where $\bar{d}_n$ and $\bar{D}_n$ are the arithmetic mean nominal diameters of thin section and loose grain sizes, respectively, on a number-frequency basis. The correlation equation for $\bar{p}$ and $\bar{B}$, using eq. 1, is

$$\bar{p} = (\pi/4)\bar{B}[(\bar{D}_n/\bar{B})(\bar{p}/\bar{d}_n)]$$
$$= (\pi/4)\bar{B}(\text{R.B.}), \quad (2)$$

where R.B. is the residual bias which is equal to the terms under the third bracket. Linearizing eq. 2, by taking the phi-transform ($-\log_2$) of both sides,

$$\phi(\bar{p}) = 0.348 + \phi(\bar{B}) + \phi(\text{R.B.}). \quad (3)$$

In a similar way one can obtain nine linear correlation equations between $\phi(\bar{p})$ or $\phi(\bar{a})$ or $\phi(\bar{b})$, and $\phi(\bar{P})$ or $\phi(\bar{A})$ or $\phi(\bar{B})$. The correlation equation for $\phi(\bar{a})$ and $\phi(\bar{B})$ will be

$$\phi(\bar{a}) = 0.348 + \phi(\bar{B}) + \phi(\text{R.B.}) - \phi(\bar{p}/\bar{a}), \quad (4)$$

and that between $\phi(\bar{a})$ and $\phi(\bar{A})$ will be

$$\phi(\bar{a}) = 0.348 = \phi(\bar{A}) = \phi(\text{R.B.})$$
$$= \phi(\bar{B}/\bar{A}) - \phi(\bar{p}/\bar{a}). \quad (5)$$

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Scanning Electron Microscopy of Normal Pores in Cytheracean Ostracoda

Among cytheracean Ostracoda the normal pores, through which sensory receptors reach the exterior lateral surface of the valve, have been classified as simple or sieve-type. Although the function of the sensory receptors is only partly understood, the morphology of the normal pores through which they pass has been used as a taxonomic criterion at the generic and family levels. It is recognized that both sieve-type and simple normal pores may occur in the same family, but genera have been regarded as having one type or the other.

Scanning electron microscopy of normal pores of members of many cytheracean ostracod families has revealed that: (1) there is widespread polymorphism in both simple and sieve-type normal pores, related to differences in function of the sensory receptors passing through them, (2) both simple and sieve-type normal pores occur together on valves of species belonging to several families, and (3) although number and arrangement of normal pores seem to be diagnostic at the specific and generic levels, there are instances of extreme variations in both.

The initial temporary effect of these new data may be to decrease the usability of normal pores as a diagnostic character. However, preliminary results suggest that, as scanning electron microscope data become available for more ostracod genera and families, an even greater diversity of normal pore structure will be found. This diversity should make normal pore structure a much more useful criterion for systematic, phylogenetic, or paleoecologic inferences.

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Evolution of Continental Margin

In the past few years, new geologic and geophysical data from the continental margin and the ocean-basin floor have permitted a more detailed reconstruction of the evolution of the continental margin off the east coast of the United States. Application of the Vine-Mathews hypothesis of sea-floor spreading suggests that continental rifting in the North Atlantic began in Late Triassic or Jurassic time. Triassic redbeds of the Newark Series may represent the stage of rifting presently seen in the African Rift Valley. The continental block or coastal plain has prograded slowly seaward (15 km during Tertiary time) and its surface has subsided slowly (5 cm/1,000 years) but remained near sea level during Cretaceous-Tertiary time.

Seismic reflection profiles, bottom morphology studies, long sediment cores (more than 300), and bottom photographs (350 stations) demonstrate that southerly flowing deep-ocean currents have constructed and shaped the large margin sedimentary wedges of the continental rise and outer ridges. This southerly flowing North Atlantic deep water is—and has been—eroding, transporting, and depositing sediment parallel with the regional contours. The present sediment surface of the lower continental rise (0–10 m) is marked by a distinct sedimentary facies of current-produced alternating thin silt laminations with hemipelagic lutites.

Seismic reflectors horizon A (Upper Cretaceous) can be traced beneath the large (1–2-km thick) sedimentary wedge of the Blake-Bahama outer ridge and also beneath the continental rise on the north, and shows that these features have been lapped adjacent to the continental block in post-Cretaceous time. The initiation of this unique sedimentary process can be linked to the growth of a strong pattern of thermohaline circulation in the North Atlantic with the widening of a growing North Atlantic basin during the Cenozoic.

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Geologic Implications of Cenozoic Subsidence and Fragmentation of Continental Margins[1]

Lithified rocks are exposed or underlie a thin layer of Cenozoic deposits, at the sea floor at depths exceeding 2.0 km along major segments of the continental margin forming the northern and eastern flanks of the Pacific basin. For example, indurated and deformed sedimentary units of Mesozoic age underlie the surface of the shelf and continental slope off southern and southwestern Alaska, submerged plutonic and metamorphic rocks crop out on the margin off central California and central and southern Baja California, and they are the most likely rock type underlying the shelf and slope off northern and central Chile.

Because crystalline and metamorphic rocks do not form at the sea floor, their juxtaposition with seawater on continental slopes signifies that large masses of formerly superjacent crustal rocks have been removed to form the surfaces of these margins. Unless massive early Tertiary submarine erosion is invoked, stripping of the superjacent rocks could have been effected by (1) submarine *décollement* sliding, or (2) a more acceptable hypothesis (to the writers) of crustal uplift (including possible horizontal shifting of continental blocks), deep subaerial erosion, and subsequent submergence.

Studied segments of continental margins that are underlain by deformed and indurated sedimentary rocks appear also to have undergone a history of

[1] Publication authorized by the Director, U.S. Geol. Survey.

uplift, erosion, and subsidence. Evidence for this conclusion comes from regional geologic and tectonic mapping and the collection of samples of shallow-water deposits of Cenozoic age at depths exceeding 1–2 km that lie on surfaces cut across deformed and indurated Mesozoic deposits.

Although the writers recognize that the origin of submerged surfaces on continental margins that are underlain by lithified rocks cannot everywhere be ascribed to subsided erosional surfaces, this explanation appears to be more generally applicable than others that have been considered. The broader implications of this conclusion are: (1) postulated offshore landmasses, *e.g.*, Appalachia and Cascadia, may indeed have existed and foundered along former continental edges, (2) continental accretion may be interrupted by relatively long episodes of continental regression or wasting, and (3) the widespread evidence for marginal foundering suggests that a general mechanism of crustal thinning, possibly including "oceanization," is involved.

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Experimental Dissolution of Calcium, Magnesium, and Strontium from Holocene Biogenic Carbonates: A Model of Diagenesis

Laboratory experiments at ordinary temperatures and pressures for periods up to 240 days on Holocene biogenic carbonate sediments showed that fresh water and seawater dissolve aragonite and Mg-calcite.

The observed rates of dissolution of calcium, magnesium, and strontium indicate that these elements are incorporated in aragonite and magnesium calcite in more than one way (in lattice positions, in lattice interstices, or in inclusions). This suggests the presence of more than one mineral phase in the skeletal materials studied; these phases differ in response to solution and probably in chemical composition. The more soluble phase may influence initiation of dissolution of the material and initiation of calcite nucleation in the aragonite-to-calcite inversion process.

Calcium, magnesium, and strontium are dissolved in proportions different from those in the original solid, *i.e.*, incongruently. The experimentally established sequence of preference is, as a rule, Mg-Ca-Sr.

Factors found to determine direction and degree of incongruency in dissolution include mineralogy (number, kind, and relative abundance of phases present), physiologic effects operating during lifetime of the organism, and chemical composition and volume of waters effective in dissolution.

Incongruent dissolution determines presence, absence, and abundance of ions derived from solids in the diagenetic environment and, hence, ion availability for precipitation in cement and for inhibition or catalysis in inversion or cement precipitation. Magnesium and strontium contents in shell material have been used by others as temperature and salinity indicators in Holocene environments. The present study shows that because of incongruent dissolution these indicators are not dependable for paleoenvironmental analysis.

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Paleochannels

The width (w), depth (d), meander wavelength (l), gradient (s), shape (w/d), sinuosity (P) of stable alluvial river channels are dependent on the volume of water moving through the channel (Q_w, expressed as either mean annual or bankfull discharge or mean annual flood) and the type of sediment load conveyed through the channel (Q_s, expressed as either the ratio of bedload to total sediment load or the percentage of total sediment load that is sand size or larger):

$$Q_w \simeq \frac{w, d,}{s}$$

and

$$Q_s \simeq \frac{w, l, s}{P} .$$

Empirical equations developed from data collected along modern rivers permit calculation of the effects of changes of hydrologic regimen (Q_w, Q_s) on channel morphology. Conversely, these relations permit estimation of paleochannel gradient, meander wavelength, sinuosity, discharge, and type of sediment load from the dimensions of the paleochannel as exposed in cross section when the bed and banks of the paleochannel are composed of alluvium transported by the ancient river.

The recognition of paleochannels within valley-fill or other complex fluvial deposits is a major problem. Some criteria for the delineation of paleochannel cross-section shape and dimensions have been developed from studies of the shapes and sediment characteristics of Australian paleochannels.

Although major changes of river morphology during both historic and geologic times support the empirical relations, they, nevertheless, must be applied with caution because the effects of colonization of the land by primitive vegetation and the progressive evolution of vegetation have influenced markedly the paleohydrology of ancient drainage systems.

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Deep Drilling Cost Trends

A yearly study by Petroleum Engineer Publishing Company tabulates the number of wells, locations, total well costs, and bit use, and notes trends toward deeper drilling in various oil-country areas such as the Delaware basin of west Texas.

Deep drilling (15,000 ft and deeper) has increased in recent years. The locality and success ratio of ultradeep drilling (20,000 ft and deeper) are reviewed, and the 1968 deep-drilling data, which are available early in 1969, are compared with 1965, 1966, and 1967 data.

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Relation of Submarine Canyons to Continental Slope

Except in areas of gentle inclination, the continental slopes are cut by numerous submarine canyons. There is ample evidence that these canyons are loci of active erosion and represent the chutes down which sediments are transported to build the great fans that have