content (853% by dry weight), porosity (89%), and plasticity as well as very low bulk density (1.09 Mg/m^3). The undrained shear strength (cohesion) of these sediments is also unexpectedly high, resulting apparently from some form of bonding of the sediment particles by organic matter. Sensitivity (ratio of natural to remolded or disturbed shear strength) is also unusually high (21), indicating a high susceptibility to failure if the sediments should become severely disturbed. All sediments along the margins behave as if they are overconsolidated. The greater the organic content the greater the degree of overconsolidation. In some areas this degree is on the order of six to seven times that of similar slope deposits but with relatively low organic contents. This degree of overconsolidation suggests that organic-matter related, interparticle bonding may be responsible for the apparent overconsolidation.

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Controls on Diatomaceous Lithofacies in Obliquely Rifted Marginal Basin: Gulf of California

DSDP Leg 64 dissected Quaternary sedimentation patterns in the Guaymas Basin which confirm many similarities but underline some differences with other Neogene circum-Pacific diatomite basins. Tectonic setting in this morphologically complex basin includes broad hemipelagic slopes, fault-controlled outer slope basins and highs, and relatively small transform-bounded, obliquely rifted deeper basins with complex ocean crust. Frequent mass flows are triggered from either muddy delta foreslopes or hemipelagic diatom ooze drape. These accumulate as mud turbidites in the narrow rift zones at rates exceeding 2,000 m/m.y. Interaction of climatic and oceanographic parameters control the intensity of biogenic productivity (ergo, the oxygen budget) producing alternating sequences of laminated and homogenous diatomaceous ooze, generally confined to slope regions (400 m/m.y.). Laminated diatom-ooze also accumulated in deeper basins which were deprived of turbidity flows during limited periods.

Sediments in slope areas contain a uniform 4% carbon but $CaCO_3$ (mostly foraminifera) ranges episodically from 2 to 25%. Phosphate occurs as fish-debris-rich laminae or rare, soft, centimeter-size pellets. Diagenetic dissolution of silica is recorded at Site 479 on the slope where finely laminated hard muds occurring below an unconformity at 380 m subbottom are now devoid of frustules, except those cemented in dolomite beds. Paradoxically, porcellanites were not encountered, although traces of clinoptilolite suggest that some silica reactions are presently active. Chert only occurs in proximity to basaltic intrusions. Dolomite precipitation occurs at shallow subbottom depths in zones of high alkalinity and methanogenesis, gradually forming decimeter-thick hard layers by slow vertical accretion. These layers commonly preserve primary fabrics. Petrologic and heavy carbon isotope evidence suggest that ions for dolomite precipitation are mainly derived from interstitial waters.

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Amorphous and Crystalline Ferromanganese Deposits from Seamounts in Gulf of Alaska

Both amorphous and crystalline ferromanganese deposits have been dredged from depths between 1,400 and 2,250 m on the flanks of Welker, Miller, Murray, and Patton Seamounts in the Gulf of Alaska (53-55°N, 140-150°W). Prominent 1 to 11-cm thick massive crusts, consisting largely of black amorphous oxide and poorly crystalline δMnO_2, occur as rounded multishelled coatings on the surfaces of alkali-basalt pillows and volcanic breccia. These crusts are characterized by a simple internal stratification constructed from isotropic oxide microlaminations in alternating colloform and columnar aggregates. Detrital fragments of quartz, plagioclase, palagonite, and mafic volcanic rock are concentrated along cusps or channels within crenulated oxide layers. Bulk-chemical analyses of the massive amorphous crusts yield Mn/Fe ratios of 1.5 to 2.5 and relatively high Ni (0.26 to 0.65%), Co (0.23 to 0.66%), and Cu (0.03 to 0.12%). The occurrence and composition of these amorphous crusts suggest that they are authigenic deposits with a growth mechanism similar to that for the top surfaces of Pacific deep-sea manganese nodules.

Thin (1 to 10 mm) subparallel crusts, interconnecting veinlets, and nodular infillings associated with friable tuffaceous sediment are composed of well-crystallized todorokite and cryptomelane; δMnO_2 and birnessite(?) are minor constituents. Complex textural variations are characteristic, but broad colloform bands of variably anistropic radiating oxide fibers, and massive zones of very coarse grained (as much as 1 mm long) strongly anisotropic acicular todorokite or cryptomelane crystals, are common. These massive anisotropic oxide zones contain abundant recrystallized radiolarian tests. Ferromanganese samples from Patton Seamount have a third association: undulating bands of columnar or nodular todorokite-rich oxide and volcanic detritus (mostly palagonite) occurring in a matrix of microcrystalline phosphorite (carbonate-apatite). Crystalline ferromanganese oxide deposits have bulk-chemical compositions similar to those of the amorphous oxides but with somewhat higher Mn/Fe ratios, higher Ni, and lower Co. In contrast to the amorphous crusts, crystalline ferromanganese accumulations on Gulf of Alaska seamounts are analogous to the bottoms of deep-sea nodules; that is, the formation of these accumulations is closely related to diagenetic modification of the associated sedimentary substrate.

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Evolution of Late Holocene Beach Accretion Plain on Pacific Coast: Grayland, Southwestern Washington

An extensive (140 km +) beach-accretion plain and lagoon-barrier coast has evolved over the last thousand years in southwestern Washington and northern Oregon. Before 1,100 years, a highly indented shoreline with a steep straight wave-cut cliff and terrace faced the Pacific much like the remainder of the American west coast. In the Grayland area, the first beach-accretion ridge formed at distances varying up to 7 to 10 km seaward from the former sea cliff, followed by two additional beach-accretion ridges with a maximum 2.5 km width of the plain at its southern end. A boring in the bog between the first ridge and older wave-cut cliff included a 1.2-m thick peat underlain by beach sands. Bog pollen is dominated by *Picea* and *Tsuga heterophylla,* with significant *Pinus,* Cupressaceae, and *Alnus,* essentially a modern flora. A basal peat RC^{14} date indicates the earliest barrier formed approximately 1,100 years ago. South of the Grayland accretion plain between Cape

Shoalwater-Cove Point and the North Beach Peninsula barrier-accretion plain, occurs a 9-km tidal shoal and channel area. A narrow tidal channel, over 20 m deep, with strong tidal currents, has eroded northward over 3 km in this century. Accompanying this erosion, the flood-tide Graveyard-Empire spit is prograding into Willapa Bay, overlapping two older spits at Tokeland and Kindred Island. The deep tidal channel between Willapa Bay and the Pacific Ocean has migrated from south to north at least three times since the initiation of the Grayland beach-accretion plain, correlating the three flood-tidal spits with the three major beach-accretion ridges of the Grayland plain. A secondary, southerly deep tidal channel is forming and may again erode northward, driven by tidal and littoral processes, initiating another beach-accretion ridge on the Grayland plain and another southeasterly trending flood-tidal spit in the near future. The geologic events causing this large late Holocene Epoch coastal plain format, unique to the Pacific coast, remain obscure.

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Hydrocarbon Exploration on Ancient Shelf-Slope Breaks

A general set of traps, reservoirs, and seals occurring on the shelf-slope break can be hypothesized based on the structural regime, provenance, and width and slope of the shelf. To evaluate this break is to look at the entire region—shelf and slope.

With a wide or moderately wide shelf, gentle slope, and peneplaned provenance, carbonate sediments would dominate in marine environments. Logically, a reefal environment (reservoir) would be expected at the shelf slope. Conversely, with a narrow shelf and a positive continental borderland in close proximity, terrigenous clastics would be expected. Deltaic-like reservoirs could be expected on the shelf; turbidites would logically occur downslope. A broad shelf with a positive provenance could inspire various lithologic deposition (depending on the environment)—reefal at the shelf-slope area, deltaic or lagoonal behind, and turbidites in front.

Examples of such former reservoirs are Empire-Abo reef trend of Texas-New Mexico; Cretaceous Stuart City shelf margin of Texas; Golden Lane-Pozo Rica trends of Mexico; Miocene pinnacles of the Salawati basin, Irian Jaya; and Kirkuk field on the Arabian Platform.

Penultimate reservoirs are the linear sands of the San Joaquin and Ventura basins; Oligocene sands of south Louisiana; Triassic sands of the North Sea basin; Cretaceous Seaway sands in the Powder River basin; and the ancient Mississippi delta and cone. Latter reservoirs are found in the eastern shelf, Midland basin, and Bombay offshore basin, India.

It is understood that for some of these reservoirs to become traps, the founding structural regime is modified, e.g., faulting, diapirism. Seals are classed as carbonate muds, evaporites, and faults. Source matter may be incorporated in marine shale and limestone deposited in anoxic environments.

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Radiolarian Distribution and Enhanced Preservation in Modern Sediments: Indicators of Oceanographic Environments

Analysis of the geographic distribution of radiolarians shows that they are preserved in restricted zones and/or enhanced under particular oceanographic environments. Surface, warm-water-dwelling radiolarians are preserved in the equatorial region. However, intermediate and deep, cold upwelling radiolarians exhibit cosmopolitan distributions in the sediments with enhancement under oceanographic convergences and divergences. Specifically artostrobids and plectopyramids appear to be enhanced in the sediments under oceanographic convergence and divergences; the *Dictyocoryne profunda-truncatum* group is enhanced under high productivity regions; and actinommids in general and collosphaerids in particular are enhanced under the oligotrophic gyre regions. The enhancement under convergences and divergences may be due to (1) mass mortality of deep and/or cold forms brought into warm surface waters via upwelling at a divergence or laterally at a convergence, (2) an increase in standing crop of deep forms under high productivity regions or higher productivity at the convergence's nutricline, or (3) a stripping of the metallic protective coating of shallow forms by bacteria at the nutricline. Collosphaerids may be enhanced in oligotrophic gyres owing to the acquisition of detrital aluminum on their surfaces which might deplete the deeper waters and inhibit deeper water radiolarian preservation. Collosphaerids are also enhanced along the Mid-Atlantic Ridge which may be due to metal abundance in the sediments, low sedimentation rates, and/or high silica concentration of interstitial and bottom waters.

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Subsurface Facies Analysis of Saltos Shale Member (Miocene), Monterey Shale, Cuyama Valley, California

Distributional analysis of the lithology, sedimentary structures, and microfauna in core samples from oil wells in Cuyama Valley allows recognition of distinctive lithofacies and biofacies in the Saltos Shale Member of the Monterey Shale. Depositional environments are determined from the interpretation of these lithofacies and biofacies. The distribution and character of the depositional environments record the basin-history for this part of the Cuyama basin during the late Saucesian through Luisian (late early to middle Miocene).

Middle bathyal, fine-grained, base-of-slope clastics predominate during the Saucesian. Intercalated, thin-bedded, turbidite sandstones are prominent in some well sections and sand/shale ratios help indicate a source to the north or northeast. Relizian depositional environments are more varied, ranging from middle bathyal shales and siltstones in the area just to the east of South Cuyama oil field, to nonmarine sandstone, conglomerate, and mudstone in eastern Cuyama Valley. The distribution of these depositional environments was controlled partly by contemporaneous tectonic activity as evidenced by depositional thinning over structural highs, abrupt thickening across at least one fault, and progradation of the shelf from the east. By Luisian time the eastern Cuyama Valley area was characterized by shelf-to-nonmarine deposition. This is in marked contrast to upper bathyal diatomaceous mudstones and diatomites which accumulated in a low-oxygen environment immediately to the west, in the vicinity of Whiterock Bluff.

The Monterey Shale is overlain by the shallow-water Santa Margarita Formation (late Miocene), which marks the final phase of marine sedimentation in the Cuyama basin.

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