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SURFACE SEDIMENTS OF KARA SEA, NORTH OF 76°

Two re-entrants or troughs extending from the Arctic basin into the northern Kara Sea, an epicontinental sea on the Eurasian continental shelf, were sampled during the summer of 1965. The program was limited to depths exceeding 100 fm.

Distinct sedimentary zones exist in the westernmost trough which is open toward the southwest. These zones are expressed most strongly by the chlorite-kaolinite clay-group distribution which reflects a mixture from two distinct sources. The chloritic clays enter from the southwest and are dispersed northward along the eastern margin.

The sedimentary zones depend more on the bottom relief, currents, and source than on the absolute water depth. The zones trend north-south, paralleling the dominant currents which consist of a north-flowing near-surface current on the east side and a south-flowing bottom current on the west. The zonation is shown on maps of clay-group facies, water content, insoluble residue, and organic carbon. Similar zonation is suggested by the distribution of the grain size, the composition of the sand-size clastic grains, and foraminiferal populations.

In terms of relative amounts, the easternmost zone or slope is characterized by a low water content, and abundant chloritic clays, sand, and Foraminifera. The deposits at the foot of the slope have a high water and organic-carbon content, little chloritic material, and the greatest amounts of soluble material, though they contain few Foraminifera. The trough-floor sediments are characterized by an intermediate water content, low amounts of organic carbon, a very low chloritic content, and varying amounts of soluble material. The easternmost trough, which is open only to the Arctic, does not contain distinct sedimentary zones, nor does it have a recognizable current pattern.

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NATURE OF CALCIFICATION IN CODIACEAN ALGAE

The true relations between $CaCO_3$ hard parts and living tissues in the algae are poorly understood. It has been known for many years that calcification in the Rhodophyta (red algae) occurs within the cell walls of the organism, and that calcification of the dasycladacean Chlorophyta (green algae) partly encloses the plant within an external calcareous encrustation. However, the nature of calcification in the very important codiacean algae (siphonaceous algae, Order Caulerpiales of modern algologists) has not been investigated previously. Because it is important to relate preserved calcareous structures to the cell morphology of the parent organism, the genus *Halimeda* was studied in detail to aid in the interpretation and classification of fossil codiacean material.

Previous work by Lowenstam showed that calcareous skeletal material of *Halimeda* is composed of acicular crystals of aragonite, but no mention has been made of the relations between the aragonite and the living cell. Living *Halimeda* was collected along the Florida Keys and preserved in formaldehyde, impregnated with Vestapol plastic, sectioned with an ultramicrotome, and studied under an electron microscope. The aragonite was found to consist of acicular to blocky crystals ranging in length from 0.10 to 1.0 micron. The crystals occur as distinctly separate individuals suspended in a slurry *outside* of the cell walls which fuse to form a rigid calcareous structure on the death of the alga. No $CaCO_3$ was seen within the cells or cell walls. *Halimeda* is an alga composed of a single coenocytic, tube-shaped cell which branches repeatedly until the tiny cell tips (utricles) form the outer surface where photosynthesis occurs. Calcification occurs outside the cell walls but inside the uticle layer, forming a calcareous mold of the living cell. Therefore, fossil codiacean algae like *Halimeda* would not contain preserved parts of the cells or cell walls, but instead would consist of calcareous molds of the cell material. Openings formed by the removal of cellular material usually are infilled with sparry calcite in fossil codiaceans, whereas the intercellular aragonite usually is composed of dense, fine-crystalline $CaCO_3$. Fossil Codiacea may be classified safely on the basis of their external cell and utricle morphology.

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MIDDLE TERTIARY PLANKTONIC FORAMINIFERAL FACIES, SAN JOAQUIN BASIN, CALIFORNIA[1]

Biofacies analyses of the middle Tertiary marine units of the San Joaquin basin, California, show that the most continuous deep-water areas were near the southern end of the basin and close to the San Andreas fault system which bounds the basin on the west. Isopach maps demonstrate that the major sediment accumulation was generally in the more rapidly subsiding and deeper water areas of the basin, suggesting that mechanisms such as turbidity currents, sand flow, *etc.*, must have been important in the deposition there.

Planktonic foraminiferal facies are restricted to the southern part of the basin. Minor planktonic facies occurred in the Zemorrian and Saucesian Stages, perhaps 28 to about 20 million yr B.P. A major expansion of planktonic facies occurred during the Relizian Stage, about 20 to perhaps 17 million yr B.P. Only minor planktonic faunas are identified with the Luisian Stage, about 17 to perhaps 14 million yr B.P. A second major expansion of planktonic faunas occurred during the Mohnian Stage, perhaps 14 to about 11 million yr B.P. After the Mohnian, the deeper oceanic connection was attenuated rapidly and planktonic faunas disappeared in the latest Miocene.

Abundance variations and distribution patterns of middle Tertiary planktonic foraminiferal facies of the San Joaquin basin indicate that (1) there was an important deep-water opening toward the west across the San Andreas fault system, (2) other possible connecting channels must have been of a much smaller magnitude, allowing no major influx of oceanic planktonic populations, (3) the main distribution pattern is counterclockwise indicating a similar counterclockwise current pattern around the southern boundary of the basin, (4) there were two major expan-

[1] Thanks are due the Gulf Oil Co. for releasing the report on the middle Tertiary of the San Joaquin basin for publication. Additional support has been provided by the National Science Foundation (GF 257).

sions of the current system and planktonic facies, and (5) the shallow-water facies west of the San Andreas fault at the south end of the San Joaquin Valley are anomalous. The facies anomaly across the San Andreas fault is consistent with the concept of major right lateral-slip movement since the middle Tertiary.

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GEOLOGY OF SHELDER FIELD, DIMWITT COUNTY, TEXAS

Although it has received very little publicity, Shelder field, discovered in the early 1930s, should be studied by all geologists and geophysicists because it represents clearly the link between the old oil-finding method and the new or modern exploration technique. Many recently developed exploratory tools first were introduced experimentally at Shelder field. In chronological summary, the successful culmination of the well-coordinated efforts of the Surface Party, Geiger Counter, Torsion Balance, Magnetometer, Seismograph, and Core Drill coverage is described. The productive history of this type of reservoir is demonstrated graphically, and a brief review of its economic significance is presented.

An amazing similarity between the discovery, development, and performance of Shelder field and many fields throughout the world will be noted.

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GEOLOGY OF MIDDLE DEVONIAN REEFS, RAINBOW AREA, ALBERTA, CANADA

Data obtained from comparatively recent discovery and exploitation of hydrocarbon-bearing Rainbow Member reefs in northern Alberta provide an excellent opportunity to examine the regional sedimentary and structural setting of the Black Creek basin, and specifically, the development of varied reef forms within the Rainbow sub-basin.

An intracratonic basin first developed during pre-Middle Devonian (lower Elk Point) time. Basin "growth" continued through this period and into Middle Devonian (upper Elk Point) time, when it reached its maximum expansion during deposition of the lower Keg River carbonates. Minor thickness and faunal changes take place in this unit; in some places, the areas where these changes take place are believed to have been loci for later Rainbow Member reef growth. In other places, such as the Hay River bank, the coincidence of reef growth and major structural elements indicates tectonic control.

The Rainbow Member reefs are characterized by high relief (up to 800 ft) and two basic geometrical forms: pinnacle (large and small) and atoll. A third form may be in the Shekilie barrier and Hay River bank reefs, but little information is available.

The increasing salinity of the seas, caused by development of the Shekilie barrier and lowering of the sea level, gradually terminated Rainbow Member reef growth. Muskeg evaporites (the Black Creek Member salt at the base, overlain by the Muskeg anhydrite) filled the Black Creek basin. The origin of the Black Creek salt beds and the time relations of reef and off-reef beds have been interpreted differently by different authors.

Detailed lithologic studies reveal the presence of 14 facies representing six depositional environments: basin, forereef, organic reef, backreef, lagoon, and shoal. Superimposed on the original facies is a variable diagenetic history: an early stage of penecontemporaneous dolomitization and a later stage of white dolomite infilling. Both are common to the atoll reefs. Geological rock types are classified in terms of five reservoir facies. The link established between rock and reservoir properties leads to a better understanding of fluid-flow behavior and recoveries in the pools. At present, there are in excess of 1.2 billion bbl of in-place reserves in the Rainbow field, whereas in the Rainbow South field, in-place reserves are in excess of 200 million bbl.

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PLANKTONIC FORAMINIFERA — A HISTORY OF OCEANS

The presence or absence of certain planktonic Foraminifera in marine sedimentary layers is indicative of oceanic conditions prevailing during the time of deposition. The oceanic conditions are in turn related to broad climatic conditions prevailing during the same time interval. Planktonic assemblages in sediments from the Scotian shelf and slope, South Atlantic, Caribbean Sea, and Mid-Atlantic Ridge are related to oceanic fluctuations during both Tertiary and Pleistocene times. Subtropical faunas in sediments from northern areas indicate the existence of warm oceanic conditions at least 15° farther north than previously believed; also, cool-temperate to boreal faunas in southern latitudes are indicative of general ocean cooling.

Analyses of several core and dredge samples show the simultaneous occurrence in northern latitudes of cold-brackish benthonics and warm West Indian planktonics during and after Wisconsin glaciation. Moreover, faunal extinctions and evolutionary changes are indicative of both abrupt and gradual climatic changes during the past 15 million yr. Faunal evidence clearly shows the nonpermanence of, and recurrence of, oceanic currents. Consequently, evidence of drastic and relatively abrupt planktonic faunal changes in marine cores must be related to changes in ocean circulation, climatic changes, continental glaciation, and other catastrophic events such as volcanism and extreme variations in salinity.

Data gathered from the Recent distribution of planktonic Foraminifera are utilized in interpreting the environments of deposition of ancient sediments. Most previous studies have suggested a relatively abrupt climatic change at the onset of the glacial period (represented by extinctions and additions in relatively short core intervals) and restriction during the Tertiary of warm subtropical waters to latitudes south of 34°00′N. The similarity of both planktonic and benthonic assemblages in northern latitudes with those in the Caribbean area during both the Pleistocene and Tertiary strongly suggests the presence (for lengthy periods) of a warm climatic belt or proto-Gulf Stream extending from the Caribbean to at least latitude 46°00′N.

Alternate warm and cold sequences in sediments from both the Scotian slope and Mid-Atlantic Ridge support the hypothesis of a fluctuating subarctic convergence in close proximity to a mid-Atlantic gyral during the Pleistocene and late Tertiary. It is the writer's contention that oscillating cooling conditions