mitted in the near future to meet the demands of the nuclear power industry.

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RESOURCE SIGNIFICANCE OF URANIUM DEPOSITS IN FLUVIOCLASTIC ROCKS IN TERTIARY VOLCANIC TERRANES

Projections of future demand for nuclear-powered electrical generating capacity indicate that a large amount of uranium will be needed by the year 2000. Uranium deposits of the type found in the Colorado Plateau region and in Tertiary basins in Wyoming have been the principal source of uranium in the United States, and potential resources in such deposits are large. Even so, they may not be fully adequate to supply all the uranium needed. For this reason, attention is focused here on a variant type of deposit that so far has not yielded much uranium, but that may have a significant potential because the deposits are widely distributed in a geologic setting that is extensive in western United States.

The deposits, like the better known Colorado Plateau and Wyoming deposits, consist of uranium minerals interstitial in continental sandstone and conglomerate that also contain carbonized plant remains. The deposits are in lenticular beds within sequences of Tertiary volcanic rocks, mostly at or near the base of a sequence. The sedimentary lenses containing mineralized rock are irregular, probably because their form and distribution were controlled in part by underlying pre-volcanic topography and in part by drainage changes on an unstable volcanic terrane.

If geologic ingenuity can discern the irregular pattern of the host lenses under a cover of volcanic rocks and establish the relation of deposits to the pattern, new uranium resources might be the reward.

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ISOTOPE GEOCHEMISTRY OF MODERN ARID SUPRATIDAL (SABKHA) EVAPORITE ENVIRONMENT, ABU DHABI, TRUCIAL COAST

Considerable data exist on the isotopic composition of ancient sedimentary sulfates. Interpretation of these data has been hampered by the absence of a base line for comparison from a modern evaporite environment.

Isotopic analyses (258 total determinations) of pore brines [$\delta O^{18}(H_2O)$, $\delta S^{34}(SO_4^=)$] and coexisting diagenetic gypsum and anhydrite [$\delta S^{34}(SO_4^=)$] in the Abu Dhabi sabkha indicate: (1) that the regional distribution of δO^{18} and δS^{34} in brines reflect the climatic regime and possible favorable fractionation of 0^{18} into H_2O of precipitated gypsum (δO^{18}); (2) that the source (marine versus continental) of fluid input into the sabkha is reflected in the brine δO^{18} and δS^{34} values; (3) that δS^{34} in diagenetic sulfate minerals reflects the favorable fractionation of S^{34} into the precipitating sulfates from pore fluids and (4) δS^{34} values of anhydrites permit the identification of anhydrites formed under a marine versus continental-derived fluid regime.

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PLASTIC DEFORMATION THEORY OF OIL ACCUMULATION

Scientifically accepted geologic ideas have never explained certain types of oil accumulations, some of which are functions of subsurface plastic deformity that can vary with overburden. Plastic deformity is a reservoir property which when acknowledged and understood, helps explain the positions of known oil pools and conversely facilitates the bracketing of new deposits. A knowledge of plastic reservoir deformity resolves some annoying mysteries concerning well fracing, drill-stem test results, and very deep reservoir producing behavior.

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NEWBURG OF WEST VIRGINIA

The Newburg (subsurface equivalent to the Williamsport Sandstone of Late Silurian age) has been the most important pre-Middle Devonian drilling target in West Virginia for several years. Seven gas fields have been discovered, covering an area of about 110 sq mi. Two wells have produced commercial quantities of Pennsylvania grade crude oil. As of November 1, 1970, the fields had produced an estimated 150 billion cu ft of gas. The median producing depth is approximately 5,500 ft.

Trapping is both structural and stratigraphic, but predominantly controlled by porosity. Reported thicknesses of Newburg range from 0 to more than 25 ft but few wells have effective sandstone thicknesses in excess of 15 ft. Porosity values of 20% or more have been reported, but few sandstone beds with porosity of 8% or more are thicker than 10 ft. Permeability values in the more productive areas range up to more than 200 md.

Fields are located in the western third of the state, and the best possibilities for future production lie in the undrilled parts of this division. Second best prospects lie within the middle third of the state which has been sparsely drilled to sufficient depth, and where two Newburg gas shows have been reported. Possibilities for the eastern highly folded belt are problematical.

Some of the early wells were acidized, but now it is almost standard practice to fracture them; usually with very beneficial results. A few wells have been completed without stimulation.

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SURFICIAL SEDIMENTS OF BARKLEY SOUND AND ADJACENT CONTINENTAL SHELF, VANCOUVER ISLAND, BRITISH COLUMBIA

The bathymetry of Barkley Sound and the adjacent continental shelf off Vancouver Island, has been affected by glacial erosion. Several fiords widen and coalesce to form the sound, which is continuous with glacially eroded basins on the inner continental shelf. Basins are flanked by flat-topped banks, the larger of which merge with the gently sloping outer shelf which terminates at the 200-m isobath, some 58 km from shore.

Studies of surficial sediments for size, color, mineralogy, organic carbon, $CaCO_3$, and fauna, led to recognition of 5 sediment types: (1) modern sediments, at present accumulating in Barkley Sound, are littoral sands and gravels, and deeper water organic-rich muds; (2) relict sands and well-rounded gravels mantle banks and parts of the outer continental shelf; (3) authigenic sands composed of mixed-mineral "glauconite" pellets are present near the shelf break, where they are closely associated with (4) residual sediments derived from submarine exposures of Tertiary mudstone; (5) organic sediments, composed of calcareous invertebrate remains, are present on small banks and beaches in Barkley Sound.

Mineralogically, relict and modern sands are similar, consisting mainly of detrital plagioclase and lithic fragments. However, there are marked differences between heavy mineral suites, which led to the establishment of the Barkley Sound and continental shelf provinces. The ultimate sources of the sediments are mainly Mesozoic diorites and intermediate-basic volcanic rocks.

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MORPHOLOGIC EVOLUTION OF CAMBRIAN ALGAL MOUNDS, TEXAS, WITH CHANGING DEPOSITIONAL ENVIRONMENT

Algal mounds within the Morgan Creek Limestone (Upper Cambrian) of central Texas, exhibit an overall change in morphology with height in the section. This "evolutionary" trend is associated with a change in depositional environment. The modification in algal-mound morphology is believed to be a response of the algal communities to change in the level of water turbulence and water depth.

The earliest forms are discrete club-shaped mounds exhibiting a relatively simple, highly arched, nonbranching, concentric structure. They are up to 1.5 ft thick and 2 ft in diameter. They are succeeded by larger mounds, 0.75–3 ft thick and 1–5 ft in diameter, with a complex, digitate internal structure. Near the top of the Morgan Creek Limestone are the largest algal mounds, biconvex lenses up to 5 ft thick and 25 ft in diameter. The overlying strata contain some flat, algal-laminated structures.

This evolution in mound form, a decrease in height-to-width ratio and from simple to complex internal structure, is associated with a decrease in water turbulence and a shift from shallow marine to intertidal to supratidal site of deposition. This environmental response demonstrates that changes of mound morphology can be useful in interpreting depositional environments.

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PHOSPHATE DEPOSITS OF CABINDA DISTRICT, ANGOLA, PORTUGUESE WEST AFRICA

Thick high-grade high-quality sedimentary marine phosphate deposits have been delineated in the Cretaceous-Tertiary strata of the Cabinda district of the Province of Angola, Portugal. The phosphate-bearing strata, a 1,500-ft sequence of sands, clays, phosphatic beds, and limestone, are underlain by redbeds and greenish-gray shales and overlain by relatively unconsolidated sands and conglomerates. The phosphate is concentrated in 2 units: an upper phosphate zone ranging in thickness from about 45 ft to 75 ft and containing from 15 to 20% P_2O_6, and a lower phosphate zone ranging in thickness from 80 to 130 ft. These are separated by 65–390 ft of sandstones, shales and conglomerates, with minor phosphate beds. The ore in the lower zone is concentrated in 3 units which are from oldest to youngest, about 10 ft, 40 ft, and 28 ft thick. They contain from about 10 to 20% P_2O_5 and are separated by 2 waste beds which are about 15–30 ft thick.

The phosphate mineral is carbonate-fluorapatite as inorganic phosphates (pellets, oolites, and nodules), and organic phosphates (fragments of fish teeth, bones, and fish scales). The phosphate in the upper ore zone is predominantly inorganic and that in the lower ore zone is about an equal mixture of organic and inorganic. Some phosphate beds (up to 10 ft in thickness) are primarily apatite and contain as much as 38% P_2O_5; however, most are mixtures of apatite with quartz sand and silt. Within any ore zone the phosphatic beds are interbedded with sand and silt beds. High-grade and high-quality phosphate concentrates (36–38% P_2O_5) can be produced by simple sizing and flotation from low-grade ore (10–20% P_2O_5).

The phosphate was deposited as continuous beds in a marine basin which covered much of the Cabinda district. This basin generally shelved gently westward from near the Congo border on the east, so most lithologic units thicken westward. Phosphate deposition was in part controlled by folding developed before and during the period of deposition. The major known fold which strikes southeast through the middle of the area was probably the predominant structural feature controlling distribution and deposition of the phosphates.

After deposition the folding continued and a strong system of southeast-trending faults developed. The fault system has resulted in the formation of several grabens, which presently form topographic highs where the major reserves of phosphate are preserved.

The major factor bearing on the economic potential of the phosphate is the leaching and oxidation of the phosphate beds by the recent downward movement of meteoric water where the beds are near the surface. Leaching extends to a maximum depth of about 300 ft and increases the grade of the beds by as much as 50%, and the grade of the apatite from 32 to 34% P_2O_5 to 38% $\pm$ P_2O_5.

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EVALUATION OF HYDROCARBON POTENTIAL FROM STRATIGRAPHIC ANALYSIS OF MESOZOIC CLASTIC SEQUENCE, SASKATCHEWAN

Jurassic and Cretaceous sediments form a northward-thinning wedge of 5,000 ft maximum thickness that occupies 125,000 sq mi in south Saskatchewan. Significant petroleum production began in the 1940s. New reservoirs were located each year to total, by the end of 1969, 73 main pools in 6 principal producing units, yielding 337,089,144 bbl of crude oil and 435,851,579 Mscf of natural gas from depths of 750 to 4,700 ft.

Middle Jurassic beach and channel-fill, marine sandstones and carbonates, enclosed in less permeable carbonates and fine-grained clastic rocks yield medium-gravity oil in southwestern Saskatchewan and are prospective both west of the oil-field trend and in southeastern Saskatchewan. Medium-gravity oil also is produced in southwestern Saskatchewan from Upper Jurassic marine sandstones forming updip mesas, buttes, and interfluves beneath a basal Cretaceous cover of locally permeable and productive continental deposits. Production of heavy oil and nonassociated natural gas is obtained where deltaic sandstones of the Cretaceous interdigitate with marine shales. The sequence is prospective throughout central Saskatchewan, particularly where sandstone-body trends may be related to major structural features. In west-central Saskatchewan, light oil and nonassociated gas are produced from sandstone bodies of good economic potential. These sandstones are hydraulically isolated within a thick sequence of Lower Cretaceous marine shales and exhibit structural features that closely reflect the texture of the dissected