

feldspathic, chaotic conglomerate/slate mixtures associated with graded-stratified conglomerates, dispersed and massive pebbly sandstones, and sandstone turbidites. Paleocurrents are toward the north-northwest. Conformably overlying these beds are quartzose cross-stratified sandstones (possibly Gog Group) consisting of facies: (1) trough cross-stratified conglomerate and sandstone; (2) graded swaley-or-hummocky cross-stratified conglomerate; and (3) isolated trough cross-stratified sandstone sets in shale. Paleocurrents are toward the east-southeast. Miette beds were deposited on a slope, possibly within a submarine canyon. These beds record deposition near a shelf break, possibly with storm influence.

In the western Kicking Horse Pass, quartzose Gog sediments belong to Facies 1-3, and (4) small-scale trough cross-stratified quartzite; (5) planar cross-stratified quartzite; (6) very low angle to horizontally stratified quartzite; and (7) shale. Absence of desiccation features and abundance of horizontal trace fossils suggest a shallow, sublittoral marine setting.

Overall cyclicity consists of the following units upsection: (a) Facies 1, 3, 4, and 7 with unidirectional west-southwesterly paleoflows; (b) Facies 5 with bimodal paleoflows; (c) Facies 1, 4, and 3 with unidirectional westerly paleoflows; (d) large scale epsilon cross-stratified quartzites; and (e) Facies 6 with bimodal to random paleoflows. This sequence may represent shoaling-up from offshore dune and bar complexes with alternating oceanic current (sequences a and c) or tidal (sequence b) influence. Above are lateral accretion deposits due to migration of a spit or ridge (sequence d), topped by high energy nearshore deposits (sequence e).

Paleoflow patterns are complex, suggesting that sediment dispersal was not simply a westerly prograding clastic wedge.

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Discriminant and Cluster Analysis as Statistical Aids in Stratigraphic Correlation

Stratigraphic interpretation has largely been done by geological, geophysical, and well-logging techniques. Statistical analysis of geophysical and well-logging data has been rather well accepted during the past 10 to 20 years. Analysis of geochemical data has only been recently accepted as a technique that aids in correlation and interpretation of other stratigraphic problems.

Two statistical techniques which have proven useful in stratigraphic or other types of geological interpretation have been cluster and discriminant analysis. These techniques are generally regarded as investigative tools. However, they can also be used in a predictive sense. This is particularly true of discriminant analysis. In both techniques, one allows the observed data to describe the similarity of formations, produced fluids, or some other measure of interest. These statistical methods have been applied using oil or water chemistry, well-logging data, and various reservoir parameters to solve stratigraphic problems or support a hypothesis. These techniques have been used successfully to recognize bypassed oil, sedimentary environments of deposition, miscorrelated horizons, and erroneous data.

In this paper, several case studies are presented that involve cluster and discriminant analysis to establish or substantiate hypotheses about reservoir continuity. These include one North Sea field, one Middle East field, and one domestic reservoir. A model which was previously proposed is further extended; this model will distinguish whether a produced water has been in contact with either oil or gas.

These techniques can be advantageous in planning future exploration strategy.

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Upper Mannville "Glauconic" Channels, Little Bow Area, Alberta: Geologic Models for Seismic Exploration

Large channels in the Glauconic interval of southern Alberta have proved to be elusive exploration targets owing to the discontinuous nature of reservoir sands. In the Little Bow area, a 20 m deep channel has been cut through sandstones and shales of the Glauconic interval and limestones and shales of the underlying Ostracod Zone. Mineralogy, texture, and geometry of the channel sands are distinctly different from those adjacent to the channels.

The montmorillonitic Bantry Shale of the Ostracod Zone is an excellent regional marker and is absent only where it has been cut out by a channel. Sediments of the Glauconic interval, which conformably overlie the Bantry Shale, were deposited in a broad, shallow subtidal marine bar system. The marine bars are tabular sand bodies only a few meters thick, and are composed of low porosity fine to medium-grained, calcite and clay cemented chertarenites.

The incised channel system contains 20-m thick point bar accretion sets and shale plugs. Point bar sands are porous medium to coarse-grained sublitharenites with high angle cross-stratification. Sand bodies are discontinuous along the length of the channel, and the channel margins are abrupt.

Geologic exploration for these discontinuous channel sands is difficult and high resolution seismic data integrated with sound geologic modeling is critical for successful prospect delineation.

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Hydrodynamic Control of the Present and Mid-Tertiary Regional and Local Geothermal Gradients, Alberta, Canada

The Upper Devonian Woodbend Group and Beaverhill Lake Formation of Alberta contain numerous crude oil and natural gas occurrences in several carbonate reef chains, which are hydraulically distinct with small but subtle differences in present reservoir temperature. Regionally, these hydrocarbon occurrences exhibit typical trends from immature gases in the shallower pools, sometimes associated with biodegraded crude oils, to deeper mature crude oils. Examination of the composition of the natural gases and the broad general characteristics of the crude oils suggests that there is imposed on these typical maturation trends differences in the fluid compositions and reservoir temperatures which are related to the different hydraulic systems and the position of each system within the low fluid-potential drain which essentially channels flow within the thick sequence of highly permeable Upper Devonian and Carboniferous carbonate rocks in the medium-depth part of the Alberta basin.

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Estimation of Organic Maturation from Seismic and Heat-Flow Data

A technique using seismic and heat-flow data was developed to estimate organic maturation level and timing of oil generation.

This technique of linking geochemistry and geophysics is especially valuable in pre-drilling evaluation of hydrocarbon potential in frontier or difficult areas where well data are not