anthracite coal gave negative values (-1.617697×10^{-6} per gram).

It is suggested that magnetic susceptibility measurements can give a first approximation as to the relative concentrations of trace elements in shales and similar rocks. Attempts are being made to establish magnetic susceptibility measurements as a simple and fast analytic method.

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NEOGENE CALCAREOUS NANNOPLANKTON, SIGSBEE ABYSSAL PLAIN, GULF OF MEXICO

A detailed study of calcareous nannoplankton from 11 upper Miocene to Holocene cores recovered by the D/V *Glomar Challenger* in the Sigsbee abyssal plain at Site 3, Leg 1 of the JOIDES Deep Sea Drilling Project, was conducted with the use of optical and scanning electron microscopes. Results show the presence of 8 of the 11 nannoplankton zones established for the late Neogene by Martini. The zones present, from youngest to oldest, are: *Emiliania huxleyi* zone, *Gephyrocapsa oceanica* zone, *Pseudoemiliania lacunosa* zone, *Discoaster surculus* zone, *Reticulofenestra pseudoumbilica* zone, *Discoaster asymmetricus* zone, *Ceratolithus tricorniculatus* zone, and *Discoaster quinqueramus* zone. Three of Martini's zones were not detected because there was no core coverage for the intervals where they most likely would be present. These include two late Pliocene zones, *Discoaster brouweri* zone and *Discoaster pentaradiatus* zone, and the Late Miocene *Ceratolithus rugosus* zone.

A total of 84 species was recognized; however, a sizable part of the assemblages consists of reworked specimens. Nearly 70% of the species present in the Pleistocene assemblage are reworked; in pre-Pleistocene sediments, 25–50% are reworked. Relative abundances of individuals vary considerably throughout the 11 cores, but only 2 samples of the 88 examined were found to be entirely barren of nannofossils. Late Neogene calcareous nannoplankton from the Sigsbee abyssal plain occur in a succession of zones that agrees with the Neogene Standard Zonation sequence; they are also comparable to nannofossil assemblages known from continental shelf deposits in the Gulf Coast region.

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REGIONAL EXPLORATIONS FOR OIL AND GAS IN USSR

No abstract available.

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MINERALOGY OF SOME HAWAIIAN COASTAL AND MARINE CARBONATES

The Hawaiian beaches are predominantly calcareous sands of skeletal origin washed in across the reef flats. Calcareous deposits also are present in the island shelf and bank environments. The carbonate minerals listed in order of decreasing abundance are high-Mg calcite, aragonite, and low-Mg calcite. Relative abundance of these carbonate mineral assemblages was determined by X-ray diffraction analyses to correlate the mineralogy, the sources, and the depositional environments. Beaches of the island of Hawaii, the youngest of the Hawaiian Island chain, have a higher aragonite content (65%) than those of the other islands, and the older the island, the lower is the aragonite content of its beach sands. This phenomenon is probably due to the maturity of the reefs. Coral and *Halimeda*, being the first to develop, formed the aragonitic framework which gradually was filled by high-Mg calcite skeletal sands, and, locally by low-Mg calcite skeletal sands.

Aragonite is most abundant in the upper part of the island shelf (50 m) and high-Mg calcite increases in abundance in the lower part of the island shelf. Low-Mg calcite makes up less than 20% of the island shelf and is uniformly distributed in it. Aragonite in the lower part of the island shelf is transported from the shallow part of the shelf. The abundance of high-Mg calcite and aragonite in Hawaiian marine sediments indicates the recentness of the calcareous deposits.

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HYDROLOGIC SYSTEMS

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TRENDS IN MODERN AGGLUTINATED FORAMINIFERIDA ACROSS CONTINENTAL MARGIN OF NORTHERN CALIFORNIA AND OREGON

Along the eastern margin of the North Pacific agglutinated forams generally increase in number from very few in the innermost sublittoral region to maxima in the middle sublittoral to upper bathyal regions. South of 30°N lat., the maxima range upward to approximately 20% of the total benthic fauna; north of 40°N lat. values range from 80 to 100%. The transition between these two realms occurs over only a few degrees of latitude. Off Oregon, the frequency of agglutinated forams decreases seaward of the maxima to values around 30% between 600 m and 1,800 m, then increases again into the abyssal region. Maxima in the latter region, however, do not reach values as high as those found in the sublittoral.

The sublittoral agglutinated populations between 37 and 43°N lat. are dominated by *Textularia earlandi* and *Spiroplectammina biformis*. These are replaced northward by *Recurvoides turbinatus* and *Eggerella advena*. There is an orderly progression of agglutinated species into the abyssal region off Oregon.

It is suggested that calcium carbonate availability may not be the only or even the principal factor controlling the ratio of agglutinated to calcareous benthic forams in the area under discussion. The amount and character of suspended detritus may be more important.

Trends of modern agglutinated forams may not be directly applicable to an interpretation of the geologic record. Many agglutinated tests are more easily destroyed than are calcareous tests. The frequency and quality of preservation of agglutinated tests drop off noticeably below the sediment surface.

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PETROLEUM GEOLOGY OF SUBANDEAN BASIN OF ECUADOR, NORTHERN PERU AND SOUTHERN COLOMBIA

The Subandean basin is an arcuate structural depression aligned in a north-south direction between the Guyana shield and the Andes. Nevadan orogenic movements there were followed by miogeosynclinal conditions that characterized sedimentation throughout the Cretaceous Period. The initial deposits of an Aptian-

Albian marine transgression were epicontinental sandstones, known as the Hollin Formation, which are the primary drilling objectives in the Subandean basin. As subsidence continued, the relief of the Guyana shield was reduced by erosion, and finer-grained uppermost Albian to Cenomanian sediments were deposited. These beds, called the Napo Formation, are mainly interbedded shale, glauconitic sandstone and bituminous limestone. They form an important oil-producing section. The source of Napo and Hollin sediments was on the east in the Guyana shield. The sub-Hercynian orogeny terminated the cycle of sedimentation and led to the beginning of deposition in a fluviatile and lacustrine environment. The predominantly freshwater environment persisted throughout Tertiary time and sediments were derived from the newly uplifted Andes on the west.

Commercial production was established in Colombia in 1967 and the producing trends have been extended south to the northern border of Peru. Oil has accumulated in mountain-front and mid-basin traps that are most commonly fault-associated anticlines.

All crude discovered has been of the "sweet" type. There is an increase in oil gravity from the eastern shelf to the western basin axis. Gas-oil ratios are low. No gas fields have been discovered.

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CORAL REEF ROCK FROM RED SEA: SEQUENCE AND TIME SCALE FOR PROGRESSIVE DIAGENESIS AND ITS EFFECT ON POROSITY AND PERMEABILITY

In modern Red Sea coral reef rock, pore spaces of corals are partly filled with fibrous aragonite precipitated subaqueously. By contrast, subaerially exposed reef rock about 115,000 years old, but with corals still composed of aragonite, lacks cement. Its porosity and permeability exceed those of modern reef rock. Emerged reef rock dating back 200,000–250,000 years may still consist of aragonite, but corals older than 250,000 years consist mostly of calcite. In these older corals dissolution removed the aragonite. Precipitation of a calcite mosaic preserved the outlines of the original corals, but the total skeletal framework preserved as calcite was less than that originally occupied by aragonite. Therefore porosity and permeability of the older reef rocks are markedly increased compared with all younger reef rocks. The waters that passed through the older emerged reefs must have been barely saturated with respect to $CaCO_3$.

As the emerged reef rocks lack interstitial fibrous cement, the corals must have been raised out of the sea before the onset of submarine cementation. An arid climate dating back 250,000 years prevented the dissolution of the aragonite of the corals. Although climatic changes more than 250,000 years ago were such that percolating fresh waters removed aragonite and precipitated calcite, the waters tended to remain undersaturated with respect to $CaCO_3$. Hence the progressive sequence of emergence of reef rock before onset of submarine cementation, dissolution of aragonite, and minor calcite precipitation by fresh water led to increase in porosity and permeability.

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ALGAL MATS, CARBONATE LAMINITES, OOIDS, ONCOLITES, PELLETS, AND CEMENTS IN HYPERSALINE SEA-MARGINAL POOL, GULF OF AQABA, RED SEA

A bar isolates the hypersaline pool from the Gulf of Aqaba. Finely laminated algal mats carpet the shallow shelf of the pool and gypsum floors the slope and bottom. Algae secrete pellets, ooids, oncolites, grapestones, flakes, and carbonate laminites. The ooids have a radial texture; hence, contrary to statements in the literature, ooids with a radial texture are formed in the depositional environment. The carbonate laminites occur between the gray and black algal mats. Although some of them are fibrous, most are cryptocrystalline. Cryptocrystalline laminites which consist of high-Mg calcite mimic the micrite of the geologic rock record; these laminites can preserve the morphology of the mats even after the organic matter has disappeared. Scanning electron micrographs show the laminites to consist of a mosaic of micron-size rhombohedrons which, during diagenesis, would stabilize to low-Mg calcite. Hence, the origin of some ancient stromatolitic limestones (pelmicrites) may be explained in terms of secretion of cryptocrystalline high-Mg calcite laminites. These laminites are lithified within the algal mats; hence, their origin does not necessitate the introduction of later cement and establishes algal secretion as a potent force in lithification. This inference may supersede the concept that all micrites result from neomorphic replacement of aragonite.

The algae create a microenvironment in which Mg becomes enriched in the organic matter, and in which high-Mg calcite with up to 40% molecular $MgCO_3$ is secreted. The total molecular percent of $MgCO_3$ in the Mg-organic complex and high-Mg calcite combined may reach 60. This preferential concentration of Mg may explain the high level of dolomitization of stromatolitic rocks in the geologic record. Amino acids devoid of sulfur, especially aspartic acid, as part of the biologic system may exert considerable influence in the precipitation of the carbonate laminites and particles.

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SAND DIAGENESIS: SOME RESULTS AND APPLICATIONS

No abstract available.

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MUDDY FORMATION OF NORTHERN POWDER RIVER BASIN—A STRATIGRAPHIC PARADOX

The Muddy Formation in the northern Powder River basin contains a stratigraphic paradox whereby the oldest basal sandstones appear to be the youngest and vice versa. Subsidence history is the underlying cause of the paradox. Relating depositional events as determined from physical and paleontologic data to the subsidence leads to a simple and consistent depositional history.

On lithology, the Muddy is subdivided into lower and upper units. The lower unit consists of thick basal sandstones and thin contemporaneous siltstones and shales that were deposited by a single southeast-to-northwest regression. These thick sandstones are important Muddy reservoirs and consist of coastal barriers (Bell Creek and Rozet fields) and distributary or estuarine channels (Recluse field).

When the lower Muddy regression had proceeded to a point northwest of the currently producing area, the character of the shoreline changed from a high-energy sandy shoreline to a low-energy muddy and tidal-flat shoreline. The shoreline remained northwest of the productive area throughout the rest of Muddy deposi-