trict of southern Illinois are submarine eorsion channels, in part triggered by faulting.

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X-RAY STUDIES ON NOVA SCOTIA ZEOLITES

The more common zeolites from the Triassic basalts of Nova Scotia were studied by single crystal photography and diffractometry techniques. These included analcite, apophyllite, chabasite (including the variety "acadialite"), gmelinite, laumontite, mordenite, natrolite, stilbite, thomsonite, and other minerals occurring as intergrowths.

Buerger precession photos were taken and cell parameters calculated directly. These parameters were processed by an IBM 1620 electronic computer to calculate all possible lines and indices which could occur in the respective diffractograms. Results were compared with experimentally obtained diffractograms, and tabulations were made of actual "d" spacings so obtained against tentative indices. Cell parameters were then re-calculated with greater precision from the indexed diffractograms.

A sequence of crystallization, related to the stratigraphy of the basalts, was tentatively formulated from field observations to be as follows: silica acting as a base, with chabasite and gmelinite as the first zeolites, followed by stilbite, heulandite, laumontite, apophyllite, analcite, thomsonite, and finally natrolite (with mesolite intergrowths).

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MIDDLE TERTIARY FORAMINIFERAL PALEOECOLOGY, SAN JOAQUIN VALLEY, CALIFORNIA*

A detailed study was made of the foraminiferal paleoecology of the Middle Tertiary of the San Joaquin Valley, California. General trends of use in paleoecology include: (1) increase of authigenes away from shorelines, (2) progressive diversification of foraminiferal species and increase in foraminiferal abundance away from shore, and (3) concentration of planktonic species in the upper bathyal and outer shelf zones of marine basins. Bathymetry of modern homeomorphs of Tertiary species serves as the basis for establishing seven major biofacies for the California Tertiary, representing depths ranging from estuarine to deep bathyal conditions.

From Zemorrian to Luisian time, water depths in the San Joaquin marine basin were about 6,000 feet; in later Miocene time there was gradual shoaling, resulting in widespread shallow marine and paralic conditions in the Pliocene. Displaced faunas were most abundant near the base of steeper slopes of the reconstructed marine environments of the Middle Tertiary. Abyssal and shoal faunas appear to have longer geologic ranges, generally, than biofacies representing intermediate depths.

Paleotectonism was assessed in terms of vertical changes; changes amounted to many thousands of feet for each stage, especially in perimeter areas of the marine basin. Volumetric analyses suggest that about 900 cubic miles of subsidence occurred in the Zemorrian, with a progressive decrease to a minimum value of about 300 cubic miles in the Relizian, and increasing values for the remainder of the Miocene.

More than 5,000 cubic miles of rock represent the marine sediment deposited in the San Joaquin basin during the middle Tertiary stages; more than 4,000 cubic miles of this were deposited in bathyal marine conditions, and most of the oil produced has come from these sediments. Oil fields occur in areas that have been active tectonically, near steeper bottom slopes of the reconstructed environment, and where there are rapid changes in biofacies.

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ELECTRON MICROSCOPIC STUDIES OF PLANKTONIC FORAMINIFERA

The wall structures and surface features of several modern planktonic foraminiferal species were examined with an electron microscope for the purpose of evaluating the taxonomic and ecologic significance of such microstructural details.

Species belonging to spinose *Globigerinoides*, non-spinose *Globoquadrina*, and non-spinose *Globorotalia* were selected because they are three representative taxa among the planktonic Foraminifera.

Surface replicas were made using the Triafol method, which has been found superior to direct shadowing and Polystyrene techniques. Photographs have been taken stepwise from low magnifications with the light microscope to higher magnification electron micrographs in stereo pairs.

In the juvenile stages when the individuals live near the ocean surface, the test wall is thin and transparent and is composed of small calcite crystals with their c- and major growth axes normal to the shell surface. In the later stages when the organisms descend to lower water depths there is additional crystal growth in the form of a calcite crust producing columnar prisms whose free ends are rhombic pyramids. As some of the prisms increase in size, other prisms are squeezed out by differential growth; the rhombic pyramids are especially well developed along the keel and apertural side of *Globorotalia menardii* and *G. truncatulinoides*.

Transitional steps in the test thickening of *G. sacculifer* have been observed from specimens having large, open pores and distinct spine bases to specimens having constricted pores, obscure spine bases, and surficial encrustment of calcite crystals.

Distinguishing between variations in primary test features (e.g., keel, pores, apertural lip) and those due to developmental phases as observed with the electron microscope is complicated by variations due to environmental influences.

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DISTRIBUTION AND MORPHOLOGICAL VARIATIONS OF LIVING PLANKTONIC FORAMINIFERS

Surface (0-10m) and vertical (300-0m) plankton samples were collected at seventy stations (116 samples) in the North Atlantic during the summer of 1962. Three faunal provinces were recognized. The subarctic fauna consisted of *Globigerina bulloides*, *G. quinqueloba*, and *G. pachyderma*. The subtropical fauna was typified by *Globigerinoides ruber* and *G. sacculifer*. The subarctic-temperate boundary was crossed five times in the western half of the northern traverse from New York to Scotland. The temperate fauna was dominated by

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