Lithofacies, Diagenesis, and Porosity, Ivishak Sandstone, Prudhoe Bay Area, Alaska

The Permo-Triassic Ivishak Sandstone is the main reservoir interval of the Prudhoe Bay field, North Slope, Alaska. Studies of cored sequences from the field and offshore (Reindeer Island) reveal that porosity development within the Ivishak Sandstone has a complex relationship dependent on both depositional (lithofacies) and postdepositional (diagenetic) history. These factors are related to the tectonic history of the basin.

Five dominant lithofacies are identified: (1) interbedded very fine sandstones and mudstones, (2) parallel laminated carbonaceous fine sandstones, (3) multistory upward-fining medium sandstones, (4) conglomerates, and (5) multistory upward-fining coarse to granular sandstones. These lithofacies occur everywhere as upward-coarsening to conglomerate sequences. In the onshore (Prudhoe Bay field) area the coarsening sequence is overlain by a gross upward-fining sequence of gravelly to medium-grained multistory sandstones. This thins dramatically to the north, and is absent at Reindeer Island. Consideration of lithofacies and thickness variation leads to an interpretative model concerning evolution of the basin with respect to tectonics and sedimentation. Thus initial progradation of an active alluvial fan-delta system from the northeast was replaced by progressive transgression from the south of more distal upon proximal facies.

Petrographic characteristics of the rocks reveal that porosity development is intimately related to lithofacies. Porosity within the medium-grained sandstones is predominantly due to dissolution of early nodular calcite. Porosity within the conglomeratic intervals appears to be much more of a primary (textural) origin.

Hypothetical porosity profiles can thus be constructed based on predicted lithofacies distribution across the area in any direction.

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Deposition and Diagenesis of Glauconite Sandstone, Berrymore-Lobstick-Bigoray Area, South-Central Alberta

The depositional environments of the Glauconite sandstone in the Berrymore-Lobstick-Bigoray area are distributary channels, delta platform, distributary mouth bars, and interdistributary bays.

The diagenetic mineralogy is consistent with the formation water chemistry. A simplified model for evolution of Glauconite sandstone water compositions includes (1) original derivation in a deltaic setting giving composition of early pore waters as brackish to normal marine, (2) alteration due to inorganic and organic chemical diagenesis, and (3) dilution through time due to meteoric water recharge. The formation waters now evolved have such a composition as to be (1) oversaturated with respect to hematite, kaolinite, and illite (late-stage cements); and (2) near equilibrium to undersaturated with respect to quartz, calcite, siderite, and dolomite.

The early diagenetic mineralogy is a function of early pore waters and thus the subenvironment. For example, ankerite cement forms early at the base of distributary channels.

The intermediate to late diagenetic cementation is a function of early diagenetic mineralogy. For example, hematite is formed by the oxidation of siderite due to meteoric water recharge. Oxidation of pyrite is quantitatively unimportant. Occurrence of late stage hematite is associated with structural highs which are most affected by meteoric water recharge.

Delta platform deposits contain gas, and distributary channel and distributary mouth bar deposits contain water. Delta platform deposits are isolated from distributary channel and distributary mouth bar deposits by a vertical permeability barrier of ankerite cement and a lateral permeability barrier of siderite and kaolinite cement, respectively.

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Subsurface Paleoenvironmental Analysis of Gas-Producing Medina Group (Lower Silurian), Chautauqua County, New York

A paleoenvironmental interpretation of the gas-producing Medina Group from the subsurface of Chautauqua County, New York, was made by making a lithologic study of a core from Panama, New York, and analyzing over 140 gamma-ray well logs. The oldest formation, the Whirlpool, is a light gray sandstone interbedded with thin lenses of siltstone. Isopach patterns reveal that the Whirlpool Formation was deposited in elongate parallel thick areas trending NE-SW which are similar to the patterns produced by modern tidal current ridges. The Whirlpool Formation is interpreted to be deposited as a tidally influenced sublittoral sheet sandstone. The Power Glen Formation is a medium dark gray shale interbedded with a light gray siltstone. It is interpreted as being deposited in: (1) a marine shelf and prodelta environment; and (2) as distal bar deposits. The Grimsby Formation has a light gray basal sandstone followed by medium red sandstone and interbedded with blackish red shales. The isopach patterns indicate that it was deposited in elongated dendritic areas that trend nearly north-south. The Grimsby is interpreted as a tidal-dominated delta, analogous to the modern Ord River delta of western Australia. There are four subenvironments: (1) channel and distributary mouth bars, (2) overbank splay deposits, (3) tidal channel, and (4) tidal flat. A regional correlation was made with the northeastern Ohio White Clinton sands to the basal light gray section of the subsurface Grimsby of northwestern Pennsylvania and Chautauqua County, New York. The Red Clinton of Ohio is correlated with the upper sections of the subsurface Grimsby.

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Temperature Anomalies Associated with Rocky Mountain Oil and Gas Fields

Over the years, a number of observers have reported on temperature observations which show a particular oil or gas field to be "hotter" at the pay depths than the surrounding rock at the same depth. Our study of 22 oil and gas fields from six states in the Rocky Mountain region demonstrates that at least 15 of these fields have positive temperature gradient anomalies at the pay level. Nine of these "hot" fields are contained in structural traps and six are primarily stratigraphic accumulations. Three of them are gas and 12 are oil fields.

All of our temperature measurements were recorded during drill-stem tests except for a few values taken from temperature logs. Drill-stem test temperatures usually are recorded a longer time after mud circulation has ceased in the well bore than are wire-line log temperatures. Therefore, the former generally are a truer measure of the formation equilibrium temperature than are the latter.

Speculating on the causes of these temperature anomalies over oil and gas fields, we conclude that upward fluid movements at depth is the most important factor. The upward-moving fluids carry heat along with them, and both heat and fluids are trapped whenever suitable trapping conditions are encountered in the reservoir rocks through which the fluids pass. The main evidence for this conclusion is the fact that observed temperature

anomalies occur over fields which are contained in stratigraphic traps.

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Structural and Stratigraphic Framework of Lower Mesozoic and Upper Paleozoic Strata, Northeast Texas

The lower Mesozoic and upper Paleozoic were investigated in a 19,430 sq km area centered about Ellis County, Texas, in an effort to define the pre-Cretaceous surface, determine the westward extent of Jurassic rocks, analyze thickness and lithic nature of the lowermost Cretaceous, delineate the extent of faulting, and evaluate the economic potential of the section studied.

The pre-Cretaceous surface dips east-southeast and consists of Paleozoic rock in the updip third of the study area and Jurassic rock in the downdip two-thirds. Regional dip increases southeastward into the East Texas basin, but is interrupted by Balcones and Mexia-Talco faults. According to seismic data, many of these normal faults extend into the Paleozoic section. They are Jurassic and younger in age and formed along preexisting lines of weakness in response to the structural development of the East Texas basin. Jurassic rock extends updip beyond the Mexia-Talco system in an onlap fashion, each carbonate formation becoming more clastic as it nears its own pinch-out. The overlying Hosston Formation was deposited in a fluvial to nearshore environment, in the study area, on the basis of reported lithologies and isopach form. The interval studied has economic potential as geothermal, ground-water, and hydrocarbon sources. Possible hydrocarbon traps include fractured Arkansas Novaculite, updip pinch-out of and porous facies within the Upper Jurassic formations, and traps against the downdip sides of faults in the Hosston Formation and underlying Jurassic formations.

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Depositional and Diagenetic Facies, Smackover Formation, Chunchula Field, Alabama

The Chunchula field lies on the northeastern edge of the South Mississippi platform and produces from dolomitic carbonates of the Smackover Formation. The Smackover section overlies the subaerial to marine Norphlet Sandstone and itself represents a general transgressive-regressive sequence of shallow-marine to supratidal facies similar to those found on the Great Bahama Bank today.

The Chunchula carbonate section is composed of at least three major units. The basal interval is the lowermost Smackover section and is composed of medium to coarsely crystalline dolomite and its upper boundary seems to be marked by a significant disconformity. The second unit is interpreted as upper Smackover and is composed of medium to coarse-grained dolomite in the central and western parts of the field, but becomes predominantly limestone along the northern and eastern edges of the field. The uppermost part of the carbonate section is a finely crystalline dolomite that represents part of a sabkha sequence and probably belongs to the overlying Buckner evaporite section.

Porosity development is restricted to the dolomitic units and seems to be preferentially associated with paleotopographic highs. The best reservoir intervals are composed of intercrystalline dolomite and pelmoldic porosity and have their maximum development in the southeastern part of the field.

Carbon and oxygen isotopes and strontium ion concentration data suggest that fresh or brackish fluids have played some role in the development of porosity in the Smackover carbonates.

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Depositional Environments and Porosity Evolution, El Abra Limestone (Cretaceous), Mexico

Reservoir quality in the middle Cretaceous Golden Lane oil field, Mexico, was enhanced by freshwater dissolution during subaerial exposure in the Late Cretaceous and early Tertiary. Study of the outcropping equivalent El Abra Limestone in the type area demonstrates the presence of repeated emergence and submergence and the formation of subaerial discontinuity surfaces.

Physical correlation has been established between El Abra quarry sections. This dovetails with a corresponding correlation of discontinuity surfaces to provide a series of reliable horizons on which to construct a shelf-edge model.

Near back-reef rocks are characterized by thin (3 m) shoaling-up sequences usually capped by thick (to 10 m) supratidal and island sequences. Storm washover deposits with strong calcrete overprint are interbedded with penecontemporaneously dolomitized supratidal rocks. Freshwater dissolution during emergence produced voluminous moldic and vuggy porosity, subsequently reduced by interlayered marine internal sediment and a radiaxial fibrous cement mosaic. Platform-interior rocks are characterized by thick subtidal deposits and 3 to 5 m shoaling-upward sequences attributable to tidal flat progradation in the lee of shelf-edge islands or the migration of tidal channels. Paleosols and karstic surfaces are present at the tops of several cycles. Moldic and vuggy porosity developed during subaerial exposure was reduced by vadose and marine internal sediment. Radiaxial fibrous cement mosaics are not present.

Porosity development in the El Abra type area is a result of synsedimentary emergence. Porosity was of local extent and largely occluded by processes active during succeeding sedimentary episodes. Post-El Abra freshwater leaching appears to have been minor. Contrasts in reservoir development between the Golden Lane and the comparatively tight El Abra type area may reflect differences in later exposure.

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Sedimentary-Exhalative Pb-Zn Deposition, Grum Deposit, Anvil Range, Yukon, Canada

The Grum deposit is one of eight stratiform shale-hosted massive zinc-lead-barite mineral deposits located in the Anvil Range, Yukon. Host sediments were deposited in a Lower Cambrian extensional basin within a trailing margin miogeoclinal wedge. During the Mesozoic, the ore deposits and their host sediments underwent lower greenschist grade metamorphism and complex deformation related to intrusion of the Cretaceous anvil batholith.

The Grum deposit consists of two sulfide horizons which were isoclinally folded into a first phase fold closure that was subsequently refolded into recumbent S-shaped second phase folds plunging to the northwest. The southeastern section of the deposit is disrupted by both steep and low angle faults.

Sulfide deposits occur at a stratigraphic transition between non-