slide deposits. The overlying laminites also are interpreted as turbidites (or deposits of salinity-driven bottom currents). Calcium carbonate and sulfate precipitated over shoals (the former banks) were transported basinward. Initially, basin-floor waters were undersaturated with calcium sulfate and only carbonate laminites persisted. With increasing basin-floor hypersalinity the sulfate persisted and carbonate-anhydrite (later, anhydrite) laminites formed.

Identical carbonate-anhydrite laminites occur within the Ordovician Red River, Stony Mountain and Stonewall Formations, forming the upper members of carbonate-evaporite cycles. Starved basin bituminous mudstones are absent or poorly developed. The thickness, lateral persistence (across and along depositional strike), and the absence of structures indicating emergence suggest that Ordovician laminites did not form in intertidal-supratidal environments.

The Ordovician laminites are believed to have accumulated within local depressions (perhaps quite shallow) which collect hypersaline brines. Brines were generated on neighboring platforms, sites of essentially no net deposition. Carbonates and gypsum, precipitated on the platform, were episodically introduced into depressions by high-energy events (storms, turbidite? flows).

In both Devonian and Ordovician laminites, mass-movement of sediment downslope, the incompetency of sulfate laminae, partial or extensive replacement of carbonate by anhydrite, and possible dehydration of primary gypsum to anhydrite caused local deformation and disruption of laminated sediments, converting them to rocks superficially resembling those formed in sabkha environments.

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PETROLOGY AND PALEOGEOGRAPHY OF MISSISSIPPIAN MADISON FORMATION IN WESTERN SASKATCHEWAN

In western Saskatchewan the Mississippian carbonate rocks may be categorized into 5 lithofacies, which individually or collectively can be used to assist the interpretation of the various environments of deposition. The five categories are: (1) impoverished calcareous mudstone, (2) skeletal calcareous mudstone, (3) micritic skeletal or nonskeletal sandstone, (4) poorly washed skeletal sandstone, and (5) calcite-cemented skeletal or nonskeletal sandstone.

The impoverished calcareous mudstones dominate the lower part of the Mississippian succession, particularly in the southern part of the study area, where they are composed of bituminous and argillaceous materials as well as nonargillaceous calcareous mudstones. The impoverished calcareous mudstones probably represent sediments deposited in water below wave base on the seaward side of the shelf edge.

Collectively, the skeletal lithofacies probably represent shelf-edge deposits. Calcite-cemented crinoidal sandstones accumulated as thick, elongate banks. The poorly washed sandstones are generally at the top and bottom of the banks and the interbank areas show outward gradations from micrite skeletal sandstones on the flanks of the banks to skeletal calcareous mudstones in the centers of the interbank areas. Micritic skeletal sandstones also form blanket deposits that commonly act as platforms upon which the crinoidal banks were built.

The nonskeletal sandstones (primarily composed of oolites) probably represent subtidal deposits on the shoreward side of the shelf edge. In the central part of western Saskatchewan they are present in the lower part of the succession and pass laterally southward into shelf-edge deposits. Farther south they are found at higher stratigraphic levels, and they are in lateral continuity with and overlie shelf-edge deposits. The relationships suggest a regression of open marine conditions from north to south.

If the Mississippian sequence of southeastern Saskatchewan is used as an analogy, a dolomite-evaporite facies representing a supratidal environment probably existed north of the subtidal deposits, that is, beyond the present subcrop edge of the Mississippian in western Saskatchewan.

This postulated distribution of facies suggests that possible hydrocarbon reservoirs similar to those of the Virden area of Manitoba are present in subtidal and shelf-edge deposits along the Mississippian subcrop in Saskatchewan.

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WATTENBERG FIELD, DENVER BASIN, COLORADO

Wattenberg field is a large gas accumulation (1.1 Tcf) in the "J" sandstone of Cretaceous age. The trap was formed in the delta-front environment of a northwesterly prograding delta.

The field is a stratigraphic trap straddling the axis of the Denver basin. Reservoir rock quality is poor and fracturing by artificial means is necessary to test a well.

Large extensions to the field may be made by following the delta-front environment trend. Industry exploration efforts will be dependent on gas price economics.

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SEDIMENTARY FACIES AND CORRELATIONS OF GALLUP SANDSTONE AND ASSOCIATED FORMATIONS, NORTHWESTERN NEW MEXICO

The Gallup Sandstone of Late Cretaceous age is a regressive clastic wedge that prograded about halfway across the San Juan basin from a probable source in southwestern Arizona. Numerous closely spaced detailed surface sections, measured along the outcrop belt on the west and south sides of the San Juan basin and extending about 70 mi south of Gallup, New Mexico, into the Zuni basin, have facilitated detailed correlations of the complex of marine, coastal-barrier sandstones and associated nonmarine paludal mudstones and fluvial channel sandstones that comprise the formation. South of Gallup the Pescado Tongue of the Mancos Shale separates the Gallup into two parts; a lower part called the Atarque Member of early Carlile to early-late Carlile age, and an upper part of latest Carlile to possibly earliest Niobrara (?) age. Only the upper part is present in the San Juan basin.

Physical tracing of some of the units indicates discrepancies of former correlations. The Horsehead Tongue of the Mancos was found to be the same unit as the Pescado Tongue, and hence the term should be abandoned. The widely distributed Juana Lopez (Sanostee) Member of the Mancos Shale was traced southeast of Gallup where it grades into a nonmarine sequence below the Pescado Tongue. Hence, the Pescado Tongue is younger than formerly considered, and undoubtedly is equivalent to the lower half of the D-Cross Tongue in the southeast. The upper pink fluvial sandstone of the type area near Gallup has been traced to the north where it merges with the coastal-barrier sequence north of Sanostee. The name Torrivio Sandstone Member of the Gallup is proposed for this unit. On the east, along the outcrop belt, it pinches out into nonmarine paludal mudstones of the Dilco Coal Member of the Crevasse Canyon Formation.

The basal transgressive upper Mancos Shale of early Niobrara age, which extends to a few miles northeast of Gallup, overlies the Gallup and associated nonmarine deposits of the Dilco. In the northwest corner of New Mexico and the southwest corner of Colorado, this transgression truncates as deep as the Juana Lopez interval. A belt 15-20 mi wide, in which the rate of truncation is greatest, coincides with the location of the so-called Gallup oil fields or pools which produce from lenticular marine sandstone bodies associated with Niobrara transgression. On the south side of the San Juan basin, another type of transgressive sand, which has been informally referred to as the "Stray" sandstone, is an offlap sequence associated with the Niobrara transgression. All these sands are genetically unrelated to the type Gallup Sandstone.

A northwesterly trending shoreline prevails for most of the units of the Gallup and associated formations.