Sunbury Shale of Central Appalachian Basin—Depositional Model for Basinal Black Shales

A model for the deposition of basinal black shales and associated base-of-slope turbidites is established in the central Appalachian basin. The model is based on an outcrop and subsurface stratigraphic study of the thin, but extensive Lower Mississippian Sunbury black shale. This model is termed the Sunbury cycle and it provides an explanation for the geometrid relations observed between basinal black shales and laterally adjacent gray/green slope shales and siltstones.

Two genetic types of black shales are recognized—transgressive and regressive. The transgressive black shale is the basal unit that initiates the cycle. Characteristically thin and widespread, it was deposited in the anaerobic zone of a stratified water column. Its sharp basal contact represents the rapid migration of the anaerobic environment over base-of-slope and slope deposits. This is caused by an increase in the subsidence rate of the active basin, decrease of clastic influx, and a minor rise in sea level. The regressive black shale overlies the basal unit. It is thicker, more laterally restricted, and represents the distal facies of base-of-slope turbidites formed by a progressive increase of clastic influx and a decrease in the subsidence rate of the basin floor. The thick regressive black shale and laterally adjacent non-black clastics represent facies of a continuous unit (base-of-slope turbidites) containing varying amounts of preserved organic material. The degree of organic preservation is the result of deposition in zones of varying oxygen content caused by the intersection of the stratified water column with the basin floor.

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Seismic Stratigraphy of Modern Carbonate Slope

Based on analysis of 1,350 km of high resolution, 5 cu in. air-gun and 3.5 kHz seismic reflection profiles, as well as 30 piston cores, the open ocean, windward, deep carbonate bank margin north of Little Bahama Bank has been divided into upper and lower slope facies. The seismic character of the post-Paleocene upper slope unit (200 to 1,000 m water depth) consists of a low-energy slope-front fill facies characterized by parallel to subparallel reflectors that downlap onto a regional unconformity near the Paleocene-Eocene boundary. Sediments of this upper slope facies are interpreted to be primarily fine-grained pelagic carbonates. In contrast, the post-Paleocene unit on the lower slope (1,000 to 1,300 -m water depth) consists of a variable energy chaotic-fill facies characterized by hummocky/discordant to wavy subparallel reflectors. Sediments of this facies are interpreted as coarse, high-energy mass transport deposits such as turbidites and debris flows. Detachment scars on the upper slope and erosional gouge on the lower slope indicate that submarine slides and sediment gravity flows originated on the upper slope. The sediment gravity flows have bypassed the fine-grained upper slope facies via numerous evenly spaced small canyons, which act as a "line source," and were deposited at the base of the slope in a broad "apron" rather than a fan. The seaward transition in the lower slope chaotic fill facies from hummocky/discordant to wavy subparallel reflectors suggests that the sediment gravity flows become thinner and more "distal" seaward. Recurrent faulting and oversteepening of unlithified carbonate slopes are believed to be responsible for the generation of mass movements. Similar facies relations should be recognizable in the rock record. In terms of hydrocarbon exploration, the coarse, lower slope sediment gravity flow facies would appear to have the greatest reservoir potential.

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Geochemical Prospecting for Hydrocarbons in Navarin Basin Province

The Navarin basin province, which lies beneath the northwestern Bering Sea shelf, is a large (45,000 sq km) frontier area for petroleum exploration. Our preliminary geochemical survey of this province measured hydrocarbon gases in near-surface sediments in search of evidence for the possible occurrence of petroleum. Hydrocarbons (methane through butanes) were analyzed from sediment samples taken at a depth of 1 m from cores collected during the summer of 1980 at 32 stations spaced approximately 50 km apart. In addition, samples at the same depth were analyzed from five stations spaced about 5 km apart over a shallow acoustic anomaly. All samples analyzed contained hydrocarbon gases, but none had significant amounts of hydrocarbons of obvious thermogenic (petroleum-related) origin. At only two stations on the shelf and one on the slope were concentrations of methane and ethane significantly above background values, whereas those of propane and the butanes were not. Concentrations of methane and ethane were 5 to 9 and 10 to 20 times, respectively, higher than background values, and ratios of ethane to ethene of 6, 30, and 25 were unusually large relative to background values of about 1. The ratios of methane to ethane + propane of 100, 140, and 180, and the large ratios of ethane to ethene, suggest that some thermogenic hydrocarbons are present. Although petroleum is potentially present at depth in the Navarin basin province, our preliminary survey did not detect surface hydrocarbon-gas anomalies that would unequivocally signal its presence.

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Subduction-Related Structure Along Eastern Aleutian Trench

Along the eastern Aleutian Trench between Kayak and Sanak Islands, the trench, magmatic arc, and active Benioff zone define a modern convergent margin 13,000 km long. The structures developed during the past 10 to 15 m.y. show the deformation associated with subduction. Fore-arc basins have been formed on pre-Neogene rock that was presumably accreted, uplifted, and then locally depressed. Structures in the basins are compressional near the shelf edge and extensional farther toward the arc. The trench lower slope is underlain by rocks that are coeval with those in the fore-arc basin, but are deformed as a result of subduction. Despite a uniform convergence history, the margin has marked structural variations along strike that reflect local non-tectonic influences on structural style. The structure could be influenced by a variety of geologic variables such as sediment volumes on the slope, in the trench, and on the ocean crust, and perhaps by the morphology of the igneous ocean crust. Although we have not yet successfully reconciled all the effects of local variation on structural style, a comparative study of these styles and local features can help define kinematic processes associated with plate convergence.

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