

ment beneath the coastal-plain strata. The continental rises are formed by a seaward-thinning wedge of sedimentary strata inclined nearly parallel with the sediment-water interface ($<1^\circ$).

However, development of the two continental margins differs. Sedimentary strata of the northwest African margin are deformed by intrusive bodies and by structures which resemble horsts and grabens. An extensive offshore Triassic and/or Aptian salt-dome province extends from Morocco to Senegal. The eastern Canary Islands and the Cape Verde Islands are a strongly folded Jurassic through Eocene fold belt. Sedimentary strata of the Hatteras margin, in contrast, are relatively undeformed except for structures which can be explained by massive rotational slumping and gravitational gliding. The sedimentary strata of neither continental slope nor rise show the effects of compressive stresses expected in models of sea-floor spreading by convection currents that turn downward at the continental margins.

Thus, the opposing continental margins investigated are not mirror images as might be expected if the two margins had been joined and then had separated and had undergone parallel development. Although much of the stratigraphic framework of the two continental margins appears to be similar, their development differs.

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ARCTIC MARGIN OF CANADA

Recent investigations have added to knowledge of the northern margin of Canada and the structure of the Arctic Ocean. The geosynclinal belt rimming the North American craton has been deformed with a sequence and style of tectonism that in Paleozoic time were generally similar to those of the Appalachians and the Brooks Range, whereas the later history bears a resemblance to that of parts of the northwest cordillera.

Problems remain with regard to the possible extension of the geosynclinal belt and structures at each end of the present exposures in the Arctic archipelago. At its west end the belt trends beneath the continental shelf toward the Canada Basin; the magnetic and gravity patterns over the shelf and continental slopes are not clearly related to known structures. A major positive gravity anomaly along the outer edge of the shelf lies athwart the projection of known geologic trends, and possible explanations of this anomaly by crustal thinning or intrusions are not supported by available magnetic and seismic data. That this area is still active tectonically is suggested by the unusual depth of the shelf which appears to have been drowned since Quaternary time but is still isostatically overcompensated, by magnetic and seismic anisotropy, modern microseismicity, and other features.

At its northeast end the geosynclinal belt of Arctic Canada abuts the geosynclines of northeast Greenland, whose faunal content and deformational history show European rather than American affinities since Paleozoic time. The relationship between these two provinces appears to be related to the evolution of the structures of the Arctic Ocean. Present evidence appears compatible with the hypothesis that the trans-Arctic Alpha Cordillera was connected with the Mid-Atlantic Ridge, and that the connection has been dislocated by the widening of the Atlantic basin, leading progressively to the development of Baffin Bay and the Nares rift val-

ley, and to the extension of the Atlantic fracture into the Siberian crustal block, splitting off Lomonosov Ridge as a continental remnant that abuts against, but does not join, the structures of Arctic Canada.

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SELECTIVE DOLOMITIZATION OF STROMATOLITES

Selective dolomitization of stromatolites occurs in the Boundary Member of the Schooler Creek Formation (Triassic) of British Columbia, Canada. The member is as thick as 34 ft and is a repetitive cyclic sequence of stromatolite-pelmicrite-micrite-pelmicrite-stromatolite.

Interpreted depositional sites are: (1) micrite—local basin center; (2) pelmicrite—nearshore to low intertidal; (3) stromatolite—intertidal; and (4) anhydrite beds—restricted intertidal. Lateral change within the member is slight except for coalescing of units toward the paleoshoreline. Landward, within the major stromatolitic interval, there are tongues of anhydrite; seaward there are tongues of pelmicrite containing composite oöoliths.

The stromatolites and beds in contact with them are dolomite with abundant large anhydrite crystals and clots of crystals. The rest of the member is limestone, slightly dolomitic in part, with sparse euhedral anhydrite crystals. The amount of anhydrite and dolomite increases toward the stromatolitic intervals.

Three conclusions are drawn: (1) the association of anhydrite clots and crystals with desiccation features indicates that diagenesis was partly penecontemporaneous with stromatolite formation, (2) dolomite in the beds adjacent to the stromatolitic intervals indicates that some dolomitization occurred after shallow burial of the stromatolite, and (3) selective dolomitization of stromatolitic intervals suggests that these intervals originally had relatively high permeability. Brines from evaporating pans in the landward area refluxed through the permeable zones and dolomitized the stromatolites.

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CORRELATION THEORY BETWEEN THIN-SECTION AND LOOSE-GRAIN ARITHMETIC MFAN SIZES ON NUMBER-FREQUENCY BASIS

Projection diameter (P , or p), the diameter of a circle having an area equal to that of the grain area, *long diameter* (A , or a), and *short diameter* (B , or b) can be measured for loose grains in a stable position in the gravitational field (capital letters) and for grains in the thin section. The stable position of an irregular loose grain in the gravitational field need not be a unique position, but generally the thickness of the loose grain (C) remains vertical. In such a situation \bar{B} and \bar{p} are the best estimators of the arithmetic mean nominal diameters B and p , respectively, on a number-frequency basis. However, \bar{B} and \bar{p} need not be unbiased estimators of the nominal diameters if some nonspherical grains are present either in the thin section or in the loose grains.

From Krumbin's theory of thin sectioning of spherical grains,

$$\bar{d}_n = (\pi/4)\bar{D}_n, \quad (1)$$

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

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

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 ($-\log_e$) 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

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

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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 MARGINS¹

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.