m of the Gates Formation in northeastern British Columbia. The basal Notikewan is a thin pebbly transgressive lag deposit overlying carbonaceous nonmarine shales, sandstone, and locally conglomerates of the Gates (Falher equivalent). Overlying the transgressive lag is a 5 to 10 m fining-upward transgressive phase of interbedded sandstone or conglomerate and shale. The sandstones are hummocky cross-stratified and the conglomerates are molded into symmetrical gravel dunes (both features indicate storm processes were common during the transgression). The regressive phase is a 20 to 30-m coarsening-upward sequence showing much less evidence of storm influence. Locally 10 to 20 m thick sandstone channels cut through the shoreline into marine sediments. The precise location of the shoreline is generally difficult to pick, unlike in the underlying Falher cycles. Specimens of *Ostrea* above the channel sandstones suggest a brackish-water depositional environment. The *Ostrea* are a good local stratigraphic marker in the Bullmoose Mountain area, in some places forming banks. Sedimentary structures in interbedded sandstones, siltstones, and shales, and reversing paleoflow directions suggest a low-energy shoreline dominated by tidal flat and, possibly, estuarine processes. Paleocurrent data indicate that shoreline orientation was generally east-west. This is in marked contrast to the high-energy wave dominated shorelines of the Fahler. The upper 20 to 30 m of the Notikewan is nonmarine floodplain and overbank deposits with thin ($<1$ m) coals, lagoonal shales and siltstones, and rare channels.

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## Reef Exploration in Michigan Basin: Problems and Solutions

The integration of all aspects of geology with geophysics is necessary in any stratigraphic exploration program. The Niagara (Middle Silurian) pinnacle reef play in the Michigan basin provides interesting insights into this multifaceted problem.

The Michigan basin is an intracratonic structural basin which has been in existence at least 500 million years. During Niagaran time, tall (up to 700 ft, 213 m) hydrocarbon-bearing pinnacle reefs grew on a ramp or shelf between a deeper basinal area and a nonproductive basin-rimming barrier reef bank. These pinnacle reefs are encased in Salina (Upper Silurian) evaporites and carbonates that effectively act as both seal and source for the hydrocarbons.

Geological studies of Niagara and Cayugan paleogeography and regional stratigraphy combined with detailed lithofacies have aided in the mapping of the pinnacle reef trends and the identification of local reef proximity indicators.

Today, seismic data is the major exploration method for actually locating the pinnacle reefs, but major problems had to be overcome before it was an effective tool. Surface topographic features (such as glacial moraines and sand dunes) plus buried preglacial valleys caused severe statics, velocity, and "noise" problems. Judicious application of good basic data processing procedures with particular attention paid to statics corrections, velocity analyses tied to well control, and f-k filtering, commonly solve these data processing problems.

Even though shooting geometry has been optimized to reduce "noise," reflections are often the third or fourth strongest mode on a field record with mode converted shear waves, refractions, multiples, and wave-guided phenomena being stronger. F-k filtering, following the principle of reflection mode amplification (introduced herein), can substantially enhance the signal to noise ratio (reflection to nonreflection ratio).

The variable distribution of the Salina evaporites and carbonates and their irregular solution margins can, however, in places, produce reeflike seismic anomalies. By careful geologic mapping with close attention to facies and lithologic detail and by using simple seismic modeling, the differences between pseudo-reef anomalies and actual reef anomalies can often be distinguished, and the presence of seismic reef proximity indicators can be confirmed with a high level of confidence. The 70% and greater wildcat success ratios maintained consistently by several companies which has allowed them to lead in the exploration of the trend are ample testimony to this.

The final results of careful attention to geologic detail during the entire geophysical analysis, from field acquisition through interpretation, are not only accurate and detailed seismic stratigraphic interpretations, but also cost-effective exploration programs.

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## Limitations of Rock-Eval Pyrolysis Assay to Characterize Kerogen

Rock-Eval is a useful new tool to study sedimentary organic matter by pyrolysis and determination of hydrocarbons and $CO_2$. Certain interpretive and operational aspects of the Rock-Eval technique, however, need to be carefully considered. Rock-Eval $S_2$ peak or Hydrogen Index (HI = $S_2$ normalized to organic carbon) is obtained by the flame ionization detector (FID) that responds to carbon-hydrogen bonds, carbon electrons, and carbon mass; thus, the FID response is very nearly the same to benzene, hexane, and six molecules of methane, but the atomic H/C of these molecules varies by a factor of 4. A further problem with the assumption that HI is proportional to H/C is that Rock-Eval does not measure either $H_2$ or $H_2O$, both of which are important pyrolysis products. Despite this, Rock-Eval HI is commonly correlated empirically with atomic H/C. Similarly the Rock-Eval oxygen index (OI) measures $CO_2$ but not $H_2O$ or CO, which are important pyrolysis products. The OI is commonly correlated empirically with atomic O/C. The fact that these two correlations exist probably is due partly to regularities in the pyrolysis mechanisms of kerogen and partly to a predominance of methane from type III kerogen, which accentuates the low HI. These factors are the reason that the HI versus H/C and OI versus O/C plots do not go through the origin but intercept the H/C axis at 0.45 and O/C axis at 0.04. Incorrect classification of kerogen types or interpretation of diagenetic history can result from these OI and HI variations from actual O/C and H/C measurements. Examples of kerogen incorrectly classified as type I and confused evolution paths are documented.

Rock-Eval should be most successful on core samples containing organic matter of relatively uniform composition. Analysis of recent samples, outcrop samples, or a single sample should not be used for unqualified interpretation of kerogen type or evolution path, but it may give useful organic richness and maturity information.

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## Application of Depositional Modeling to Coal Exploration, Green River Basin, Southwest Wyoming

Data from over 1,400 coal exploration drill holes, 21 measured sections, and 90 deep mine maps, in conjunction with cursory examination of oil and gas logs and seismic sections, have been used to reconstruct the depositional settings of the Rock Springs Formation in the Green River basin.

From examination of approximately 20 coal seams in the Rock