstones in the Niton field. (1) The topography of the unconformity governed the lateral extent of estuarine sand bodies deposited during the transgression. Maximum thickness of the sand bodies occurs either (a) along the long axes of paleovalleys, or (b) at entrances to the paleovalleys. (2) Diagenetic patterns of cementing were related to the original environments of deposition. The occurrence of swamps on the topographically high areas generated acidic ground waters which leached carbonate and silica from underlying sediments. This leached material was reprecipitated as silica cements in sediments overlying topographic highs and as calcite cements in tidal-flat sequences of the estuary fringes. These cements reduced porosities and permeabilities sufficiently to produce updip and capping seals to reservoir sandstones. Open marine sandstones deposited at the mouths of estuaries were only lightly cemented and, therefore, became the primary reservoir sandstones.

By comparing the depositional setting of the Niton area with modern analogs along Holocene transgressive coastlines, it is apparent that similar stratigraphically controlled sandstone bodies should exist along depositional strike in other drowned estuarine river valleys.

Thus, by comprehending the depositional and diagenetic setting of the Basal Quartz Formation, the energy explorationist has a predictive tool that can be used to discover new areas of reservoir potential sandstones.

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How to Improve Your Exploration Success Ratio: A Case Study

This paper stresses the importance of integrated studies utilizing all available data and is intended to show how we can learn from experience. It can be demonstrated through studies of 51 producing fields in offshore Louisiana that in some places wildcat wells were not optimally located, thereby resulting in dry holes. By applying this experience, we can avoid unnecessary dry holes, extend our fields, and discover additional fields.

Field studies determined the type of traps present, the timing of the traps, and where seismic hydrocarbon indicators appear to work. Integrating these field studies with other studies and evaluations reveals that we must not only have detailed seismic control and use the latest technology, but also thoroughly evaluate and integrate the geologic and geophysical data if we expect to be successful in our drilling program. In this regard, we must use technology such as True Amplitude Recovery seismic data, waveform analysis, and modeling, as each could contribute to our exploration program. Examples, compiled to support this statement, reveal that in selected cases the locations of wildcat wells were not optimally located and so resulted in dry holes, although they could be considered near misses. In other cases, it was found further development of fields may be possible if the drilling of outpost or field extension wells would occur. To help avoid these dry holes, discover additional fields, and extend existing fields, a suggested exploration program is submitted.

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Influence of Grain Size and Thermal Maturity on Intergranular Pressure Solution and Quartz Cementation in a Quartz-Rich Sandstone

Detailed cathodoluminescent petrography and scanning electron microscopy reveal that grain size and thermal maturity have significantly influenced intergranular pressure solution and quartz cementation in the quartz-rich Hartshorne Sandstone of the Arkoma basin. Mean grain size of Hartshorne sandstones ranges from very fine to medium-grained. In any stratigraphic section, a negative, linear relationship exists between grain size and volume of silica dissolved via intergranular pressure solution. In contrast, either a positive, linear relationship or no significant relationship

exists between grain size and volume of quartz cement. These relationships indicate that silica was selectively dissolved via intergranular pressure solution in finer grained sandstones and that, at least locally, quartz cement was selectively precipitated as overgrowths on detrital grains in coarser grained sandstones. Little primary porosity is preserved in the pressolved, finer grained sandstones, whereas appreciable primary porosity may be retained in coarser grained sandstones that contain more quartz cement.

These relationships are also sensitive to thermal maturity, which increases eastward across the basin. This thermal trend is probably related to elevated temperatures associated with intrusions in as much as maximum burial depth of the Hartshorne decreases eastward. As thermal maturity increases, more intergranular pressure solution is evident for a given grain size whereas the volume of quartz cement does not change significantly. Thus, primary porosity tends to be preferentially preserved in areas of lower thermal maturity.

In areas of higher thermal maturity, the sandstones have lost more silica via intergranular pressure solution than has been precipitated as quartz cement whereas the opposite is true in areas of lower thermal maturity.

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Depositional Facies of Cretaceous Spring Canyon Member, Blackhawk Formation, Book Cliffs, Utah

Facies study of the Spring Canyon Member indicates a shoreline characterized by beaches and river mouth bars. We envision the wave-affected river mouth bars building seaward and furnishing sediment to the downdrift, protected beaches. The beach sequences are characterized by a shoreface containing laminated-to-burrowed beds overlain by cross-bedded sands and a foreshore of parallel laminated sand. In contrast, the river mouth bar sands are hummocky bedded.

Associated transitional marine facies include channel-fill, splay, levee, swamp, and bays containing coal deposits. Three principal coal seams within this facies are related to the three Spring Canyon beaches. The lower two formed in a delta plane. The upper coal is associated with a marginal marine sheet sand. Low sulfur content, roots, plant remains, and continuity of coal seams suggests in-situ coal deposition in swamps flanking channels. Paleocurrent directions within most channels indicate a landward flow perhaps due to storm surges or flood tidal effects. The transitional facies contains abundant marine indicators including oyster shells, terrido borings, *Ophiomorpha,* and holes excavated by rays.

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Paleo-Oceanographic Significance of Cretaceous and Cenozoic Diatomites Along Eastern Pacific Margin

Diatomaceous mudstones and laminated diatomites punctuate the upper Mesozoic and Cenozoic marine sequence of California. These largely bathyal deposits provide a clear record of upwelling, primary productivity, and development of oxygen minima along the eastern margin of the North Pacific Ocean during the past 80 million years. Marine diatomites exposed in uplifted continental margin sequences in California include the uppermost Cretaceous Marca Shale Member of the Moreno Formation, the middle and upper Eocene Kreyenhagen Formation, and the middle to upper Miocene Monterey Shale. All three of these deposits contain pelletal or nodular phosphorite and represent fossil analogs of various Recent basin plain, slope, and outer shelf settings in which organic-rich diatomaceous sediments are currently accumulating beneath the well-developed oxygen minimum layer of the marginal eastern Pacific. Moreover, each of these units forms a known or potential source rocks for hydrocarbons in this region. The deposition and preservation of Cretaceous, Eocene, and Miocene diatomites along the California margin each demand: (1) a period of intensified upwelling, primary productivity, and associated development of oxygen minima via climatically induced accelerations of atmospheric and oceanic circulation; (2) coincident reductions in the flux of terrigenous clastic material to the continental margin through eustatic and/or tectonic adjustment of adjacent strandlines and pathways of sediment distribution; and (3) tectonic production of appropriate continental margin depocenters. Each diatomaceous unit can be correlated with a major climatic event or threshold associated with increased polar refrigeration, resultant increases in the pole-to-equator thermal gradient, compression of middle and low latitude surface circulation, and associated intensification of upwelling and siliceous productivity.

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Predication of Organic Maturation Levels: Scotian Shelf

Recorded maximum bottom-hole temperatures may vary significantly from true formation temperatures. Circulation time and time since circulation are important variables in estimation of equilibrium bottom-hole temperatures. A theoretical temperature correction technique incorporating these factors was applied to well log-heading data to compute 191 static temperatures for 64 wells in the Scotian Shelf. A linear regression, performed on 140 computed temperatures produced an average geothermal gradient of 2.66°C/100 m; correlation coefficient 0.97. A geothermal gradient map constructed from the corrected data shows that areas of thicker sediment accumulation are marked by thermal highs (e.g., Abenaki, Sable subbasins), whereas areas of shallow basement coincide with thermal lows (e.g., LeHave Platform, Canso Ridge).

A technique for calculating maturation level of organic matter based on Lopatin's method and corrected bottom-hole temperatures was developed for the Scotian Shelf. A geologic model is constructed by superimposing a temperature grid on burial history curves. From this, TTI (Time-Temperature Index) values are derived which give the maturity level for specific sedimentary horizons. A comparison of 47 calculated TTI values with vitrinite reflectance measurements for 13 wells established a calibration of this technique for the Scotian Shelf. A correlation coefficient of 0.96 was obtained for the relation, log TTI = 6.7367 log Ro + 2.7317. This particular calibration of TTI is probably valid only for the Scotian Shelf since tectonic age and history play a role in the calibration. The procedure of calculating TTI values is readily adaptable to a computer since a standard approach is followed for every well.

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Initiation of Salt Flow, East Texas Basin

Salt structures constitute five domains subparallel to the basin margin and the Louann Salt updip limit: (1) thin ( < 340-640 m) planar salt wedges at the margin; (2) low-amplitude periclinal salt pillows (mother salt 550-625 m thick); (3) intermediate-amplitude elongated salt anticlines separated by synclines evacuated of salt