ative position of mean high tide and the lagoon or channel margin at the time of deposition.

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Discrepancies Between Anomalously Low Reflectance of Vitrinite and Other Maturation Indicators from an Upper Miocene Oil Source Rock, Los Angeles Basin, California

In the westernmost Los Angeles basin, the "nodular shale," a distinctive, richly organic bituminous and phosphatic mudstone, occurs just above the unconformable base of the upper Miocene Modelo Formation. This 11.5 m.y. old bathyal oil-source rock is present in wells to burial depths >3,810 m (12,500 ft), and is inferred to be present within the central syncline of the basin beneath about 9 km (5.5 mi) of late Miocene to Holocene clastic cover.

Forty-four subsurface samples of the nodular shale were collected from 14 selected wells located mostly between the Playa del Rey and Crescent Heights oil fields. Sites were selected to give the widest available range of sample depth and temperature where present burial depths are maximal, and where geothermal gradients are firmly established. Median random reflectance (%R_o) of first-cycle vitrinite is least in the shallowest samples, clusters about 0.24% in the deeper samples, and exceeds 0.30% only in the deepest and hottest samples. Extremes in the range of measured median %R_o are tabulated below with corresponding extremes of sample temperatures, depths, Time-Temperature Indices (TTI), and calculated %R_o equivalents of the TTI values.

%R_o (measured)	Temp. (°C)	Depth (m)	TTI	Calculated %R_o from TTI
0.12	105	1,664	4	0.4
0.40	153	3,810	70	1.0

All measured values of R_o are significantly depressed compared to other maturity criteria. Significantly, second-cycle and oxidized vitrinite from these same samples show normally elevated reflectance.

Eight of the samples processed for reflectance measurements were analyzed for total organic carbon content, which ranges from 2.21 to 9.41%. Most of the organic detritus is amorphous degraded algal material; less than 10% is structured vitrinite. Thermal alteration index values for the amorphous material range from 2 to 2½, corresponding with hypothetical conversion R_o values between 0.45 and 0.75%, again notably higher than the measured values. The ratios of extractable hydrocarbons to TOC in the 8 samples suggest "mature" levels of thermal evolution, as do carbon preference indices of 0.93 and 1.14 from extracts of 2 samples.

Strikingly similar patterns of vitrinite reflectance values have been described from alginites in some Australian coalfields and oil shales. The data suggest to us that hydrogen-rich organic matter matures at lower temperatures and at a substantially faster rate (and lower TTI values) than detritus dominated by structured organic matter of lower hydrogen content. The depressed R_o measurements evidently reflect the hydrogen-rich nature of the dominant detritus and thus are not reliable indicators of either paleotemperature or thermal maturity in the most oil-prone source rocks. In fact, depressed R_o values may be indicators of ultra-rich source rocks when normalized for other influences.

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Feldspar Transformations During Sandstone Diagenesis (SEPM Presidential Address)

No abstract.

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Role of Cementation in Diagenetic History of Devonian Reefs, Western Canada

Devonian (Givetian and Frasnian) reef reservoirs in Alberta and British Columbia contain 60% of the conventional recoverable oil and 20% of the recoverable gas in the Western Canada sedimentary basin. Although the depositional history of these reefs is well understood, it is the diagenetic "overprint" that is often responsible for their reservoir quality.

Frasnian (Woodbend and Beaverhill Lake Group) reefs are characterized by stromatoporoid and coral knoll reef belts deposited near moderately sloping bank edges. Bank margin sediments are composed of skeletal lime grainstones, packstones, rudstones, and rare framestones. In contrast, bank interiors are often extensive (e.g., Redwater, Swan Hills) and characterized by cyclic deposition of lagoonal and tidal flat sediments. Certain Givetian reefs found in evaporate basins (e.g., Rainbow or Zama) usually occur as "pinnacle" reefs with steep (>20°) margins and only minor bank interior development. Frasnian reef complexes range in size from 1 km² (0.4 mi²) to greater than 600 km² (230 mi²) with thicknesses from 100 to 400 m (330 to 1,300 ft). Givetian pinnacle reefs are commonly as much as 300 m (984 ft) thick, but with areal extents of less than 1 km² (0.4 mi²).

Regardless of differences in size, depositional history, and age, most reefs have been subjected to diagenesis in essentially three environments: (1) submarine (marine to hypersaline pore waters), (2) subaerial (fresh to brackish pore waters), and (3) subsurface (below phreatic aquifers, saline to brackish pore waters). Fibrous calcite cements, syndepositional fracturing, displacive calcite cements, micrite cements, and bored hardgrounds are typical submarine diagenetic fabrics, particularly at bank margins in Rainbow reefs and certain Leduc reefs (e.g., Golden Spike, Ricinus). Subaerial disconformities are numerous in most reefs, and associated vadose diagenesis produces localized paleosols, microstalactitic and meniscus cements, and abundant solution porosity. Phreatic or shallow burial cements usually include clear, equant calcite or dolomite that vary in Fe^{++} and Mn^{++} concentrations. Subsurface cementation produces nonferroan calcites and dolomites which are often related to stylolite formation (e.g., Kaybob, West Pembina D-2, Strachan, Ricinus). Other diagenesis occurring during burial includes dolomite and anhydrite replacement, sulfide mineralization (e.g., Pine Point, Presqu'ile barrier reef), and bitumen formation (e.g., Clarke Lake, Rainbow).

Primary porosity and permeability are altered by the "overlapping" processes of cementation and solution (vadose and/or phreatic) that occur early in the diagenetic history. In reef interiors these subaerial processes produce stratified reservoirs with impermeable barriers (cemented beds) to vertical flow (e.g., Golden Spike, Swan Hills, Judy Creek). Submarine cementation is rare in most reefs but can be locally pervasive resulting in occlu-