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NEARSHORE DEPOSITIONAL ENVIRONMENTS OF UPPER CRETACEOUS PANTHER TONGUE, EAST-CENTRAL UTAH

The Upper Cretaceous Panther Tongue of east-central Utah is exceptionally well exposed in the Book Cliffs and Wasatch plateau and offers an unusual opportunity to study, in three dimensions, the morphology and internal structure of a nearshore depositional complex. Lithology, sedimentary structures, geometry, and trace fossil assemblages, considered collectively, permit recognition of seven depositional environments during Panther time.

Transition from the underlying Mancos Shale to the coarser terrigenous clastic sediments of the Panther Tongue is represented by densely mottled gray siltstone in which primary lamination has been destroyed by the activity of detritus-feeding organisms. Overlying the gray siltstone is a very fine-grained sandstone which has a high matrix content and contains an abundant and varied trace fossil assemblage. This very fine-grained sandstone is present in bar and backbar depositional environments, but is divided into two areas of occurrence by an elongate sandstone body believed to be a longshore bar. The wedge-shaped forebar contains wavy laminated sediments near the base which grade upward into thin-bedded mottled sediments. Trace faunas in the forebar change in nature vertically and laterally away from the longshore bar. In the backbar, sediments are more poorly sorted and stratification is thin- to thick-bedded. The trace fossil assemblage in the backbar shows very little lateral change and is less variable than in the forebar.

The longshore bar strikes northeast-southwest, and its cross section is well exposed in the western Book Cliffs and northern Wasatch plateau. The bar is characterized by massive bedding, lenticular shape, and asymmetrical flanks. Large-scale, low-angle (10°) foreset beds at the Panther type locality north of Helper, Utah, represent the seaward (southeast) face of the bar. These foreset beds have ripple-marked surfaces and contain an abundant and varied suite of sole marks. The dip and predominant current direction of sole marks are southwest, indicating that longshore currents flowed along the seaward side of the bar. Current ripples and oscillation ripple marks, however, developed in response to tidal action, as is indicated by orientation of their crests parallel with the longshore bar. The bar and bar shore-face contain a characteristic trace fossil assemblage which is dominated by filter-feeding organisms and vagrants which left various surface trails on bedding planes. Behind the bar, a series of short, low- to medium-angle (5–20°), cross-stratified sandstone beds built landward over the backbar environment.

A marine transgression late in Panther time truncated the previously deposited sediments, and a sequence of horizontal to subhorizontal strata was laid down across the erosional surface during a second regression of the sea. Panther deposition ended with the return of the Mancos sea and the deposition of clay and mud.

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TOROS-ZARGOS FOLDING AND ITS RELATION TO MIDDLE EAST OIL FIELDS

The southern foredeep of the European-Asiatic alpine orogenic belt containing the oil fields of the Middle East is very wide and deep in its eastern and southeastern parts, but it becomes narrow and shallow in the western and northwestern parts. Lower Tertiary, Mesozoic, and, in some places, Paleozoic sediments are buried under a thick Tertiary cover in the southern and southeastern parts of the foredeep, as are the lower sections of the tectonic structures which they comprise. However, they are exposed at the surface and thus are accessible for direct investigation in the western and northwestern parts of the foredeep or, at least, are accessible for geophysical research (southeast Turkey, north Syria, northwest Iraq). Intensive geological work has been done in the Turkish Toros ranges because of the abundant copper and chromite occurrences. Thus, the features of this part of the Toros-Zagros ranges are well known today.

With these data, it is possible to reconstruct the geological history of the deep pattern of the foredeep, and also of the Toros-Zagros folding and its relation to Middle East oil fields.

The foredeep is bounded on the north by the folded zone of the Toros-Zagros belt, consisting of large overthrust bodies, the central parts of which contain Mesozoic metamorphic rocks, and a zone of local thrusts formed partly by submarine gravity slides. This zone is the southern border of the Toros-Zagros thrust region and was pushed southward over the Miocene cover of the foredeep.

The southern limit of the foredeep, in contrast, is less definite; structures and stratigraphic units of the foredeep grade gradually into those of the shield and no "borderline" can be drawn here.

Numerous tectonic features of different origin and age exist in the foredeep; remains of Hercynian and even Caledonian folds, old relief elevations caused by erosion, and fault blocks and fault zones are found adjacent to young folds. The influence of the Alpine orogenic movements originating in the Toros-Zagros belt (*e.g.*, the widespread early Late Cretaceous, the less pronounced early Eocene, and the general late Miocene-Pliocene movements) is not the same over all the foredeep. Next to features which range from strongly or moderately affected to almost unaffected by a later movement are structures folded during one of the Alpine cycles. However, in the Tertiary cover, the existence of all these features is reflected by the presence of more or less similar domes and anticlines.

Tectonic events during the Late Cretaceous may have produced stratigraphic, lithologic, and structural oil traps in Upper Cretaceous and Tertiary rocks. Today, these trap possibilities are of economic importance for southeast Turkey, north Syria, and northwest Iraq, where occurrences of Tertiary reservoirs in the Asmari Limestone are small or non-existent. In the future these possibilities could be important in Turkey, north Syria, and northwest Iraq, as they already are in the rest of Iraq and in Iran.

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PLIOCENE-MIOCENE BOUNDARY IN TEMPERATE EASTERN PACIFIC

Clockwise surface-current motion in the North Pacific deflects colder isotherms (California Current) south along the Pacific Coast of North America. This cool-water mass contains a planktonic foraminiferal fauna characterized by *Globigerina pachyderma* (sinistral coiling north of Lat. 45°N.), *G. bulloides, G. quinqueloba,* and *Globigerinita uvula*. A similar *Globigerina bulloides* fauna dominates planktonic assemblages in middle Miocene through Holocene sediments exposed along the Pacific Coast north of Lat. 28°N. Therefore, the sequence of tropical planktonic species commonly used to zone Tertiary sediments is difficult to utilize at the leading edge of the northern East Pacific. Nevertheless, variations in percentages and coiling directions of temperate and cool-water species, together with restricted occurrences of tropical species, allow paleo-oceanographic definition of that part of the stratigraphic record currently accepted as the Pliocene-Miocene boundary, specifically the interval from 13–10 $\times$ 10^6 yrs. ago.

Bathyal upper Miocene sediments exposed north of Lat. 30°N. are characterized by a subarctic to cool-temperate planktonic fauna marked by a zone of sinistral-coiling specimens of *Globigerina pachyderma*. A warm-temperate to subtropical fauna characterized by *Globigerina eggeri, G. conglomerata, Globorotalia inflata, G. menardi tumida, G. crassaformis, G. hirsuta, Globigerinoides ruber, G. triloba, G. conglobatus*, and *Sphaeroidinella dehiscens* occurs in sediments deposited at Lat. 34°N. (Repetto Formation of southern California) approximately 10–9 $\times$ 10^6 yrs. ago. This tropical to warm-temperate facies can be traced within a wedge of bathyal marine sediments extending north from Lat. 8°N. (Charco Azul Formation of Panama) to Lat. 47°N. (Quinault Formation of Washington). North from the equator the number of subtropical and tropical species characterizing the biofacies decreases; *Pulleniatina obliquiloculata* is absent within the biofacies north of Lat. 25°N.; *Sphaeroidinella dehiscens, Globigerina conglomerata, Globigerinoides triloba, G. conglobatus*, and *Globorotalia menardi tumida* are not present north of Lat. 35°N. At Lat. 47°N. the biofacies is marked only by dextral-coiling specimens of *Globigerina pachyderma* and rare occurrences of *Globorotalia crassaformis* and *G. hirsuta*.

The initial appearances of *Globorotalia crassaformis, G. inflata*, and *Sphaeroidinella dehiscens* are currently used to mark the Pliocene-Miocene boundary in tropical latitudes. Consequently, their first appearance possibly can be used as a correlative Pliocene-Miocene boundary in the temperate eastern Pacific. However, expansion of warm isotherms from the equatorial region during the early Pliocene can not be considered instantaneous. Indices of the tropical to warm-temperate biofacies appeared later at progressively higher latitudes. A choice must be made between utilization of a time-transgressive biologic datum or a radiometric datum for an epoch boundary. Given a framework of absolute dates, appearance and oscillation of planktonic foraminiferal faunas can be evaluated in terms of paleo-oceanographic parameters rather than emphasized as criteria for establishing highly controversial epoch boundaries.

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Pore Geometry of Carbonate Rocks

In most clastic rocks a relatively simple relation exists among producibility, porosity, and permeability, depending on the degree to which size and shape of framework particles influence these factors.

Carbonate rocks do not exhibit such a simple relation. In addition to porosity between framework particles, the particles themselves may be porous. Carbonate rocks are subject to leaching, replacement, and recrystallization to a vastly greater degree than are clastic rocks. During the course of diagenesis of carbonate rocks, type and degree of porosity and permeability may be so altered that they no longer offer a satisfactory measure of the producibility of the rock. Two carbonate rocks may have identical porosities and permeabilities, with one forming a good reservoir rock whereas the other is incapable of storing or producing oil or gas. A study of the pore geometry of a carbonate rock commonly is necessary to determine whether it is capable of producing hydrocarbons.

By relating previously devised systems of classification of carbonate-rock particles, grain-size, porosity, and texture to mercury capillary-pressure measurements, a petrophysical classification has been devised which classifies carbonate rocks by producibility. Families of capillary-pressure curves are related to families of carbonate-rock types. Once such a classification has been made for a carbonate rock in a given area, it is possible to predict the shape and amplitude of its capillary-pressure curve from a visual examination of the rock.

By relating rock characteristics to depositional environments, maps may be made that predict what the producibility of rocks in an area may be. Such maps can help reduce the number of dry holes drilled in areas where anticipated closure is less than that dictated by the pore geometry required for the rocks to produce hydrocarbons.

The pore geometry of dolomitized rocks differs greatly from that of limestone. Work done in the past has led to the conclusion that dolomitization creates and then destroys porosity and permeability. In the field, rocks commonly are found which appear to invalidate this conclusion. Pore-geometry studies indicate that the time during diagenesis at which dolomitization occurs and the original petrographic characteristics are the critical factors that determine whether dolomites will develop into reservoir rocks capable of hydrocarbon production.

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Significance of Distribution of Planktonic Foraminifera in Equatorial Atlantic Undercurrent

The relation between distribution of living planktonic Foraminifera species and selected elements of the equatorial Atlantic current system has been investigated through the use of depth-controlled, opening-closing net, quasi-synoptic plankton samples, as well as hydro-casts, S-T-D lowerings, and direct current measurements. Physico-chemical data collected with the biologic samples were used to define major biotopes within the current system. They showed salinity variation to be one of the most important factors affecting foraminiferal distribution and temperature variation to be of lesser importance; variations in salinity as small as 0.5 ppt. appear to exert strong influence on population variation within the planktonic Foraminifera. Because of such sensitivity, planktonic Foraminifera may be very useful as water-mass indicators in studies of oceanic-current and circulation patterns.

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Some Aspects of Sedimentation and Paleoecology of Middle Devonian Winnipegosis Formation of Saskatchewan, Canada

The Middle Devonian Winnipegosis Formation of Saskatchewan is divisible into upper and lower mem-