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LATE PLEISTOCENE PLANKTONIC FORAMINIFERAL TRENDS OFF OREGON

Oscillations in radiolarian-planktonic foraminiferal ratios with increasing depth in several deep-sea sediment cores from the southern Cascadia basin and the adjoining Blanco fracture zone off Oregon are thought to be the result of climatic fluctuations. Greater production of planktonic foraminifers compared with radiolarians seems to have occurred during glacial advances of the Pleistocene, whereas radiolarians predominated during glacial retreats. At least four intervals are evident in the deep-sea sediment record of the last 50,000–70,000 years. Based on radiocarbon dates, these intervals correspond approximately with late Wisconsin glacial advances and retreats as defined for the Puget lowlands of Washington.

Five species generally make up 90 per cent or more of the planktonic foraminiferal assemblage. *Globigerina pachyderma* and *Globigerina bulloides* together compose more than half of the assemblage. In grain-size fractions of less than 177 microns, *Globigerina quinqueloba* and *Globigerinita uvula* predominate. A few specimens of *Globoquadrina hexagona*, *Globigerina digitata*, and *Globigerinoides ruber* have been observed.

The species composition of planktonic Formaminifera does not appear to reflect the change from glacial to post-glacial climates. Neither do the coiling habits of *Globigerina pachyderma*. This species is dominantly left-handed throughout the sections examined. Right-handed forms reach a maximum of 13 per cent and average 2.7.

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NIGER DELTA OIL PROVINCE: RECENT DEVELOPMENTS ONSHORE AND OFFSHORE

The Niger delta oil province includes about 40,000 square miles underlain by thick Tertiary deltaic deposits. These have been subdivided into three formations: at the surface, the continental, sandy Benin Formation; the intermediate and transitional Agbada Formation of alternating sandstone and shale; and, at the base, the marine, shaly Akata Formation. The principal oil discoveries have been made in the Agbada Formation.

The accumulations are controlled largely by growth faults and rollover anticlines which are located primarily by seismic surveys. Exploration drilling on these structures has been highly successful. By mid-1966, there were 136 discoveries of 261 wildcats drilled for Tertiary objectives.

Subsequent development drilling has proved equally encouraging. The most productive onshore field, Bomu, and the first commercial offshore field, Okan, are described. Both fields have active water drives, production per well averaging about 3,000 BOPD. Production in Nigeria has increased from 5,100 BOPD in 1958 to 350,000 BOPD during the first half of 1966. It is expected that the daily rate will exceed 500,000 barrels before the end of 1966.

Parallel with this production buildup, exploration activities should continue at a high level, not only in the Niger delta oil province, but also in the area of possible Cretaceous objectives bordering the delta.

* Senior author now is GLEN W. LEDINGHAM, Nigerian Gulf Oil Company, Lagos, Nigeria. This correction came after pages were numbered.

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TRACE ELEMENTS AS POSSIBLE ENVIRONMENTAL INDICATORS IN CARBONATE ROCKS

Carbonate sediments are composed chiefly of biogenic fragments. The biogeochemistry of the shells or skeletons of organisms contributing to the sediments reflects some of the variables in the chemistry of the water in which they lived. An important factor determining the composition of the trace-element biogeochemistry of the shells appears to be the availability of certain trace elements in the waters in which the organisms lived. The trace-element composition of fresh water differs from that of sea water. Three elements particularly showing differences in concentration between fresh and marine water are barium, iron, and manganese. The average amount of barium in marine water is about 0.05 ppm.; in fresh water the barium content may exceed that of marine water, be less, or be approximately the same. The average iron content in marine water is about 0.008 ppm. in contrast to 1.0 ppm. for river water. The average manganese content of marine water is about 0.003 ppm. and of river water is near 0.03 ppm. Lagoonal waters contain more iron and manganese for uptake by organisms than do waters of an open-marine environment.

A study of marine, lagoonal, and fresh-water gastropods and pelecypods shows that the shells of non-marine and lagoonal mollusks contain a greater abundance of barium, iron, and manganese than do those of marine mollusks. The difference between marine and non-marine is independent of taxonomic rank or mineralogy of the shells. Modern molluscan shells as well as Recent carbonate sediments from Florida show, as a rule, a greater abundance of iron and manganese than do those from a marine environment. Scatter plots of one against the other of these three trace elements, despite some overlap, show groupings which correlate with environment.

Could trace elements become a prospective tool in environmental recognition? Perhaps they could under some special circumstances. The problem is that, during diagenesis, the mineralogy and chemistry of carbonate sediments, including the trace element assemblage, are drastically changed.

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RECOGNITION OF DEEP-WATER LIMESTONE SEQUENCES, AUSTRIAN ALPS

Jurassic fine-grained limestone and radiolarian chert in the northern Limestone Alps of Austria contain evidence of bathyal to abyssal depositional sites. Evidence for a deep-water origin of the Alpine Jurassic sequence has been noted by a succession of European geologists including Fuchs (1887), Steinmann (1925), and Trümpy (1960), and has strongly influenced the European view of geosynclinal sedimentation. The major lines of evidence for deep-water deposition of this Jurassic section are:

1. *Fauna and rock composition.*—The fauna consists predominantly of planktonic and nektonic forms such as ammonites, radiolaria, and calpionellids. Electron microscopy reveals that much of the fine-grained limestone consists of nannoplankton.