HECKEL, PHILIP H., Department of Geology, Rice University, Houston, Texas

DEPOSITIONAL ENVIRONMENT OF THE DEVONIAN TULLY LIMESTONE OF CENTRAL NEW YORK

Recent investigation of the Tully Limestone has resulted in the recognition of several general facies. Certain key beds appear to be relatively synchronous units that permit environmental reconstruction of several phases of deposition.

In general, Tully deposition occurred in a carbonate mud-depositing sea with an eastern clastic source that exerted decreasing influence through time.

The lower part of the Tully Limestone consists of arenaceous deltaic beds of limited areal extent. On the east, abundant *Chonetes aurora* and occasional *Leptostrophia* represent the restricted fauna of the brackish nearshore environment. Westward, the addition of other brachiopods, notably *Hypothyridina*, *Atrypa*, and *Schizophoria*, characterizes the more marine facies.

Above the lower part of the formation, sandy limestone overlies the beveled eastern end of the delta and grades eastward into an iron-rich oölite which contains pebbles of dark siltstone. Deposition was extended also to the west, where purer carbonate mudstone is developed.

The upper part of the Tully Limestone consists of carbonate mudstone characterized by the presence of metriophyllid and auloporid corals, styliolines, trilobites, and pelmatozoans. Toward the middle of this part, and representing normal marine conditions, is a diverse fauna developed to the east in dark calcareous shale and to the west in limestone.

Erosion surfaces with burrows, channels, local carbonate-pebble conglomerates and filled mud cracks are evidence for the intermittent nature of carbonate mud deposition and are observed especially in the central and western regions.

In the upper part of the formation near the town of Borodino, two elongate mounds of pure carbonate mudstone, about 15 feet high, contain structures similar to stromatactis and grade laterally into much thinner pelmatozoan calcarenites. These mounds are overlain by similar calcarenites which locally contain pebbles of carbonate mudstone. Whereas the lower mound contains a network of auloporid corals that could have been responsible for its development, the upper mound lacks auloporids. The position of the upper mound on the western flank, and quite possibly in the lee, of the lower mound suggests a current-controlled origin.

Tully deposition was ended by the reducing environment of the Geneseo Black Shale, which encroached progressively from the west. Local lingering of the carbonate environment is shown by dark argillaceous limestone at the top of the section which contain only scattered remnants of the Tully fauna.

HEROY, WILLIAM B., SR., The Geotechnical Corporation, Dallas, Texas

PROJECT MOHOLE, A PROGRESS REPORT

HERRIN, EUGENE, Dallas Seismological Observatory, Southern Methodist University, Dallas, Texas

HETEROGENEITY OF THE UPPER MANTLE

In their investigations of the interior of the earth, geophysicists have generally regarded the mantle as composed of homogeneous shells and have considered the crust of the earth as varying laterally in composition and thickness. Evidence from measurements of the gravitational field and of the heat flow to the surface have suggested that differences exist in the composition of the upper mantle. Very recent information on seismic velocities and attenuations clearly indicates that substantial lateral variations in the physical properties of the mantle exist beneath both continents and oceans. The geological complexities evident at the earth's surface now appear to be reflected in the upper mantle.

HILLS, JOHN M., Penn, Hills & Turner, consulting geologists, Midland, Texas

LATE PALEOZOIC TECTONICS AND MOUNTAIN RANGES, WESTERN TEXAS TO SOUTHERN COLORADO

Underlying the Permian rocks of the West Texas basin are the roots of a Paleozoic mountain range. In direction of strike and structure, the folds of these mountains bear a general resemblance to the mountains of central Colorado. However, the Permian and younger rocks of the West Texas basin were not refolded during the early Tertiary as were the ranges of central Colorado. In this paper, the author attempts to show the reason for this difference in tectonic history which has resulted in the absence of a folded front range province from northern New Mexico as far south as the Sierra Madre Oriental in the Republic of Mexico. In the course of the investigation, paleogeologic maps were constructed of the area from Big Bend of Texas to central Colorado for the beginning of Pennsylvanian and the beginning of Permian time. From them a tectonic map showing elements existing at the beginning of Permian time was built and compared with a similar map showing present elements. Cross sections were made comparing homologous tectonic units of the West Texas basin with the Cordillera of central Colorado.

In this manner the author has come to the conclusion that the pre-Permian folds of the West Texas basin are not tectonically related to the younger folds of central Colorado although they do have certain characters in common. The Paleozoic rocks of the two areas were laid down in different basins separated by the Precambrian massifs of the continental backbone throughout most of Paleozoic time. These massifs, together with the tightly folded Paleozoic rocks of the Marathon-Ouachita belt, absorbed and distributed Laramide stresses and preserved the West Texas Permian basin from early Tertiary mountain building in spite of the presence of structural and sedimentational features favorable to mountain building.

HSU, K. JINGHWA, Shell Development Company (A Division of Shell Oil Company), Exploration and Production Research Division, Houston, Texas

CROSS-LAMINATIONS IN GRADED-BED SEQUENCES

Thin units of cross-laminated sandy and silty sediments are common in graded-bed sequences. One characteristic common to all is that the thickness of the cross-laminated bed does not exceed 3 inches and rarely exceeds one inch. These sediments have been commonly interpreted as turbidity current deposits because of their association with graded beds. The writer offers evidence to demonstrate that such cross-laminated sediments in several instances were transported by turbidity currents to deep-sea bottom and deposited originally as graded beds, but subsequently were reworked and redeposited by the rippling action of deep-marine bottom currents. Evidence includes these facts: (1) deep-marine bottom currents exist and are occasionally strong enough to ripple deep-sea bottom as indicated by photographs; (2) cross-laminated deep-sea