

upper parts of depositional units, paleosol-associated cements are common; caliche crusts, rhizocretions, needle-fiber cement, and lath-crystal cement are present. Phreatic-type cements are present, but generally are unimportant volumetrically. A reconstruction of the Pleistocene paleohydrology of the atoll indicates that the section has occupied the meteoric-vadose environment during emergent periods. The similarity of Pleistocene limestones beneath Eniwetok and other Pacific atolls studied by drilling suggests that, for many atolls, most alteration of shallow subsurface Pleistocene limestones has occurred in the meteoric-vadose diagenetic environment.

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Analysis of Hydrocarbon Distribution and Finding Rates Throughout United States Sedimentary Basins

These are interim results of a comprehensive long-range study of hydrocarbon distributions in the various sedimentary basins of the United States utilizing the computerized LORENDAS exploration data base. This data base, developed over the last 5 years, includes an exploratory well file, an oil field file, and a gas field file; together, they contain the principal statistical elements of exploration histories, as well as sedimentary volumes by depth zones, for each sedimentary basin in the United States. These data have been used to investigate correlations (1) between exploratory drilling density and observed oil field and gas field size distributions, accounting for depth and geologic setting; and (2) between cumulative exploratory drilling and discovery rates.

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World Oil Resource Assessments and Relation to United States Oil History

Over the last 30 years, there have been about 2 dozen assessments of world oil resources. These may be reduced to about a dozen independent assessments, based on various methods such as historical statistics, geologic analogy, etc. In 1977, there was a major contribution, the Delphi study (27 experts), for the Conservation Commission of the World Energy Conference. A detailed analysis of the answers to the Delphi poll leads to better understanding of the many factors which influence future world oil availability.

The role and relation of the United States are of particular interest. First, most of the assessments have been made by U.S. experts, and a major share of the world geologic expertise belongs to major U.S. companies. Second, because of its maturity, U.S. oil history is most often used as a model for other countries and/or world regions (this was implicitly used in the conclusions of the Delphi results to calculate possible world oil production curves). So, the opinion we have of real long-term oil potential of the United States heavily influences all the assessments regarding world oil resources.

However, it is also interesting to investigate what could be the results of various values of world oil resources on the future U.S. oil situation.

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Current Estimates and Methods of Potential Gas Committee

The Potential Gas Committee is the only group specifically organized for the exclusive purpose of estimating the potential future supply of natural gas in the United States. It is composed of about 120 people—geologists, engineers, and others from industry, government, and academic institutions. They have developed methods, definitions, and guidelines for making the estimates. The genius of the committee is the expertise of its individual members and their access to highly classified information not available elsewhere. No other group—corporate, academic, or governmental—has the experience, insights, and specific knowledge of the geology and future gas potential that this committee possesses collectively.

The potential gas supply is that volume of gas believed to exist in addition to proved reserves—gas not yet discovered by the drill. The Committee's estimates are based on intensive investigations covering the lower 48 states and Alaska. All potentially productive areas and geologic formations are considered. All available geologic data are included in the studies.

The basic technique is the comparison of factors that control known occurrences of gas with factors present in prospective areas. The estimates are divided into three categories—probable, possible, and speculative—which reflect the relative degree of geologic knowledge and exploratory data available.

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Gas Versus Oil in Far East and Middle East

The Far East, including Australia, is largely a gas province (the USSR and China are excluded from our study). The Middle East is largely an oil province with respect to Tertiary and Mesozoic reservoirs, and a gas province with respect to lower Mesozoic and Permian reservoirs. The geologic and geochemical parameters which determine the predominance of gas over oil or oil over gas are well known. They include type of source rock, source rock position in the total sedimentary sequence, burial history, temperature gradients, timing of hydrocarbon generation, and trap formation, retention, and related geologic factors. In the Far East, the relation between coal or coaly matter as source rocks and the occurrence of natural gas is obvious. Australia is a striking example. In the Middle East, the Sargelu formation is one of the most prolific source rocks. It is of Middle to Late Jurassic age, kerogenous and fully marine, which, in combination with other factors, explains the predominance of oil in Tertiary and Mesozoic reservoirs in and around the Arabian Gulf. At deeper stratigraphic levels, huge quantities of gas are ascribed to Paleozoic sources, the nature of which has not yet been fully assessed. Much of this gas, especially in southwest Iran, can be regarded as thermally degraded oil.

In areas of intense Neogene deformation (Tertiary basins of Indonesia and Burma), a large part of the gas phase has probably escaped, whereas the oil phase was largely retained. Many examples illustrate the validity

of the general principles without ignoring the complexity of the gas versus oil problem.

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Authigenic Illites in Sandstone Reservoirs

Authigenic illites have been found in pores of many sandstones which are known to be hydrocarbon reservoirs. Typical samples are from the Norphlet Formation in southern Mississippi, the Wilcox Formation in south Texas, and the Lance Formation in Wyoming. Illites in these sandstones are mainly in the form of laths with perfectly developed morphologies. Laths have widths of 0.1 to 0.3 μ and lengths ranging up to 30 μ . Scanning electron (SEM) images show that these "hair like" illites fill many of the pores of these sandstones, and cause a serious reduction in permeability. Elemental analysis of the laths with EDAX energy dispersive X-ray analyzer shows that Si, Al, and K are the major constituents and Mg is the minor constituent in the chemical composition of the laths. Transmission electron images show that illite laths have grown from an amorphous core which is rather similar to an irregular smectite aggregate. X-ray diffraction patterns display the coexistence of discrete illite (9.9 Å) with an illite/smectite mixed layer with a distinct reflection varying from 10.5 to 11.0 Å. In the sample from the Wilcox Formation the laths form regular arrangements which lead to the development of platelets.

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Geological Significance of LANDSAT Data on Some Known Giant Fields

No abstract available.

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Pore Types in Sunniland Limestone (Lower Cretaceous)

The Sunniland Limestone of south Florida produces hydrocarbons from five types of porosity in carbonate reservoirs. (1) Primary interparticle pores are volumetrically most abundant. Secondary pores after dissolution of aragonite are common but less abundant than primary pores and occur both as (2) matrix porosity and (3) vuggy porosity. (4) Fracture porosity is important in one reservoir and occurs at several localities in the lower Sunniland Limestone. (5) Intercrystalline pore space in dolomite occurs in thin intervals in several reservoirs. Any one reservoir contains two or more of the pore types.

Three types of dolomite are present in the Sunniland Limestone. A presumed early tidal-flat (sabkha) dolomite is composed of 1-to-10 μ m crystals that are strontium- and calcium-rich and iron-poor compared with other dolomite from the unit. The dolomite is enriched in C^{13} and O^{18} relative to PDB-1 standard. It is associated with tidal-flat sedimentary structures and is nonpo-

rous. A second dolomite, composed of crystals up to 500 μ m along an edge, is porous, iron-rich and strontium-poor relative to earlier dolomite, enriched in C^{13} but depleted in O^{18} , and is considered to be a later replacement. A rare third type of dolomite is petrographically distinct as pore-filling crystals up to 1 mm in width with markedly undulose extinction ("baroque" dolomite).

Cementation by a thin calcite fringe around grains and a later blocky calcite cement is present locally. The latter cement precipitated in part during or after compactional grain fracture. Sunniland carbonate rocks contain less than 100 ppm manganese, and a manganese/iron value below 0.06. These low values are believed responsible for a lack of cathodoluminescence in Sunniland limestones and dolomites.

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Porosity Preservation and Early Freshwater Diagenesis of Marine Carbonate Sands

Observations from Holocene and Pleistocene limestones of south Florida and the Bahamas provide the basis for a general outline of freshwater alteration of marine, primarily aragonitic, sands. Porosity and mineralogical data suggest that metastable carbonate recrystallization takes place before significant porosity loss. The outline proposes the following main points: (1) porosity is only slightly modified during mineralogical stabilization and early cementation; (2) secondary porosity development during early cementation preserves overall porosity; (3) early cements formed during metastable-phase recrystallization are almost entirely autochthonous on a reservoir scale. The time of stabilization may be as short as 10^4 years but may be slowed for long periods (e.g., by salt water intrusion, dry vadose conditions, stagnant water). Major porosity reduction occurs after stabilization and takes longer periods of time $>10^6$ years (e.g., extended period of subaerial exposure, burial diagenesis). Our observations of the effects of early freshwater diagenesis underscore the importance of later diagenetic events in porosity reduction of limestones.

This outline suggests that reservoir limestones developed through early freshwater diagenesis of aragonitic sands should be characterized by high porosity, most of which is secondary. Conversely, high-porosity reservoirs with considerable amounts of primary pore space have either escaped pervasive freshwater diagenesis or are developed in sediments that were originally calcite.

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Hummocky Cross-Stratification—Indicator of Storm-Dominated Shallow-Marine Environments

Hummocky cross-stratification (HCS), as formally defined by Harms and others in SEPM Short Course 2, is the preferred term for very distinctive, low-angle (2 to 15°), curved to undulating laminae which are broadly