

detected between the facies, owing to the high percentage of preserved intergranular porosity in the sand sheet. Intergranular porosity is preserved by the development of thick clay coats, composed of illite and smectite, which inhibited porosity reduction by quartz and potassium feldspar overgrowths.

The clay coats are derived from mechanically infiltrated wind-blown clay deposited penecontemporaneously with the sand. This type of clay deposition is common in modern deserts. The thickest clay coats develop in facies where the grains undergo the least abrasion, such as sand sheets and interdunes. Therefore, upon lithification, sand sheets and interdunes will retain a high percentage of their intergranular porosity and will not act as permeability barriers to fluid migration.

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Electron Microprobe Study of Mg Distributions in Recent Mg Calcites and Recrystallized Equivalents from Miocene of Eniwetok Atoll

To determine the effect of early freshwater diagenesis on Mg distributions in former high Mg calcite (HMC) cements, Mg distributions were determined by electron microprobe analysis of two groups of samples as follows: (1) HMC in limestones not yet exposed to fresh water, and (2) HMC and recrystallized equivalents after freshwater exposure. Mg varies little in pristine HMC, and traverses through the cements show no trends or large-scale zonations. Mg content is not related to inclusion abundance. Former HMC from the Miocene of Eniwetok Atoll, most of which are now radial, prismatic calcites, have a much greater variation in Mg content, and traverses through the calcites display definite trends. Generally, the Mg content of the calcite is inversely correlated with abundance of inclusions.

The small variation in Mg content in original HMC cements is a valuable point to be aware of when interpreting Mg trends in recrystallized equivalents. Because Mg content can be related to inclusion abundance in recrystallized, former HMC, but not in pristine HMC, Mg trends in the altered materials most likely reflect dissolution/precipitation processes, not original Mg trends. A likely cause for the low Mg content associated with inclusion-rich growth layers in the recrystallized Mg calcites is relatively high rates of dissolution and reprecipitation in these relatively permeable layers. In some places, the cloudy growth layers and increased permeability are due to infestation by endoliths. Such organisms may often cause the cloudiness observed in other radial calcites.

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Attempted Heuristic Approach to Total Potential Estimation of a Petroleum Basin

Several methods have been described in the literature which attempt to estimate the total hydrocarbon resources of large terranes, based on the concept of the petroleum basin. The approach described here employs heuristic procedures which incorporate optimization methods, and are applied to data files drawn from the world's major petroleum basins. Basin variables used include the area, thickness and volume of the sediments, characteristics of facies models, sedimentary cycles, and sedimentary rates; the historical record of depositional and tectonic events; environmental setting; geothermal gradients; potential of viable reservoir units. A diagnostic relationship is developed from a summation of linear nondecreasing functions, each linked with a specific variable.

The goals of this study include a numerical classification of the petroleum basins of the world, the isolation of variables which are both diagnostic and satisfactory, together with evaluations of their individual information content, and the development of a predictive technique for the estimation of the total potential in newly explored territories.

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Source-Rock Analysis, Bear River Formation, Western Wyoming Overthrust Belt

Source-rock analysis was performed on shales from the Lower Cretaceous (Albian) Bear River Formation in the Darby thrust plate of the western Wyoming overthrust belt. Measurements of total organic carbon (TOC); vitrinite reflectance ( $R_0$ ); visual kerogen analysis, including determination of thermal alteration index (TAI) and kerogen morphology; and pyrolysis provide information concerning the amount, type, and maturation levels of kerogen in the Bear River shales. TOC analysis indicated that the shales are moderately rich in organic matter (1.0 to 1.5 wt. % TOC). Kerogen morphology (structured) and pyrolysis data (suggestive of type III organic matter) indicated that organic matter in the Bear River Formation is humic and gas prone. TAI and  $R_0$  values suggest that Bear River shales are in the oil-early gas-generating range (0.7 to 1.1%  $R_0$ ) in the northern and southern parts of the Darby plate whereas organic maturities are substantially more advanced (1.8 to 2.0%  $R_0$ ) in the central part of the plate.

The levels of thermal maturation, as defined by TAI and  $R_0$  values, were used as constraints on a Lopatin-type time temperature index (TTI) thermal model. The TTI modeling suggests that normal depositional burial could account for the levels of thermal maturation observed in the northern and southern parts of the Darby plate, whereas an additional heat source, possibly burial of the Bear River Formation beneath the Absaroka thrust plate, is necessary to account for the relatively advanced thermal maturation measured in the central part of the Darby plate.

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Dissolution Kinetics of Biogenic Carbonates—Effects of Mineralogy, Microstructure, and Solution Chemistry

Previous models of early carbonate diagenesis assume mineralogy controls alteration sequence, with magnesian calcites dissolving more rapidly than aragonites. Results of this study indicate that: (1) mineralogic effects can be overridden by microstructure; and (2) dissolved magnesium enhances dissolution rates.

The study determined laboratory dissolution rates of biogenic grains found in modern carbonate environments and evaluated the relative importance of grain mineralogy, microstructure, and solution chemistry by determining dissolution rates at various undersaturations in seawater and in freshwater solutions containing different amounts of dissolved magnesium.

Although aragonitic grains dissolved more rapidly than low-magnesian calcites of the same grain size, most aragonites also dissolved as fast, or faster than, magnesian calcites containing 12 to 17 mole %  $MgCO_3$ . Mineralogy alone, then, is not the sole control on reactivity.

Dissolution rate is also affected by microstructure. Microstructure determines the amount of surface area available for dissolution and may exert greater control over reactivity than

mineralogy. For example, the porous but smooth surface of an echinoid (magnesian calcite) dissolves much more slowly than aragonitic coral and gastropod grains, which have more complex microstructures.

The presence of dissolved magnesium enhances rates of dissolution, but does not strongly affect the relative reactivity between different grain types. The absolute dissolution rates show a strong progressive decrease in magnesium-depleted solutions.

Thus, assumption of mineralogic control over grain reactivity during early diagenesis is an oversimplification. Microstructure and solution chemistry emerge as important variables with predictive power for modeling both porosity development and diagenetic evolution within carbonate sequences.

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#### Diagenetic Fabric and Structures in Ordovician Slope Limestones

The very thin continuous bedding characteristic of the calcareous Ordovician slope sediments from western Newfoundland and Virginia is not a primary depositional fabric but a severe diagenetic modification caused by extensive physical compaction and pervasive pressure solution. The very thin-bedded (0.1 to 0.5 cm) units commonly are only 20 to 30% carbonate, but occur in a sequence with thicker (1 to 20 cm) limestone turbidite layers.

Some groups of very thin layers thicken laterally into elongate limestone lenses composed of quartzose, peloidal, and radiolarian-sponge spicule packstone to wackestone. Layers in the lenses have a primary depositional fabric. Each layer thins away from the lens by 50 to 80%, but is generally traceable for over tens of meters or from lens to lens where they are repetitive along bedding. As a layer thins away from a lens, fine carbonate is lost and peloids and most other carbonate grains are partly to completely pressure solved against more resistant grains or along fine solution seams. Radiolaria become crushed and spicules reoriented from essentially random to parallel with layering. Individual layers are commonly traceable from lens to lens with no change in amount of insoluble quartz, spicules, or other resistant grains.

The thickened layers associated with limestone lenses are interpreted to be remnants of once-continuous layers that have been dramatically thinned through pervasive pressure solution.

Further, there are numerous very thin layers that cannot be traced into a thicker limestone-rich zone. These layers are very similar to those which pass into thicker lenses. It is very probable that each of these layers is a remnant of a once much thicker carbonate-rich layer.

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#### Quaternary Mixing-Zone Dolomite, Eastern Yucatan Peninsula

Dolomite occurs in Pleistocene limestones a few meters below the water table on the eastern margin of the Yucatan Peninsula. It is present in five of seven cores (surface to depth of 11.5 m) which penetrate three stratigraphic units, the youngest of which is dated at 122,000 years B.P. Each unit consists of platform-margin reefs and back-reef facies, and there are no indications of evaporites or restricted conditions during deposition.

The most extensive dolomitization (up to 48 wt. %) is in the on-ly reef-facies core from the middle unit. This core is calcite and dolomite in contrast to three cores in the back-reef facies which are calcite and aragonite. Dolomite occurs in a variety of forms

including: (1) coarsely and finely crystalline pore-lining cement, (2) finely crystalline replacement of matrix and bioclasts, and (3) internal sediment in dissolution cavities. Most of the dolomite cement is precipitated in molds of aragonitic fossils. There are three types of dolospar cement: (1) limpid euhedral to subhedral crystals ( $\text{Ca}_{57}\text{Mg}_{43}\text{CO}_3100$ ), (2) zoned crystals of dolomite and calcian dolomite ( $\text{Ca}_{63}\text{Mg}_{37}\text{CO}_3100$ ), and (3) corrugated layers of alternating calcian dolomite and calcite. The calcian-dolomite layers in the zoned crystals and in the corrugated layers are partly dissolved. Typically, adjacent pores within the same sample contain different types of dolomite and dolomite-calcite intergrowths.

The complex mineralogy of the middle unit is evidence that this limestone was subjected to several changes in phreatic-water geochemistry. Concurrent work by Hanshaw and Back demonstrated the existence of a geochemically active and fluctuating phreatic environment in the zone of freshwater and seawater mixing immediately inland from the Yucatan coastline today. Similar mixing zones must have passed through the Pleistocene limestones during past sea-level changes. The geologic setting, textures, and mineralogy of these young limestones suggest that their complex variety and occurrence of dolomite is best explained by mixing-zone diagenesis.

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#### Hydrologic Setting, Occurrence, and Significance of Gypsum in Late Quaternary Salt Lakes, South Australia

Well-exposed, commonly laminated gypsum sequences occur in many Quaternary salt lakes in southern South Australia. The gypsum in the salt lakes is classified by increasing grain size into gypsumite, gypsarenite, and selenite. The salt lakes are classified by age and hydrologic setting into (1) coastal salinas which are Holocene seawater-fed ground water lakes, and (2) continental playas which are late Pleistocene endorheic basins. A study of the relations between coastal salina hydrology and the associated gypsum deposition has shown that different types of gypsum form under distinct hydrologic regimes. As the hydrology above a coastal salina depositional surface changes through time, so does the type of gypsum deposited. Application of a gypsum depositional model derived from a study of the coastal salina gypsum to those parts of a continental-playa gypsum unit where deposition is no longer occurring confirms the applicability of the model to non-salina gypsum deposits.

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#### Early Carbonate Fabrics in Silurian Reefs of Gotland, Sweden

The Hogklint reefs of Gotland occur within a shallowing-upward sequence and are developed in the outer zones of a carbonate wedge adjacent to a shale belt. Shoal and peritidal sequences are the major carbonates which occur in the inner parts of the wedge and are preferentially associated with erosion surfaces.

The Hogklint reefs show carbonate fabrics that are inferred to indicate syndepositionary marine cementation of the reefs. These fabrics are: (1) pseudofibrous calcites that are believed to have replaced acicular/fibrous cements with original aragonite and/or Mg-calcite mineralogy, (2) pelmicspare-pelmicrite areas, (3) stromatolite-like crusts, and (4) early micritic cements. The reefs also show evidence of subaerial exposure by the occurrence of erosion surfaces at the top of the reefs, dissolution cavities, and vadose crystal silt infills in cavities in the algal biofacies which cap the reefs.