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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 as-