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Effects of Arkosic Sandstone Diagenesis on Reservoir Rock Properties

Upper Miocene channel turbidite sandstones of Yowlumne and Rio Viejo fields, southern San Joaquin Valley, California, are clean arkoses buried to depths of 11,000 ft (3,550 m) or more. Petrographic analyses of cored intervals from seven wells show that these medium-grained sandstones have no detrital constituents other than quartz and feldspars (at an approximately 2:1 ratio). The relative abundance of K-feldspar to plagioclase, however, varies among the intervals studied. This variation has given rise to different paths in clay authigenesis, which then control reservoir-rock properties. Nearly all clays, which constitute from a few percent to more than 20% of the rocks, are derived from feldspar alteration.

Sandstones with high K-feldspar relative to plagioclase yield clay assemblages dominated by kaolinite, with minor amounts of illite and vermiculite. Those with high plagioclase content yield abundant expandable clays. Chlorite is practically absent in all intervals studied. Besides detrital composition, abundance and mineralogy of the clays are also affected by depth of burial of the rock.

Feldspar alteration has resulted in porosities in the range of 14 to 20% and permeabilities up to 200 md at depths of 11,000 to 15,000 ft (3,550 to 4,570 m). In contrast, other reservoirs of different composition in the same area have greatly reduced reservoir properties at the same depths. Knowledge of sandstone composition and diagenesis, therefore, is important to exploration.

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Geology of University Waddell Devonian Field, Crane County, Texas

The primary production in the University Waddell field in Crane County, Texas, is obtained from Devonian siliceous carbonates. Since its discovery in 1948, the field has produced 42 million bbl of oil through primary and secondary production.

The field's structure is an asymmetric anticline created by the upthrown side of a reverse fault. The anticline dips steeply into the fault on the west side of the crest and dips gently away from it on the east. The seal and source rock for the field is the Woodford Shale (Devonian), a black pelagic shale. Updip migration from the Woodford provided the source for the three productive zones in the reservoir rock. Production is directly related to fracture porosity (7 to 12%) in beds with abundant replacement chert. Permeability through the productive zones is discontinuous and generally low (less than 5 md). The fractures in the Devonian siliceous limestones developed as a response to Pennsylvanian compression that created the reservoir structure.

The siliceous lithologies make up 60% of the Devonian sequence. The cherts are black, white, or gray and occur in brecciated or massive beds. Associated limestones are light-gray bioclastic packstones.

The chert is thought to be of secondary origin. The silica was derived from in-situ spiculites, locally reprecipitated as chert. A basinal environment is interpreted for the Devonian siliceous limestone and carbonate units. The Devonian carbonates deposited after the Silurian pelagic shales indicate a period of shallowing in the basin.

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Geometry of Tertiary Coal Seams as a Response to Changes in Structural Framework

Diminished subsidence of the Williston basin at the end of the Cretaceous was followed by accumulation of thick lignite seams in the Ravenscrag Formation (Paleocene). The formation of seven coal fields in southern Saskatchewan was also influenced by contemporaneous subsidence structures that originated as collapse of overlying strata above areas of salt leaching from the buried Devonian Elk Point evaporite basin. Lignite seams, up to 10 m thick, accumulated in successively younger coal fields that prograded to the southeast across southern Saskatchewan toward the cratonic depocenter in western North Dakota. The shape of the older coal basins conformed to the areas of salt solution activity and both the coal fields and component beds accumulated as circular forms. Salt-solution collapse effects diminished upsection with more pronounced cratonic influence that originated with intermittent movements between Precambrian crustal blocks forming the Williston basin. The thicker areas of coal seams in the middle of the 300-m coal-bearing section accumulated parallel with the cratonic lineaments but oblique to the coal-basin forms that retained a geometric relation to the salt solution. The uppermost coal basins were almost completely dominated by cratonic influence with thick coal bed areas parallel with cratonic lineaments and dispersed in a reticulate pattern. Younger coal fields distant from the cratonic depocenter were elongated parallel with lineaments oriented toward the cratonic depocenter, whereas coal fields next to the center of the Williston basin accumulated as arcuate forms along the strike of the basin. The activity of salt-solution subsidence structures during the formation of the uppermost coal fields was sufficiently weak to favor greater regional bed thickness but not affect lateral basin form.

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Breccias, Mudflows, Turbidites, Fossil Soils, or Transposition Structures? A Case Study from Eocene Green River Formation, Wyoming

Sedimentary structures in carbonate micrite sediments of the Green River Formation (Eocene) have been interpreted as breccias, mudflows, turbidites, or fossil soils. After careful study of these sediments and their vertical and lateral associations, they are actually seen to be transposition structures that result from intrastratal viscous or hydroplastic flow.

Some of the features that are associated with the soft-sediment deformation include microfaults, microfolding, flair structures, ball-and-pillow type structures, lense- and tear-shaped intraclasts, lineated intraclasts, unusually shaped intraclasts, "roof-pendant" intraclasts, and "fluidized" sediment.

When deformed units are traced laterally for even small distances (< 1 m) they may grade into undeformed units. Many units form boudinage structures and completely disappear laterally for short distances. Discontinuous "breccias" can be traced laterally or vertically in many instances to intact, undisturbed sedimentary units. Vertical associations are large-scale arcuate or fold structures (wavelengths 3 to 4 m), soft-sediment injection features, and mudcracks up to 2 m deep.

This case study points out the necessity of caution when interpreting carbonate micrite sediments that contain intraclasts that may at first appear diagnostic of primary breccias, mudflows, turbidites, or fossil soils.

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Depositional Systems on Upper Jurassic Smackover Carbonate Ramp: Sedimentology of South Texas Frontier Play

The Smackover Formation, which is economically significant throughout the Gulf Coast region, is virtually untested in south Texas. The Smackover and lower part of the Buckner formations comprise a thick regressive sedimentary sequence deposited on a carbonate ramp. Four major depositional systems are recognized: (1) basinal, (2) open shelf, (3) shoal, and (4) sabkha. High-energy grainstone facies were concentrated landward; muddy low-energy facies were deposited seaward.

Basinal facies are dominated by laminated carbonate mudstones, deposited from suspension, and irregularly laminated carbonate mudstones, the product of sediment reworking by oscillatory bottom currents. The outer *shelf* facies is characterized by burrowed carbonate mudstones containing crustacean pellets and a pelagic fauna. The inner-*shelf* facies is composed of burrowed wackestones containing a benthic fauna. Burrowed oncolite and pellet packstones characterize the outer-*shoal* facies and cross-bedded mixed-allochem, oolite-intraclast, and oolite grainstones compose the high-energy, inner-*shoal* facies. The *sabkha* system consists of cyclic subtidal to supratidal facies. Subtidal units are burrowed gastropod-pellet wackestones and oolite wackestones to grainstones, whereas the intertidal facies is characterized by cross-laminated sandstones and algal-laminated dolomite mudstones. The supratidal facies consists of anhydrite intercalated with carbonate and terrigenous mud, and siliciclastic sand and silt.

Reservoirs as thick as 33 ft (10 m), with porosity ranging from 4 to 26% and permeabilities ranging from 0.1 to 6.5 md, have been cored at depths below 18,000 ft (5,486 m). Nearly complete dolomitization has resulted in the development of intercrystalline porosity in inner-shelf wackestones and shoal-complex grainstones. In addition, some grainstones have subsurface-derived secondary oomoldic porosity.

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Pre-Cretaceous Geologic History of Deep Southeastern Gulf of Mexico

Analysis of seismic data and the results of DSDP Leg 77 reveal a complex pre-Cretaceous, pre-rift to post-rift geologic history for the deep southeastern Gulf of Mexico that is probably related to the early opening of the North Atlantic. The area is underlain by an extensive rifted and attenuated continental crust or transitional crust formed mainly in Late Triassic through Jurassic time owing to large-scale translational motions as the Yucatan–South American block pulled away from North America. Shallow holes drilled into the tops of tilted basement blocks encountered examples of this transitional crust (early Paleozoic metamorphic rocks intruded by Mesozoic diabase). The rifted basement is infilled and covered by an extensive syn-rift sequence of probable Jurassic age and nonmarine origin (up to 2 km thick). Interpreted within this sequence is a narrow north-south-trending salt basin, which may be equivalent to the Louann salt in the northern Gulf basin and the salt in Cuba. Rifting mainly occurred during Late Triassic through Jurassic time, although in one broad area faulting and collapse of the basement apparently continued into the Early Cretaceous. The syn-rift sequence is overlain by a thick post-rift section of marine sedimentary rocks. DSDP Leg 77 drilled the upper part of the sequence and encountered a complete section of Lower Cretaceous deep-water carbonates. The lower part of the sequence lying below the deepest horizon drilled (Berriasian) has a similar character and is inferred to represent Upper Jurassic marine rocks, probably equivalent to the Late Jurassic (post-Louann) marine transgression observed around the periphery of the Gulf.

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Facies, Fabrics, and Porosity, Duperow Formation (Upper Devonian), Billings Nose Area, Williston Basin, North Dakota

The Duperow is a substantial hydrocarbon-producing formation in the "Billings Nose" area. Included in the Billings Nose are the TR (Theodore Roosevelt), Big Stick, Whiskey Joe, Four Eyes, White Tail, Fairfield, Elkhorn Ranch, and Tree Top fields.

Duperow rocks consist principally of dolomites, limestones, and anhydrites. Most of the dolomites appear to be of diagenetic origin although some primary dolomites do occur. Primary dolomites are parallel and wispy laminated mudstones, deposited principally as part of the supratidal facies in association with stromatolites. Secondary replacement dolomites occur throughout the section, but seem to selectively replace the matrix in the stromatoporoid zone of the shallow subtidal facies and intraclasts in the intertidal facies. Included in the supratidal facies are anhydrites. Anhydrites range in habit from the typical replacive nodules to the less common "chickenwire" and layered forms. Layered types appear to be associated with ephemeral hypersaline ponds in the supratidal. In general, porosity is poor in this facies.

The intertidal facies consist of intraclastic wacke-packstone. Intraclasts and fragmented brachiopods and mollusks are the principal allochems. Bioturbation has destroyed most laminations. Apparent selective replacement of intraclasts constitute the majority of the porosity in this facies.

The subtidal facies includes stromatoporid and bioturbated zones. Sparsely fossiliferous wackestones are the predominate fabric, but stromatoporid boundstones and coral, brachiopod packstones are common. Good intercrystalline porosity occurs in the matrix of the stromatoporid zone.

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Facies, Fabrics, and Porosity of Kaskaskia Rocks in Williston Basin, North Dakota

Kaskaskia rock sequences in the Williston basin, North Dakota, comprise most major carbonate facies, fabrics, and porosity types. Stratigraphic units discussed are the Mission Canyon, Ratcliffe, Frobisher Alida, Bakken, Birdbear, Duperow, Winnipegosis, and the Ashern formations. All of these have produced substantial amounts of hydrocarbons except the Ashern Formation. Slabs of cores show different facies, fabrics, and some porosity types associated with each.

Kaskaskia sequence deposits represent a period of waxing and waning sedimentation during overall transgression and regression of the late Paleozoic. Facies represented, except for the Ashern, are cyclic, composed of supratidal, intertidal, and subtidal depositional settings. Ashern facies are supratidal to highest intertidal. Some facies can be further subdivided into