sippi, exerted significant control on the areal distribution of this facies. Porous and permeable intervals in the deeply buried Smackover are restricted to this facies. The most significant textural parameter of the dolomitic facies is crystal size. Finely crystalline dolostone is normally of low porosity and low permeability, whereas coarsely crystalline dolostone exhibits more-favorable reservoir properties.

The distribution of these diagenetic facies has important implications on future hydrocarbon exploration in the deeply buried Smackover Formation.

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Visual Kerogen Assessment of Thermal History

The microscopic particulate organic matter occurring in sedimentary rocks is referred to as visual kerogen when examined by use of strew slides prepared from a kerogen concentrate. Examination under a high-powered microscope in transmitted light yields information on both the organic matter type present and the level of organic metamorphism (LOM). This presentation concentrates on the LOM aspects of visual kerogen and addresses it from a utilization point of view.

The color of the kerogen, preferably plant cuticle fragments or pollen and spores, is used to determine the level of organic metamorphism. Various scales have been proposed to reflect this change in coloration. The TAI scale is most commonly used. Visual kerogen assessment is considerably less precise than vitrinite reflectance. It is a subjective call made by the analyst. Additionally, the equivalent reflectance range broadens as higher LOMs are attained. However, the ability to visually discern differences in the suite of organic material present can override its drawbacks in precision. Caved versus indigenous populations can be recognized, as can recycled versus primary vitrinite. Thermal history can also be established in sections that are barren of vitrinite. As is the case with nearly all organic geochemical techniques, reliable interpretations can be make if the limitations of the method are considered and the results are cross-correlated with other methods.

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Geochemical Investigation of Australian and New Zealand Crude Oils

Australian and New Zealand oils are derived predominantly from terrestrial source material. Relatively sparse information exists in the geochemical literature on the distribution of biomarkers in terrestrially derived crude oils. A detailed geochemical investigation of oils from a number of basins in this region has revealed interesting and unusual distributions of biomarkers. The compound classes that were analyzed included sesquiterpenoids, diterpenoids, triterpenoids, and steranes. From the information obtained, it has been possible to correlate the oils from several basins, in particular the Gippsland, Surate, and Carnarvon, into a number of source-related families. Evidence was also obtained that indicated a contribution from coal-like source material for many of the New Zealand oils.

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Emplacement Mechanism and Trapping Potential of Gravity-Driven Allochthons

Gravity-slide blocks of Paleozoic carbonate detached from the Snake River Range show evidence of episodic emplacement into the Salt Lake group (Mio-Pliocene) in the Palisades reservoir area near Alpine, Wyoming. The allochthons lie in a large graben system created by the Grand Valley listric normal fault, a reactivated thrust that soles into a ramp in the underlying Absaroka thrust. In the Alpine 7½-min quadrangle, one of the detached blocks is 2½ mi (4 km) by 1 mi (1.6 km) in map view and contains the Ferry Peak thrust as well as other Laramide structures. Structures and formations of the Alpine allochthon may be matched to those in the range to restore approximate predetachment position. Very low-angle westward translation at or near the surface moved the blocks across the Grand Valley fault into the graben. The current location and attitude of these allochthons are due to subsequent movement and rotation on the Grand Valley fault. The allochthons occur at different stratigraphic levels in the Salt Lake group, each level corresponding to the time of a specific emplacement event.

Catastrophic emplacement of a fractured allochthon, a potential reservoir, into a lacustrine or other source rock depocenter creates a unique and potentially predictable type of petroleum occurrence. Paleogeographic reconstruction may explain anomalous occurrence of discrete allochthons in structurally low areas where it can be shown that a gravitational potential existed for detachment and sliding. The resulting trap would consist of allochtons encased in autochthonous source rock.

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Geochemistry of an Insular Phosphate Deposit, Nauru, Equatorial Pacific

The world's largest insular phosphate deposit is found on Nauru, an uplifted coral atoll in the western equatorial Pacific. This deposit, which is draped over a dolomitized karstic surface, has an earthy pelletal texture; it is oolitic at its base and structureless in its upper part. The only phosphate mineral found is a carbonate fluorapatite with the stoichiometry $Ca_{10}(PO_4)_{5.6}(CO_3)_{0.6}F_{1.6}(OH)_{1-x}$. This mineral is slightly depleted in F^- and CO_3^{2-}, relative to PO_4^{3-}, to be considered a true francolite.

Abundant specimens of corals and micromollusks within the dolomite are representative of two contrasting atoll environments: a coral reef and a deep-water lagoon. The biostratigraphy has not been determined. Radiometric dates give a minimum age of 200,000 yr.

The source of the phosphorus is bird guano. The $\delta^{18}O$ and $\delta^{13}C$ values of the apatite and dolomite suggest that phosphatization occurred in meteoric water, possibly within and above a Ghyben-Herzberg lens; whereas dolomitization occurred in hypersaline water that refluxed from the lagoon when it became isolated from the open ocean during uplift. This interpretation is supported by the occurrence of as much as 15% gypsum in lagoonal sediments.

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Log-Analysis Problems Associated with Bimodal Pore System, Interlake Formation, North Dakota

The Interlake Formation is a Silurian-age sequence of dolostones, which produces hydrocarbons in the Williston basin. Log analysis of numerous Interlake wells from the Nesson anticline reveals that both water-productive and hydrocarbon-productive zones commonly have calculated water saturations in excess of 60%. These high calculated water saturations, in zones that produce water-free hydrocarbons, appear to be the result of a bimodal pore system.Non-fabric selective vugular pores are the major type of porosity seen in visual examination of Interlake cores. These vugs have been interconnected by fracturing and are responsible for most of the hydrocarbon production. The matrix that separates the vugs is composed of small equant dolomite crystals and also contains large amounts of intercrystalline microporosity, which is interconnected by pore throats less than 0.5 μm across. These small pore throats result in low permeability and high capillary pressures; thus the microporosity is capable of holding 100% irreducible water, whereas the vugular pores produce water-free hydrocarbons. Because it composes up to 50% of the total porosity, this microporosity drastically reduces the resistivity of the formation.

Recognition that a formation contains a significant amount of microporosity is important not only in preventing bypassed production, but also in determining reserves and exploration economics. Determination of the percentage of effective porosity cannot be made using electric log or conventional core analysis. A combination of special core analysis and petrographic techniques is needed to better define the amount of effective porosity.

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Cenozoic and Upper Cretaceous Sedimentary Facies of New Jersey Continental Slope and Rise

Recent Deep Sea Drilling Project (DSDP) coring along U.S. Geological Survey (USGS) multichannel seismic lines 25 and 35 provides direct sampling of the depositional sequences that constitute the lower continental slope and upper continental rise of New Jersey. The sedimentary record from four core sites, integrated with a closely spaced grid of multichannel seismic profiles, reveals 12 depositional sequences in the upper Campanian to Quaternary section that are bounded by erosional unconformities. Equivalent unconformity-bound depositional sequences are present on the contiguous continental shelf and upper slope; most sequences have counterparts in the Vail depositional model. Of particular interest is a complicated, stacked series of buried erosional channels dramatically displayed on seismic lines paralleling the depositional strike of the upper continental rise. The channels, which cut the upper surface of nearly every depositional sequence, probably formed during periods of low sea level. Channels on the lower Eocene surface display the greatest physiographic relief. Integration of seismic and bore-hole data suggests alternative correlations for several stratigraphically significant regional reflectors, such as A^*, A^c, and A^u.

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Early Diagenetic History of Late Pennsylvanian Calclithite Beds, Hueco Mountains, El Paso County, Texas

Calclithite beds exposed on the western escarpment of the Hueco Mountains were deposited in a fan-delta system featuring fluvial channels, marine bars or beach sands, shallow-marine shale and limestone, and tidal flats and lagoons. Two distinct calclithite types occur. One is a coarse, poorly sorted gravelly sand with angular to subrounded grains. This type occurs in discontinuous or channel-shaped beds. Sedimentary structures include fining-upward sets, imbrication, and trough cross-bedding. These characteristics indicate sporadic unidirectional flow, as would be expected in ephemeral streams. The second calclithite type is fine to medium-grained well-sorted sand with very well-rounded grains. This type crops out as thin, relatively continuous units. Sedimentary structures include ripples, small-scale cross-beds, low-angle and horizontal or planar bedding.

The early diagenetic history of the calclithites reflects their depositional environment. The coarse calclithite was deposited in undersaturated freshwater conditions, shown by the absence of early cement. Early compaction of the coarse calclithite, indicated by intergranular microstylolitization and shale-clast deformation, is the most commonly observed texture. The fine-grained calclithite exhibits a markedly different diagenetic history. The first recognizable "diagenetic" event is micritization of marine-derived fossils and calclithite grains. Early cementation in the marine phreatic environment resulted in isopachous rims of fibrous aragonite and bladed Mg-calcite cement. Pore centers contain a later equant calcite cement. Little or no early compaction occurred in the fine calclithite. Freshwater flushing is indicated by the replacement of former aragonite cement rims by finely crystalline equant calcite.

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Environmental Significance of Evaporitic Textures of Mississippian Mission Canyon Formation, Williston Basin, North Dakota

The Mission Canyon evaporite wedge, the Frobisher-Alida interval, has commonly been interpreted as typical nodular or "chicken-wire" anhydrite from a sabkha depositional setting. Upon examination of over 190 cores from North Dakota and Montana, we identified a variety of evaporite textures and interpreted several distinct origins for them. The following evaporite textures were recognized: (A) precipitative or primary, (B) intraclastic, (C) evaporite cement, (D) replacement, and (E) dissolution-stage.

Depositional evaporites (A, B) form by direct precipitation in supersaturated solutions (primary texture) or by reworking of primary evaporite (intraclastic texture). Primary texture forms by direct precipitation from a supersaturated brine occurring in shallow lagoons or tidal ponds (subaqueous evaporite) or within the sediment (nodular anhydrite). Three types of subaqueous textures were identified: (1) isolated laths, (2) rosettes or clusters of laths, and (3) large "swallowtails." Intraclastic texture results from the reworking of previously precipitated evaporite. It is recognized by angularity of the clasts, size sorting, and association with carbonate intraclasts. Depositional environment of this texture is interpreted as evaporitic shallow-water lagoons, punctuated by occasional storm events.

Diagenetic textures include cementation, replacement, and evaporite dissolution. Cementation by evaporite was found primarily in carbonate grainstones and is usually poikilotopic. Replacement textures may develop early or late in the diagenetic history of the rocks. Early replacement was found in primary restricted carbonate facies. Original texture (algal laminations, bioturbation, carbonate grains) were usually preserved after replacement. Late-stage replacement was observed in more marine facies, with the original texture not preserved. Isolated nodules of fibrous anhydrite result.

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Exploration Applications of a Transgressive Tidal-Flats Model to Mississippian Midale Carbonates, Eastern Williston Basin

Midale (Mississippian) production was first indicated in 1953 in Saskatchewan, Canada. The unit was initially defined in the subsurface as the carbonate interval between the top of the Frobisher Anhydrite and the base of the Midale Anhydrite. This same nomenclature is used in this paper. In 1953, Midale production was found on the United States side of the Williston basin in Bottineau County, North Dakota. Later exploration extended Midale production westward into Burke County, North Dakota, in 1955. Cumulative production from the Midale is approximately 660 million bbl with 640 million from the Canadian side of the Williston basin.

Initially, hydrocarbon entrapment in the Midale was believed to be controlled by the Mississippian subcrop, with the Burke County production controlled by low-relief structural closure. Petrographic examination of cores and cuttings from the Midale in both Saskatchewan, Canada, and Burke and Bottineau Counties, North Dakota, indicates that production is controlled by facies changes within the unit. Stratigraphic traps are formed by the lateral and vertical changes from grain-supported facies deposited in tidal-channel, subtidal-bar, or beach settings; seals are formed by mud-rich sediments. Use of a transgressive carbonate tidal-flats model best explains current production patterns and indicates substantial potential for additional production in eastern North Dakota and South Dakota.

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Provincial Variations in Cap Rock Source Materials of Gulf Coast Salt Domes

Isotopes of strontium, carbon, and oxygen are used to model hydrocarbon, brine, and meteoric fluid interactions during cap rock evolution. Provincial isotopic variations occur between older salt domes of the east Texas (ETx) and northern Louisiana (NLa) basins and the younger domes of the Texas-Louisiana (Tx-La) coastal basin. ETx and NLa cap rocks exhibit normal, mid-Jurassic seawater values ($^{87}Sr/^{86}Sr = 0.7068$ to 0.7076), very wide $\delta^{13}C$ ranges (-5 to -49 per mil PDB) and $\delta^{18}O$ values (-6 to -11 per mil PDB) that are slightly lighter than Tx-La (-4 to -10 per mil). Tx-La domes yield remarkably high $^{87}Sr/^{86}Sr$ ratios (0.7073 to 0.7100), and their $\delta^{13}C$ values (-8 to -41 per mil) have means which are 5 to 15 per mil heavier than ETx and NLa domes.

Detailed studies of the Hockley dome (Tx-La basin) reveal chemical diversity not recognized in domes farther inland. Anhydrite from the salt stock (mid-Jurassic Louann evaporites) mixed with two separate strontium sources during calcite formation. Calcites near the dome's center formed from an intermediate Sr ratio fluid ($^{87}Sr/^{86}Sr \cong 0.7090$), which, based on heavier than average $\delta^{13}C$ values, was enriched in CO_2 relative to CH_4; peripheral calcites evolved from a high Sr ratio fluid ($^{87}Sr/^{86}Sr \cong 0.7105$) with a lower CO_2/CH_4 ratio.

High $^{87}Sr/^{86}Sr$ ratios in other Tx-La anhydrite cap rocks compared with normal mid-Jurassic type values in ETx and NLa cap rocks suggest