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SECONDARY AND POSTDEPOSITIONAL REDBEDS OF DUCHESNE RIVER FORMATION (EOCENE-OLIGOCENE?), UINTA BASIN, UTAH

Clastic sedimentary rocks of the Duchesne River Formation are largely red or reddish brown. Red pigment (hematite) is present as very fine-grained iron oxide, as staining on grain surfaces, and in cement. Apparently most of the pigment was derived originally from red sedimentary source rocks of the Uinta Mountains. Fine-grained red material and red-stained grains survived erosion and transportation from the source area and deposition over large areas of the Uinta basin, but much of the red pigment has been mobilized subsequently and removed from some of the deposits.

The types and colors of cements are related to the color of sandstones. Red, reddish-brown, and brown sandstones contain predominantly silica cement. Sandstones of orange or yellowish brown color are cemented with both silica and carbonate cements, and most of the carbonate cement is stained. Green, yellow, and gray sandstones contain mainly carbonate cement, most of which is not stained. Petrographic relations indicate that the earliest cement was silica. Later carbonate cementation in many sandstones mobilized some of the red pigment derived from the source area. Additional red pigment was derived from the partial oxidation of iron-bearing detrital grains. In some sandstones another stage of carbonate cementation again mobilized pigment, reducing or removing most of it. As a result, most of the rocks retain the reddish color inherited from red sedimentary source material, either in its original form or redistributed in cement. Postdepositional red pigment has further stained many of the rocks, but red pigment has been removed from some after deposition.

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TRANSPORT AND DEPOSITION OF SUSPENDED SEDIMENTS ON ESTUARINE TIDAL FLATS

The suspended sediments in water flushing on and off an estuarine tidal flat have been examined for relative changes in concentration as a function of wind speed, local wave conditions, salinity, temperature, and tidal currents. The shallow water was sampled by "plumbing" the upper 20 cm of the sediment surface with buried plastic pipes and pumping water samples from an orthogonally spaced matrix of intake valves positioned across the tidal flat to permit observation of "natural" sedimentary processes. The sediment interface has been modified over parts of the matrix by introducing roughness elements in the form of small closely spaced stakes and stabilizers, such as eel grass.

The data show a decrease in sediment concentration as the water floods over the tidal flat primarily as a function of dilution by more marine waters. As high slack tide is reached, sediment deposition occurs when wave heights are at a minimum. This deposition appears to continue even on the ebbing tide until water depths are extremely shallow, at which time a minor resuspension usually is noted. In contrast, if a slight "surface chop" develops, the falling water maintains the sediment in suspension and flushes it out on the ebbing tide.

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STRATIGRAPHIC TRAP POTENTIAL, PERMIAN PHOSPHORIA FORMATION OF CENTRAL WYOMING

There are good opportunities for finding stratigraphic traps in the Permian Phosphoria Formation of central Wyoming. Ideally, hydrocarbons may be trapped in an updip reentrant of porous carbonate rock extending into redbed-anhydrite facies or in a porous algal leaf and oocastic mound enclosed in impermeable carbonate rock.

Three facies are found as bands of dolomitized carbonate rocks on the Wyoming shelf between the marine limestones of the Phosphoria Formation and redbeds of the Goose Egg Formation. Westward, the shelf deposits grade into basinal phosphatic and cherty beds.

Two transgressive-regressive marine cycles are present in which limestone grades through dolomite into a redbed-anhydrite facies. Stratigraphic work on the carbonate members (Ervay, Franson, and Grandeur) has defined three mappable facies exhibiting porosity and permeability due to secondary dolomitization. These facies consist of (1) algal oolitic-pellet mounds, (2) algal pellet mounds, and (3) oocastic carbonate rocks.

Traps formed where the algal oolitic-pellet mounds of the Ervay Member grade into impermeable redbed-anhydrite and dense carbonate rocks have proved the most important economically. Cottonwood Creek field, containing 45 million bbl of reserves, is an excellent example. This facies relation can be traced from outcrops in the northwestern Big Horn Mountains, through the Big Horn basin, to wells drilled on the south flank of the Wind River basin, where drilling so far has failed to find a productive trap. The Laramide orogeny further complicated the conditions of entrapment.

The oocastic facies, best developed in the Ervay and Franson Members, is directly west of the algal oolitic-pelletal facies and trends as a band across central Wyoming. This facies has excellent porosity but poor permeability, and has produced mainly from fractured reservoir rock on structures such as Winkleman dome, Circle ridge, and Beaver Creek.

The algal-leaf facies, found as lenses in fine-grained nonporous carbonate rock, parallels the depositional trends of the other facies; it also is interbedded with the algal oolitic and oocastic facies of the Ervay and Franson Members. The algal-leaf facies has excellent capacity and, if oil-saturated, constitutes an excellent reservoir. This facies is the primary pay zone in No Water Creek field in the Big Horn basin. Identification of this facies is difficult in wells, so cores and thin sections are needed.

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ESPÍRITO SANTO—PATTERN OF BRAZILIAN MARGINAL BASINS

The Espírito Santo basin lies in the eastern continental margin of Brazil, as a member of an assemblage of Cretaceous/Tertiary basins correlatable by close stratigraphic and structural analogies. It is considered as the most complete model of this group of basins, and can serve as a pattern for a study of their origin and evolution.

The basin originated by Early Cretaceous tectonism that fractured the original cratonic mass into elongated grabens bounded by normal faults. Immature fluviolacustrine sediments were deposited in this tectonically active rift valley.

Sea-floor spreading caused the subsequent widening of the basin, and allowed the first marine transgression that formed a long and narrow embayment—the primitive South Atlantic Ocean. Here, due to restrictive conditions, an evaporitic section was deposited.

The combined effect of the enlargement of this embryonic ocean by eastward migration of the Mid-Oceanic Ridge since Late Cretaceous time, and basin tilting due to detumescence of the pre-rift arching, determined the deposition of a thick, predominantly marine section with deltaic sedimentation near the Doce River area, and of shallow-platform carbonates in the central and eastern parts of the basin.

This upper marine section, although only weakly structured by the progressively decreasing reactivation of the Early Cretaceous faulting, underwent adiastrophic movements by growth faulting and halokinesis.

Late Cretaceous to middle Eocene submarine volcanic activity built up the framework of a 30,000-sq km accretion to the preexisting continental shelf.

The process of origin and evolution, and the structural and stratigraphic characteristics of the Espírito Santo basin, cause consideration of the basin as potentially petroliferous, and warrant the exploration program that is being carried out.

The accumulated knowledge of the Espírito Santo basin, that reflects the regional situation of the whole Brazilian continental margin, affords an important clue to the study of continental drift of South America and Africa.

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SEDIMENTARY MODELS, CYCLES, AND DELTAS, UPPER CRETACEOUS, WYOMING

Sedimentary models developed from modern sedimentation alone are of limited usefulness to the petroleum geologist because of (1) lack of variation resulting from deposition during a consistent trend of sea-level change; (2) poor control in the vertical dimension, particularly in intermediate and deeper water environments; and (3) the lack of direct association with petroleum accumulation. More widely useful models can be derived from certain ancient rock sequences, utilizing principles based on modern sedimentation. Good outcrops, abundant well control, bentonite marker beds, and dominantly stratigraphic oil and gas production make the Upper Cretaceous formations of Wyoming particularly useful in providing models pertinent to both industry and academic needs.

The Ericson Sandstone of southwestern Wyoming and its nonmarine and marginal-marine equivalents can be combined with marine elements of the model from eastern Wyoming to produce a complete, wide-shelf model consisting of fluvial, paludal, barrier-island, shelf, slope, and basinal facies. Significant differences between the resulting model and previously proposed models are the podlike configuration, the presence of thick slope deposits, and the significant submarine topography present at the epicontinental slope. A narrow-shelf model can be derived from the Lewis Shale, Fox Hills Sandstone, and Lance Formation of the Red Desert basin.

The complete sedimentary cycle consists of the same units as the complete model. Only regressive sedimentary cycles have been recognized. The maximum marine transgressive shift recognized is reflected in a basinal facies directly overlying the paludal facies of the Parkman in southwestern Powder River basin.

The complete model includes a distinct fluvial facies deposited at the mouth of a river and, by definition, a delta. An incomplete sequence consisting of paludal, barrier-island, and a thin shelf facies is interpreted to be interdeltaic. Several deltas can be delineated on this basis from the Ericson and time-equivalent rocks of Wyoming and adjacent states. When related to sequences interpreted as deltaic in older and younger Upper Cretaceous rocks of the area, a shifting pattern of deltaic sedimentation similar to that of the modern delta complex is suggested. If this pattern of shifting loci of deposition is correct, some stratigraphic concepts may require reexamination.

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A METHOD OF FINDING OIL—UNORTHODOX THINKING

Orthodox thinking proceeds in patterns established by past experience and is principally useful in solving the problem of why "other" people discover all the oil. Unorthodox thinking (as here used) is a deliberate pattern of denying (or doubting) the validity of each accepted basic concept and seeking new alternatives. In this sense unorthodox thinking is a method of generating new ideas in a regular and continuing stream.

The unorthodox approach challenges accepted ideas of oil generation and migration, suggesting new and untested trends for major oil accumulation. Similar trends, discovered largely by accident, already have produced vast quantities of hydrocarbons. Such accumulations, although a mystery to orthodox thinkers, are a challenge and an education to the unorthodox. Unorthodox thinking (a method of finding oil) is also a method of organizing and perpetuating creative energy.

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CONCEPTS OF MICROPALEONTOLOGY APPLIED TO PETROLEUM GEOLOGY

Micropaleontologic correlations by means of planktonic microfossil zones, defined on either an evolutionary or paleoceanographic basis, show that there are major time-transgressive features for paleontologic zones based upon benthic forams. This problem is especially acute in tectonically active basins where rapid sedimentation is combined with differential subsidence rates. Stage boundaries based on benthic species may occur progressively down-section toward submarine fans; conversely, such boundaries are progressively higher in the section toward deep-water depositional areas that are far from sediment sources. Thus, the misidentification of stratigraphic objectives can lead to drilling errors of many hundreds of meters in exploring different depositional centers within a basin. This aspect of correlation precision is especially acute in areas of continental margins.

Paleoenvironmental logging of sections and wells, employing primarily benthic foram faunas, makes possible (1) definition of paleobathymetric cycles, (2) detection of areas with truncated cycles, (3) definition of principal depositional centers and their migration in time, (4) proper evaluation of sediment bodies such as turbidites and submarine landslides, and (5) definition of paleotectonic rates which lead to the definition of structural trends developing within a basin.

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BASIC DISPOSAL-WELL DESIGN