ico margin west of De Soto Canyon record Mississippi and other river input and its extensive lateral dispersal by regionally important mass flow.

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Preliminary Study of Distribution and Transport of Radium, Radon, and Their Alpha Emitting Daughters Using Nuclear Emulsions and Polonium-210

Drill cores obtained during the drilling of the Bendix/Department of Energy radon emanometry grid, Red Desert, Sweetwater County, Wyoming, have been analyzed for Polonium-210 and studied using alpha sensitive, nuclear emulsions. These nuclear track plates provide descriptive information on the physical distribution of U-238 and its alpha emitting daughter products. Microscopic examination of exposed and developed plates on which non-ore zone core samples were dispersed suggests that U-238 and its long-lived daughters U-234, Th-230, and Ra-226 deposit on grain surfaces in very low concentrations (U-238 in sub-picogram amounts). Many of these atoms are bound to the surfaces so lightly that they, as well as Rn-222, are free to enter the underlying emulsion where their decays are recorded. Concentrations of alpha activity usually associated with discrete uranium minerals were not observed. Ra-226 appears to be more mobile than Rn-222. Measurements of Po-210 in the sequential decay, Rn-222 (3.8 days) $\rightarrow$ Pb-210 (22 years) $\rightarrow$ Po-210 (138 days), provide an indirect means of estimating the number of Rn-222 atoms that have decayed in a sample over the last 80 to 100 years. Many Po-210 highs have been observed in the Red Desert cores, some directly associated with uranium mineralization. To date, evidence for the predicted Po-210 concentration gradient produced by the decay of mobile, unsupported Rn-222 either in transit to the surface or over short distances, has not been found. These Po-210 analyses and microscopic studies suggest that observed Rn-222 and Po-210 surface anomalies may be associated with widely dispersed very low concentration halos of Ra-226 or its longer lived parents which surround the ore.

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Depositional Provinces of Paleozoic and Uppermost Precambrian Rocks in Great Basin, Western United States

From late Precambrian to Late Devonian time, shallow-water carbonate strata were deposited on a broad continental shelf along the west margin of North America in a region that is now the Great Basin. This deposition created a wedge of sedimentary rocks, the Cordilleran miogeocline, that thickens from about 1,000 m in cratonic areas in central Utah to nearly 10,000 m in central Nevada. Abrupt facies changes along the west margin of the miogeocline reflect depositional provinces from outer continental shelf to continental slope. Farther west in the Great Basin, coeval rocks consist mainly of shale, radiolarian chert, quartzite, and mafic pillow lava, considered to be mainly deep-water oceanic deposits.

Depositional provinces of the Great Basin were markedly changed by the Antler orogeny during Late Devonian and Early Mississippian time. This orogeny created the Antler highland, an upland belt trending north-northeast through central Nevada, along the former edge of the continental shelf. During Mississippian, Pennsylvanian, and Permian time, the Antler highland was either emergent or the depositional site of thin shallow-marine or continental coarse detrital sediments and shallow-marine carbonate. A foreland basin east of the Antler highland received thick deposits of coarse, chert-rich detritus during Mississippian and, to a lesser extent, Pennsylvanian and Permian time. A shallow-water carbonate shelf lay east of the foreland basin. Mississippian, Pennsylvanian, and Permian rocks west of the Antler highland consist of shale, sandstone, conglomerate, radiolarian chert, silty limestone, and mafic lava, all deposited in a deep-water oceanic environment.

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Geology and Hydrocarbon Potential of Antarctica

Antarctica covers approximately 14 million sq km, an area greater than the United States and Mexico combined. About 98% of this expanse is buried beneath a continental ice sheet having an average thickness of 3,000 m.

Seven nations have territorial claims to parts of Antarctica; however, parts remain unclaimed. The 1959 Antarctic Treaty, extending to 1991, freezes territorial claims for its duration. The treaty does not cover mineral or hydrocarbon exploration or exploitation.

Available data indicate the presence of 13 major sedimentary areas or basins on or fringing the Antarctic craton. Published descriptions of sedimentary outcrops in Antarctica plus litho-paleogeographic plate reconstructions and consideration of the stratigraphy of the adjacent landmasses allow prediction of sediment age and lithology in the 13 basins. The sediments are predominantly clastic. The onshore basins contain some Paleozoic sediments but the offshore basins are anticipated to contain only Mesozoic and Cenozoic sediment. Five of the 13 basins are onshore and subglacial whereas eight are considered as offshore basins. Five of the offshore basins are accessible with today's exploration technology and of these, three are considered highly prospective for hydrocarbons. Preliminary exploration efforts are beginning in this truly virgin area and future development will be exciting to watch and, hopefully, participate in.

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Kaolinite Formation in Clastic Reservoirs: Carbon Dixoide Factor

Thermodynamic modeling of diagenesis in clastic reservoirs was used to quantify geochemical and geohydrologic constraints on the formation of kaolinite. The formation of significant amounts of kaolinite depends upon four conditions: (1) a source for aluminum; (2) the presence of acidic pore fluids; (3) the pH buffering capacity of the fluids; and (4) the quantities of such fluids moving through the reservoir. The first condition is usually satisfied by the unstable mineral assemblage. The second and third conditions can depend upon CO_2 released during hydrocarbon maturation, and the final condition requires an open system.

The presence of dissolved CO_2 buffers the pH so that the pore solution is undersaturated with respect to illites, chlorites, and smectites while kaolinite is being precipitated. Minimum limits of f_{CO_2} in equilibrium with fluids forming appreciable amounts of kaolinite were computed as a function of unstable mineral assemblages, temperature, and fluid compositions. Volumes of fluid necessary to form 5 wt. % of kaolinite are presented as a function of fCO_2 and the above variables.

Formation of kaolinite can be related to hydrocarbon maturation. Decrease in O/C atomic ratios of different types of kerogen during maturation initiates the eventual release of oxygen as CO_2 into the pore fluids. Subsequent precipitation of kaolinite is thus an indicator of hydrocarbon maturation. To quantify this indicator, more research is needed to delineate the controls on the formation of CO_2 during maturation.

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Synsedimentary Tectonic Controls on Facies Evolution of Late Miocene Barrier Reef Complex: Upper Coralline Limestone, Maltese Islands

The central Mediterranean Maltese Islands constitute a local high on the Malta-Ragusa platform, a positive bathymetric feature extending northward to southeastern Sicily. Three main structures are recognizable within the islands and adjacent offshore areas: (1) a prominent north-south structural high through Malta which has been a positive feature since at least the Oligocene; (2) a northwest-southeast fault that has formed the western margin of the islands and controlled facies patterns since the late Miocene; and (3) east-west normal faults of post-Miocene age that form horst and graben structures in north Malta and south Gozo.

The upper Coralline Limestone was deposited in a shallow basin bounded to the east by north-south structure. Evolution of facies patterns with progressive shallowing started with open circulation and deposition of relatively condensed glauconitic grainstones and foraminiferal rudstone shoals. These shoals were then colonized and stabilized by a *Lithophyllum-Thalassia*? association, which on further shallowing was replaced by frame-building coralgal reef and associated facies, or high-energy oolitic and bioclastic grainstones. Terminal stages of deposition are represented by shallow intertidal/supratidal sediments, followed by complete subaerial uplift.

High-energy frame-built and grainstone facies are localized by the northwest-southeast fault. Restricted circulation and shoreline sediments initially formed close to the north-south structure. As basin filling continued, more open-circulation, higher energy facies extended eastward until finally, highest units of the formation are represented 15 km east of the north-south structure. This apparent eastward "transgression" concurrent with shallowing to the west can be explained in terms of regional hinging about the north-south structure. Rotation to the east would allow transgression eastward while simultaneously uplifting western areas.

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Isotope Geochemistry of Calcite and Clay Minerals in Volcanogenic Rocks, Great Valley Sequence, Northern California: Implications for Organic Diagenesis

Petrographic and isotopic data from an 8,500-m thick section of the Great Valley sequence indicate that widespread calcite cement in sandstones and mudstones was precipitated during at least two distinct stages that are linked to organic and clay-mineral diagenesis.

The range of $\delta^{13}C$ values for calcite in mudstone is -11.6 to $+1.0$ ppt PDB, in sandstones is $-9,7$ to $+4.5$ ppt PDB, and in veins is -16.7 to -2.2 ppt PDB. The $\delta^{13}C$ values are heavier in progressively older and, presumably, more deeply buried strata. A strong shift to heavier $^{13}C/^{12}C$ ratios of calcite in mudstones and sandstones corresponds with an abrupt 20 ppt shift to more enriched δD values of OH-hydrogen in diagenetic smectite and a 10A clay-mineral from mudstones. Clay D/H ratios range between -69 to -49 ppt SMOW. The stratigraphic position of the shift corresponds to a modeled burial temperature estimate of about 80 to 100°C. This is interpreted to be the burial temperature for late-stage dehydration and conversion of smectite to a 10A clay-mineral phase.

Theoretical considerations indicate that a shallow burial phase of predominantly pore-filling calcite formed in association with bacterial production of methane ($<80°C$), or with migrated thermogenic gas. A second stage of calcite, found in deeper strata, and mostly of replacement origin, formed from deep formation waters ($>80°C$) that contained thermogenically produced low C_2+ gases. Release of dry gas at increasingly elevated temperatures was characterized by continuous ^{13}C-enrichment in CH_4. Depleted calcite carbon in the most basal strata was derived from CH_4-rich basement fluids. Estimation of δD values of formation waters indicates that CH_4-H_2O equilibrium was not attained.

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Oceanographic Controls on Organic Matter in Miocene Monterey Formation, Offshore California

Analyses of the type and amount of organic matter in Tertiary through Quaternary sediments drilled during DSDP Leg 63, off the coast of California, can be used to provide insights into the controls of deposition of the Monterey Shale. The regional oceanography, rather than basin silling, controls the accumulation of organic matter in these sediments. The laminated, siliceous, and organic-rich Monterey Shales were deposited under anoxic conditions within a well-developed oxygen minimum zone like that in today's Gulf of California. The oxygen minimum zone became strongly developed in response to increased upwelling and productivity caused by global cooling following development of an Antarctic ice sheet 13 to 14 m.y. ago. A drop in sea level 10 to 11 m.y. ago lowered the base of the anoxic oxygen minimum zone to water 2,500 to 3,000 m deep permitting substantial accumulation of organic matter in the late Miocene and early Pliocene of the California borderland at DSDP Site 467. The base of the minimum stayed near this level until the Quaternary, then rose to 1,500 to 2,000 m, where it remains today. Phosphorite, indicative of a high rate of supply of nutrients, formed at the same time as the Monterey Shale, during the period of intensive upwelling from 13 to 14 m.y. into the Pliocene. A lessening of upwelling and supply of nutrients, and development of the oxygen minimum zone from the early Pliocene into the Quaternary, is implied by these data. The changes are associated with a warming trend and a rise in sea level.

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Diagenesis and Migration of Hydrocarbons in Monterey Formation, Pismo Syncline, California