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PORE-WATER CHEMISTRY AND EARLY DIAGENESIS OF NEARSHORE MARINE SEDIMENTS

Pore-water chemistry and mineralogy of carbonate and terrigenous sediments from Kaneohe Bay, Oahu, Hawaii, were analyzed to determine differences in pore-water compositions, in nature and extent of early diagenetic reactions, and in fluxes of constituents between these sediment types. Pore waters, extracted at *in-situ* temperatures and analyzed for pH and concentrations of Ca^{++}, Mg^{++}, K^+, Na^+, Cl^-, $SO^{=}_4$, reduced sulfides, SiO_2, NH^+_4, PO_4, NO^-_3, and Sr^{++}, of 23 1-3-m gravity cores show chemical gradients of dissolved species with sediment-burial depth.

The sediment pore waters are anaerobic, exhibiting an increase in reduced sulfides, H^+, and alkalinity and a decrease of $SO^{=}_4$ with depth. Owing to reactions resulting in the formation of diagenetic ferrous sulfide, the pH's of terrigenous sediment pore waters are higher at an equivalent depth than those of carbonates, whereas reduced sulfides are lower and sulfate reduction is more rapid.

Calcium and Mg^{++} are removed from pore waters with increasing depth as a result of (1) formation of protodolomite, *or* (2) precipitation of calcite and substitution of Mg^{++} for Fe^{++} in clay minerals resulting in formation of ferrous sulfide ("Drever reaction"). Dissolved SiO_2 increases with depth by solution of siliceous plankton or amorphous aluminosilicates, whereas NH^+_4, $PO^{\equiv}_4$, and NO^-_3 increase with depth because of bacterial oxidation of organic matter. Sodium, K^+, and Cl^- vary sympathetically, reflecting the original salinity of the pore waters.

Lateral gradients of dissolved species in bay pore waters reflect the fact that the southern end of the bay is a more efficient trap for organic matter. These gradients imply a lateral component of flux of dissolved constituents.

This study shows that (1) calculations of fluxes in and out of marine sediments must take into account variability of pore-water compositions and fluxes among sediment types, and (2) nutrient regeneration in pore waters can be a significant source of nutrients to overlying waters, whereas reduced sulfide fluxes may be significant enough to inhibit infaunal and epifaunal growth.

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SEDIMENTARY ENVIRONMENTS, PENNSYLVANIAN AND EARLY PERMIAN, SOUTHEASTERN ARIZONA

In southeastern Arizona, Pennsylvanian and Early Permian strata have 15 complex transgressive and regressive cycles. Sedimentary environments were influenced primarily by a stable central Arizona shelf (divisible into Papago inner shelf, San Pedro outer shelf, and Mogollon inner shelf) and an unstable Pedregosa basin on the southeast.

Morrowan and earliest Derryan deposits (Black Prince Limestone) have a basal red clastic unit overlain by thin, sheetlike carbonate units. During late Derryan and early and middle Desmoinesian deposition (lower part of Horquilla Limestone), successive carbonate banks separated the 3 parts of the central Arizona shelf, but there was little differentiation of sediments on the San Pedro outer shelf and in the Pedregosa basin. During the latter part of the Desmoinesian, a clastic influx from the north initiated carbonate-poor depositional cycles.

Missourian and Virgilian deposition (upper part of Horquilla Limestone) produced more clearly differentiated carbonate-bank margins around the Pedregosa basin and San Pedro outer shelf. Northward, these strata become dominantly clastic and pass into interdistributary bay and lagoonal deposits and supratidal, deltaic redbeds and conglomerates of the Supai Formation.

Wolfcampian depositional environments (part of Supai and Earp Formations) shifted southeast with time. On the Mogollon inner shelf, supratidal deltas and gypsiferous lagoonal deposits form this part of the Supai Formation; and on the San Pedro outer shelf, shallow-shelf sandstones, siltstones and shales intertongue with a few thin limestones. Massive, lenticular carbonate banks enclosed the Pedrogosa basin, and within the basin, dark fetid clastics and carbonates suggest restricted environments. Latest Wolfcampian or early Leonardian sediments (part of Supai and Earp Formations) are sandy dolostones and siltstones with impoverished faunas that suggest a series of poorly aerated lagoons.

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INTERSTITIAL WATERS, MINERALOGY, AND DIAGENESIS OF SHALES, DARE COUNTY, NORTH CAROLINA

The Atlantic coastal plain of North Carolina contains a complex stratigraphic sequence of Mesozoic and younger rocks. Sidewall cores were taken in the shale sequences of 2 closely spaced wells for analysis of their mineralogy and interstitial waters. In both wells, interstitial waters from all shales are less saline than sea water—even in those shales that are distinctly marine. Typical samples from the first well are mostly NaCl; sulfate is commonly high—around 4,000 ppm or more, and calcium also is above its seawater concentration. The waters in the adjacent sands, which are calculated from logs and assumed to be NaCl, have salinities that range from 30,000 to 40,000 ppm. There is no regular relation between salinities in shales versus the associated sands.

In the second well, interstitial waters in corresponding shales are of equal or lower salinities, in some only half as saline as in the first well, and contain more nearly pure NaCl. However, the salinity in the adjacent sands is always greater than 40,000 ppm and increases with depth to over 100,000 ppm. Thus, the correlative shale and sand beds in these 2 wells contain very different interstitial waters. There is no obvious geologic explanation for the different diagenetic history. The mineralogy of all shales is similar, with kaolinite, montmorillonite, and quartz predominant, illite always present, and calcite sparingly present. Neither salt nor gypsum was present in the second well, although many samples in the first well are nearly saturated with gypsum. Temperatures are not especially high, and there is no evidence for extensive mineral diagenesis.

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GEOLOGIC INTERPRETATION OF RADAR AND SPACE IMAGERY OF CALIFORNIA

Side-looking airborne radar (SLAR) imagery in California is interpreted in terms of geologic structure and rock type. Field checks and comparison with published geologic maps indicate some revisions of existing maps. In particular, linears on the radar imagery point to previously unmapped faults. In outcrops where surface texture is related to bedrock lithology, the radar signature may indicate rock type.

The unmanned Earth Resources Technology Satellite (ERTS) telemeters multispectral-scanner imagery that is reconstituted into reflected-infrared-color imagery. With respect to radar imagery, the ERTS imagery has poorer spatial resolution and smaller scale; nevertheless, useful regional patterns may be interpreted. Repetition of ERTS imagery on an 18-day cycle should enable us to determine the season for obtaining maximum geologic information.

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MAP OF PARTS OF FLOOR OF SANTA BARBARA

CHANNEL, CALIFORNIA, COMPILED FROM SIDE-SCANNING SONAR RECORDS

Side-scanning sonar surveys of parts of the floor of the Santa Barbara Channel, California, carried out in March 1969 in connection with the U.S. Geological Survey's study of the oil-spill area, provide the basis for an acoustic-geologic map of the area. Navigation during the field work was controlled closely and continuously by means of aircraft-tracking radar onshore that communicated with the ship by 2-way radio.

The side-scanning-sonar equipment consisted of a towed transducer housing a dual array of piezoelectric-crystal hydrophones, each 4 ft long, one operating at 27.5 khz and the other at 30 khz. These were triggered alternately with 0.5-m sec pulses at 1-sec intervals and scanned the bottom to ranges of 375 m on both sides of the track or in a single-channel mode to ranges of 750 m on one side or the other. The shipboard equipment included the electronic systems, power supply, and recorder, which displayed returns on linear sweeps of an intensity-modulated Alden helix recorder, 45 cm wide, printing 45 lines/cm of length on wet paper.

Features mapped include smooth bottom, rippled sand bottom, ledges of folded bedrock, drilling towers, pipelines, and features of unknown origin. Sonar records delineate changes in strike of the north-dipping strata on the flanks of the east-west-trending Rincon anticline, and identify a structural depression along the anticlinal crest at long. 119°40′W.

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SEDIMENTOLOGY AND SHALLOW STRATIGRAPHY OF MID-ATLANTIC RIDGE MOUNTAIN TOPS

Bottom photographs and drilled rock cores, obtained from several mountain tops along the crest of the Mid-Atlantic Ridge near 45°N, show a patchy distribution of basic igneous rock outcrops and localized mixed deposits of basaltic boulders, cobbles and pebbles, ahermatypic-coral skeletal fragments, and calcareous mud. Coralline limestones repeatedly have been observed underlying unconsolidated pebble and mud deposits.

Between 900 and 1,200 m water depth on the south slope of Confederation Peak (45°23′N, 28°10′W), outcrops of fractured igneous rock are surrounded by deposits of angular cobbles and pebbles in a calcareous-mud matrix. Downslope, exposed, igneous rock outcrops are surrounded by pebble deposits with about a 60% calcareous-mud matrix. A basalt conglomerate core drilled near the top of this mountain (914 m) is composed of manganese-coated pebble and cobble-sized basaltic fragments cemented by a calcareous matrix that may have lithified, in part, during subsequent vertical uplift of this deposit to its present elevation. At 1,042 m water depth, porous coralline limestone was encountered by the drill after 143 cm of penetration through unconsolidated sediments. The surface of the north side of Bald Mountain (45°13′N, 28°56′W) between 1,555 and 2,380 m is composed of outcrops of basic igneous rock alternating with angular cobble and gravel deposits, probably of similar composition. An intermittent cover of calcareous mud is evident starting at about 1,900 m water depth. Slightly porous and friable, coralline limestone, covered by 81 and 155 cm of coral skeletal material, basaltic pebbles, and calcareous mud has been drilled at 1,426 and 1,682, respectively. Generally, limestones covered by a relatively thin layer of unconsolidated sediment and those situated at relatively shallow water depths show a greater degree of induration. Five whole-sample radiocarbon dates determined for the upper parts of several limestone cores range approximately between 31,000 and 39,000 years, suggesting that deposition and (or) lithification may have been associated with a moderately warm interval following the early Wisconsin glaciation (Emiliani's Stage 3).

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DEPOSITION OF COCCOLITHS IN CALCIUM CARBONATE COMPENSATION REALM OF ATLANTIC OCEAN

Recent coccoliths deposited in the Atlantic Ocean undergo selective dissolution in the calcium carbonate compensation realm, resulting in an increase in the relative proportion of solution-resistant placoliths in the assemblage. Solution of the coccoliths proceeds through gradual selective removal of ultrastructural elements in a sequence characteristic for each taxonomic group.

Selective dissolution of coccoliths permits recognition of 3 zones. (1) A basal dissolution zone about 500 m thick immediately overlies the calcium carbonate compensation depth. Sediments in this zone lack planktonic Foraminifera, have a low $CaCO_3$ content, and contain a coccolith assemblage of low diversity composed of solution resistant species, chiefly placoliths. In the southern and equatorial Atlantic, these sediments are bathed by Antarctic bottom waters. (2) A middle zone in the region from 500 to 1,500 m above the calcium carbonate-compensation depth contains corroded and fragmental tests of planktonic Foraminifera and a coccolith assemblage, with abundant resistant species and some corroded, less resistant forms. (3) An upper dissolution zone extends from about 1,500 m above the calcium carbonate compensation depth to the calcium carbonate saturation depth. Sediments contain normal planktonic foraminiferal assemblages and diverse, well- to moderately well-preserved coccoliths, with only a few species showing obvious signs of corrosion.

Selective dissolution with depth removes tropical species, so that assemblages deposited at greater depths resemble living assemblages from higher latitudes.

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ABYSSAL BENTHONIC FORAMINIFERA AS INDICATORS OF PRESENT AND PAST DEEP-SEA CIRCULATION IN NORTH ATLANTIC OCEAN

Analysis of surface-sediment samples from 5 transects across the western North Atlantic Ocean shows the existence of 2 distinct populations of benthonic Foraminifera. The distribution of these populations correlates well with the distribution of the cold North Atlantic deep water (*Epistominella exigua* assemblage) and the very cold Arctic/Antarctic bottom-water masses (*Epistominella umbonifera* assemblage). Slight, but detectable, faunal differentiation is associated with the Arctic and Antarctic deep-water masses respectively. Abyssal, benthonic Foraminifera thus can be utilized to trace the thermohaline circulation of the deep ocean.

Analyses of core samples, dating from the last full-glacial period, indicate a shifting of faunal boundaries. First information points to an areal diminution of the fauna associated with the very cold bottom water, indicating a general warming of the bottom water during the last ice age, that possibly was due to the pack-ice cover over ocean areas that now provides the very cold bottom waters.

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DIAGENESIS OF UPPER CRETACEOUS CHALKS FROM NORTH SEA, ENGLAND AND NORTHERN IRELAND

Cores of chalks from the Ekofisk field in the North Sea have been compared with outcrop samples of the "Upper Chalk" in southern England, Yorkshire, and Northern Ireland. Techniques used included petrography, scanning electron microscopy, and isotope and trace-element geochemistry. Although all of the chalks appear to have shared a similar initial composition,