Petroleum Exploration and Wrenching Model, Michigan Basin

The writer has previously proposed a wrenching model for the Michigan basin based on the close relation of lineaments gleaned from Landsat imagery to the geometry of shear faults and related shear folds anticipated in such a model.

Recent studies by colleagues have been focused on old linear oil producing structures where (1) the density of wells permits structure maps drawn on a small contour interval, and (2) sufficient well samples allow the construction of dolomite-limestone ratio maps. Geometry of dolomite distribution patterns in Middle Devonian carbonate rocks shows close comparisons to pay zone distribution coincident with shear faults and related shear folds, cross faults, and cross folds—all related to the wrenching model. Producing well patterns follow dolomite distribution patterns. Lateral displacement can often be detected along shear faults on structure maps. Some faults not detectable on the structure map are shown on the dolomite-limestone ratio map. The application of the wrenching model to future exploration for linear producing fields in the basin appears self evident; strike-slip faults in nearly horizontal rocks are elusive seismic targets. The shear faults generally show little vertical movement. Not all shear faults developed shear folds, as in the giant Albion-Scipio field (Ordovician).

Evidence suggests that movement along shear faults was episodic, with the axes of related shear folds showing some migration downward. Further testing of the shearing mechanics in this regard may assist in exploration for deeper targets.

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Shale—an Overview

Shale and mud form at least 60% of the world's sediments, have been deposited throughout geologic history, and occur in every major depositional basin. They are major source beds for hydrocarbons, hosts for metallic minerals, sources of ceramic materials, cause of unstable foundation conditions, and precursors of soils that produce our food. Yet the study of shales has lagged far behind that of other sedimentary rocks. Factors that have retarded the study of shales are: (1) we are presently unable to isolate, study, and deduce the histories of the single particles that form shales. Consequently we have had to rely on bulk properties which are based on the average of many particles of diverse origin; these combine the effects of source area, depositional environment, and post-depositional change; (2) we fail to recognize and interpret in shale the equivalents of the "vertical profiles" that have been so successful in the study of sandstones and carbonate rocks. Such sequences for shales should be based on the vertical variation of bedding, on bioturbation and fossils, and on the amount and type of organic matter. These properties most closely reflect primary depositional processes; (3) we rarely have an idea of the paleocurrent or paleocirculation system of most shaly basins; (4) finally, we have not integrated our present knowledge of shales with the geometry of shale bodies nor has it been common to study the associated lithologies, bounding contacts, and positions of shale bodies within basins.

These factors, and others that will emerge, appear to be the directions in the future sedimentologic studies and interpretations of shaly basins.

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Drilling in San Andreas Fault

Research on earthquake prediction prior to 1978 depended largely on the gathering of geophysical observations prior to earthquakes. These include measurements of changes in seismicity, strain, magnetic field etc. Recently, however, in an attempt to relate these observations to a physical model of the pre-earthquake failure process, the U.S. Geological Survey has begun a program of direct measurement of the properties of faults through drilling holes in and near the active fault trace.

Laboratory data on failure of rocks show that nonlinear strains develop just prior to rupture, but the character of the failure process is strongly dependent on material properties, pore-fluid pressure, and applied stresses. These parameters are virtually unknown in faults at depths where earthquakes occur. The drilling and in-situ measurements program was designed to determine these quantities and provide samples of the actual fault-zone materials.

Preliminary results from holes near the San Andreas fault can be tentatively interpreted to show that the level of shear stress on the fault is surprisingly low, about 100 bars. The fault-zone rocks at a depth of 600 m are a low-permeability clay-rich gouge in the first hole drilled along the creeping part of the fault. The hole is presently being deepened to allow measurements of stress and pore pressure at depths of 1 km.

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Paleogeography of Northern Arizona During Deposition of Permian Toroweap Formation

Stratigraphic and facies analyses of the Toroweap Formation have yielded reliable indicators of the paleogeographic conditions that existed in northern Arizona during the Permian. Four depositional environments have been recognized that are based on definitive facies. The four environments and their respective facies laterally from west to east are: (I) open marine; skeletal packstone and wackestone, pelletal wackestone; (II) restricted marine; aphanitic lime mudstone, dolomite mudstone, sandy dolomite; (III) sabkha; gypsum, horizontal and gnarly bedded sandstone; and (IV) eolian dune; cross-bedded sandstone.

A marine transgression encroached upon coastal and continental sabkhas eventually drowning a large eolian dune field in its eastward advance across northern Arizona depositing the Toroweap Formation. Eventually the sea slowly withdrew westward and thick prograding sabkha and dune facies were deposited over marine carbonate rocks. Desert conditions prevailed at the eastern edge of the sea as it transgressed eastward and regressed westward across northern Arizona. Eolian dunes with south-dipping cross-beds were formed by trade winds blowing southward toward the paleoequator south of Arizona during the Permian. Extensive coastal and continental sabkhas formed between the restricted mud flats and the dune fields. Westward, the restricted marine deposits of dolomite characterized by bivalves and gastropods gave way to shallow open-marine deposits of brachiopods, byrozoans, corals, and crinoids. The westward regression ended with a rapid transgression that deposited the Kaibab Limestone across the sabkhas and dune fields of the Toroweap and Coconino formations.

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Carbonate Depocenters and Facies Distribution on Passive Cambrian Shelf and Middle Ordovician Foreland Basin, Appalachian Orogene, Virginia

Depocenters in the southern and central Appalachians in Virginia appear to have been a major influence on thickness and carbonate facies distribution on the passive Cambrian-Ordovician shelf and in the Middle Ordovician foreland basin.

The Upper Cambrian Nolichucky Formation illustrates sedimentation patterns associated with a shelf embayment (located above the southern Appalachian depocenter) on the passive Cambrian shelf. The Nolichucky Formation is an onlap-offlap, shallow ramp to deep shelf sequence that consists of peritidal stromatolitic carbonate rocks, ooid grainstones, deeper ramp ribbon carbonate rocks, and embayment plain shale/siltstone/flat-pebble conglomerate facies. Facies bands are normal to the regional shelf edge and parallel the outline of the shelf embayment.

The Middle Ordovician sequence illustrates the influence of depocenters on foreland basin evolution during a time of profound tectonism, when the shelf edge was uplifted, deformed, and subjected to erosion. The Middle Ordovician ramp-to-basin sequence is an onlap-offlap package, that consists of peritidal fenestral lime mudstones, shallow subtidal cherty wackestones, ramp and downslope skeletal buildups, deeper ramp shaly skeletal wackestones, and basinal black limestones and shales. Widespread ramp and basin deposition commenced in southwest Virginia during south to north transgression from the southern depocenter. Widespread downwarping extended the basin into northern Virginia. Rapid clastic influx coupled with progradation of the carbonate ramp caused the southern basin to fill.

Recognition of depocenters associated with carbonate sequences in orogenic belts is important if controls on direction of transgression, facies distributions, and thicknesses of units are to be better understood. Furthermore, the carbonate depocenters appear to localize development of subsequent clastic wedges.

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Fluorescence of Acritarchs in Study of Marine Kerogen

Acritarchs, the organic-walled palynomorphs of algal affinities, exhibit strong fluorescence colors depending upon species type, stage of thermal maturity, and degree of oxidation.

This fluorescence readily enables identification of acritarchs in gross kerogen concentrates and provides a means of distinguishing acritarch fragments in poorly preserved kerogen assemblages.

Although acritarchs show similar fluorescence colors in an autochthonous assemblage, there may be minor differences as a result of different types and wall thicknesses. Similarily, the varying degrees of oxidation of individual palynomorphs can give differing colors.

Thick-walled marine algae also fluoresce but can be distinguished from acritarchs by the differences in intensity of the fluorescence colors.

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Depositional Environments and Kerogen Types

No abstract available.

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Hypothesis Involving Dilation and Natural Hydraulic Fracturing to Explain Petroleum Reservoirs in Monterey Shale, Santa Maria Area, California

Fractured reservoirs in the siliceous Monterey Shale of the Santa Maria area represent anomalous lithology and anomalous type of fracturing. Some, pehaps all, reservoirs are not fractured chert but chert embrittled by dolomitization. Abundant reservoir extension fractures are disordered and open, commonly containing epigenetic dolomite breccias. These fractures are partly dolomite-cemented but contain common open voids, many 15 cm across, some larger. Breccias locally have an exploded appearance and contain matched fragments separated by veins, which apparently were injected as a slurry of water, oil, and fragments of dolomite and dolomitic Monterey Shale.

The highly organic Monterey served also as source rock and probably originated as richly diatomaceous slope sediment beneath an oxygen-minimum zone at a depositional site much larger than the Santa Maria area, and not confined to a specific silled basin. Local dolomitization may have been due, at least in part, to rising solutions and injected slurries.

These reservoirs are explained by an hypothesis involving repeated episodes of rock dilation followed by natural hydraulic fracturing, all produced by continued episodic tectonic compression of the region (principal, maximum, effective stress oriented northeastward). High fluid pressures enlarged underpressured dilation microfractures into macrofractures and produced breccias by hydraulic fracturing. Viscous oil derived from the Monterey Shale was forced into voids as part of overpressured slurries whose breccia fragments were