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Relationship of Roberts Mountains Thrust to Oil and Gas Exploration in Nevada

The Roberts Mountain thrust is the oldest and probably the largest of many eastward-moving regional thrust plates that make up much of the Basin and Range province. The fault can be traced from the state of Washington through central Nevada into California. Movement commenced during Late Devonian-Early Mississippian time (Antler orogeny), probably as a result of plate collision and subduction farther west along the margin of the eastern Klamath geanticlinal arc.

Ordovician to Devonian age, eugeosynclinal, highly organic (2 to 5%), dark-colored shales, siltstones, cherts, and limestones—the "western siliceous facies"—perhaps originally totaling 20,000 ft (6,100 m) are thrust over "eastern-facies" carbonate and clastic shelf deposits. Movement along the thrust continues sporadically into middle Permian, by which time much of the eugeosynclinal rocks were eroded eastward as a flysch. These clastic deposits of Mississippian, Pennsylvanian, and Permian age are deposited along with shallow-marine units in local basins and sags.

Outcrops of thin-bedded, oil-bearing shales (25 gal/ton) and black cherts of the "western siliceous facies" Vinni Formation are present at Roberts Mountain. This unit is a potential source, seal, and possible reservoir rock, averaging several thousand feet in thickness, which "floors" many of the Miocene valley basins west of the leading edge of the thrust. Oil potential is considered to be good although fewer than 15 wells have been drilled in the area. Many had oil shows but none has tested the Vinni or the overlying Cretaceous-Eocene sedimentary units at depth. Free oil has flowed from perforations at approximately 7,200 ft (2,195 m) from possibly Mississippian or Devonian dolomites in the Amoco-Getty 3 Blackburn Unit, (Sec. 8, T27N, R52E, Pine Valley, Eureka County, Nevada). This is the first substantial oil recovery from the Paleozoic rocks in any valley basin other than Railroad Valley in the Nevada portion of the Basin and Range. Oil appears to be of Paleozoic source. In some valleys the overlying Cretaceous and Tertiary units may provide additional source, seal, and reservoir rocks.

East of the thrust trace, in several valley basins, Paleozoic source and reservoir rocks are present and intertongue with the flysch of the Roberts Mountain thrust. In some valleys, these units are also overlain by sedimentary Cretaceous and Tertiary rocks which may also be potential source, reservoir, and seal for any oil accumulations. Noncommerial Tertiary and Paleozoic free oil and gas have been recovered in several test wells drilled in T29N, R55E, Huntington Creek valley basin, Elko County, Nevada.

Local horst and graben structures, combined with Tertiary truncation similar to that found productive at Trap Spring and Eagle Springs fields, are present in valley basins both east and west of the thrust.

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Microfabric Analysis of Fine-Grained Clastic Rocks as an Independent Criterion for Determining Depositional Environment

SEM examination of clay fabric in siltstones as old as Pliocene has proved useful in distinguishing rapidly deposited muds from hemipelagic clays: turbiditic siltstones are characterized by random orientation of clay minerals and hemipelagic units show preferred (parallel) orientation of clay minerals. Random orientation of clay minerals has been recognized in Paleozoic shales, indicating that postdepositional compaction of shales does not always result in parallel alignment of clay minerals. Therefore, the possibility exists that original depositional fabric of clay minerals is retained in rocks of Paleozoic age, and that clay-fabric analysis would provide an independent tool for interpreting the depositional environment of fine-grained clastic rocks.

This study shows that original depositional fabric of clay minerals is preserved in texturally homogeneous, nonbioturbated mudstones as old as Middle Cambrian. Clay fabric may be used in determining whether the mud deposition was rapid or slow (e.g., pelagic). Rapid mud deposition is characterized by a random clay fabric; slow sedimentation is characterized by preferred alignment of clay minerals. Bioturbation and bimodal grain size within a sample (e.g., a clayey siltstone) also are associated with a disordered clay fabric, so this analysis is most confidently used with mudstones that have a homogeneous texture and show no evidence of bioturbation. Therefore, environmental interpretations based on SEM analysis of clay fabric can be used with confidence provided that the caveats of bimodal grain size, bioturbation, and diagenesis are anticipated.

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Deposition and Preservation of Supratidal and Intertidal Shell Deposits in a Back-Barrier Environment, Wassaw Sound, Georgia

Extensive supratidal and intertidal shell deposits occur along the margins of Wassaw Sound and major tidal rivers of the Georgia coast. Shell material, primarily from oysters, is derived from the sound, salt marsh, tidal channels, and tidal flats. The deposition and accumulation of supratidal and intertidal shell facies depends on five factors: (1) fetch, (2) storm frequency, (3) wind direction, (4) supply of shell material, and (5) shoreline stability.

Shell berms and shell aprons, the major accumulations of shell in the area, are deposited above mean high tide on the sound and river margins by storm tides and waves. Shell berms are elongate ridges, 15 cm to 2 m (6 in. to 6.5 ft) high and 25 cm to 30 m (10 in. to 98 ft) wide, of accumulated oyster and other shell, marsh float, sand, and organic matter occurring in varying proportions. Shell aprons are lobate deposits, 2 to 30 m (6.5 to 98 ft) wide and up to 2 m (6.5 ft) thick, which are comprised of shell material with or without a sand matrix. These supratidal deposits will be preserved if quickly covered by the relatively impermeable tidal flat and marsh muds to depths below the redox potential discontinuity. Intertidal shell pavements, the result of storm and tidal action on oyster reefs, often have a distinct fabric of vertically packed, tightly wedged shells which are stable under all but storm conditions. Pavements and other intertidal shell deposits are widespread on the tidal flats of Wassaw Sound and are the most easily preserved shell facies. Rapid progradation of the upper tidal flat accompanied by vertical accretion of salt-marsh sediments will result in the rapid burial and consequent preservation of shell aprons and intertidal shell facies. Preserved shell deposits occur on and under the salt-marsh surface in the study area, and are interpreted as oyster reefs, shell aprons, and shell pavements based on their shell orientation, shell body geometry, stratigraphic position, and matrix material.

Preserved supratidal shell aprons, intertidal shell pavements, intertidal and subtidal oyster reefs, and subtidal tidal-channel lag deposits can be differentiated in outcrop by the distinctive geometry, fabric, structure, shell condition, and stratigraphic position of each. The presence of preserved shell berms, aprons, and pavements in outcrop is a reliable environmental indicator of a storm-influenced, estuarine or lagoonal coastline, and of the relative 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 km^2 (0.4 mi^2) to greater than 600 km^2 (230 mi^2) 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 km^2 (0.4 mi^2).

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-