Instead, the data favor a "punctuated diagenesis" in which clay transformation occurred in a relatively brief episode early in the history of the sediment. Once formed, the clay particles persisted as closed isotopic systems. Rapid clay diagenesis in a thick package of sediment could release an enormous amount of interlayer water, and this release would have been a potential mechanism for transporting cement constituents as well as petroleum from the deeper shale beds.

Oxygen isotope data from these clays can be interpreted as supporting a smectite-to-illite conversion at a much lower temperature than those prevailing at depth today. Low-temperature early diagenesis could reduce permeability through precipitation of released silica. Further burial would then have created an optimal situation for the formation of geopressure by aquathermal pressuring.

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Thermoluminescence Evidence of Uranium Migration: Jackpile Mine Area, New Mexico

Uranium (U), equivalent U (eU), and natural thermoluminescence (NTL, corrected for sensitivity variation) were analyzed on a large number of core samples from the Jackpile uranium deposits, New Mexico. These parameters were also analyzed on outcrop samples collected from the Jackpile sandstone which hosts these deposits. NTL, U, and eU show a positive correlation reflecting the secular equilibrium among U and its daughter products in these deposits. The U anomaly for the outcrop and core samples and the eU anomaly (from gamma log) are both areally restricted to within these deposits. However, NTL of the outcrop samples produced an anomaly several times larger in area than the U and eU anomalies. Further, the trend of this NTL anomaly parallels the sediment transport direction of the Jackpile sandstone.

The Jackpile uranium deposit is probably about 100 m.y. old. The NTL anomaly appears to be detectable long after (60 m.y.?) uranium was leached out from the present barren outcrop areas. Though this work was done on a sandstone uranium deposit, findings of this investigation are applicable to exploration of other types of uranium deposits.

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Base-of-Slope Carbonate Aprons: An Alternative to Submarine Fan Model

Along the deep margins of carbonate platforms, classic submarine fan deposition typically does not occur. Rather, coarse turbidites and debris flows are deposited as a wedge-shaped apron of debris that parallels the adjacent shelf edge. The carbonate slope north of Little Bahama Bank is a good example of a wedge-shaped base-of-slope debris apron. This slope consists of a relatively steep ($\sim 4°$) upper slope (200 to 900 m, 660 to 3,000 ft) that is heavily dissected by small (50 to 150 m, 160 to 500 ft, in relief) submarine canyons; and a broad, smooth, gentle (1 to 2°) lower slope (900 to 1,300 m, 300 to 4,300 ft), devoid of any well defined canyons or "fan valleys." The upper slope developed during the Tertiary as a prograding slope-front-fill facies of fine-grained, peri-platform oozes, whereas the lower slope has developed as a chaotic-fill facies of large slide blocks, coarse debris flows, and turbidites. Sediments along the upper slope are derived from both the overlying water column and the adjacent shallow-water banks. Sediments along the lower slope are "internally" derived via submarine cementation and subsequent submarine sliding of upper slope sediments. Debris flows are generated by these submarine slides and evolve from mud to grain-support, and commonly develop turbidity currents along their tops as they travel across the lower slope. As such, this base-of-slope apron can be divided into: (1) a proximal apron facies, characterized by thick (up to 5.5 m, 18 ft) mud-supported debris flow deposits and thick (up to 2.6 m, 8.5 ft), coarse-grained turbidites interbedded with subordinate amounts of peri-platform oozes; and (2) a distal apron facies, consisting of thinner, grain-supported debris flow deposits, and thinner, finer grained turbidites interbedded with subordinate amounts of peri-platform oozes. Seaward of the distal apron facies is a basinal facies of thin (< 20 cm, 8 in.), fine-grained turbidites interbedded with peri-platform oozes that comprise 60+% of the near surface sediments.

Such a model for base-of-slope, peri-platform carbonate sedimentation offers an alternative to the submarine fan model for those geologists and explorationists working with ancient carbonate mass-flow deposits. A good understanding of modern carbonate slope processes and products should aid in unravelling the complex stratigraphy of ancient carbonate slopes.

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Detection of Shallow Hydrocarbons with High-Frequency Seismic Reflection Data

High-frequency (200 to 15,000 Hz), high-resolution seismic reflection profiles can be a valuable tool in the exploration for offshore hydrocarbon accumulations. The occurrence of hydrocarbons (particularly natural gas) either in the water column or shallow subbottom can result in strong acoustic impedance (density × velocity) contrasts which may produce a number of anomalous seismic responses including: (1) water-column anomalies, which are strong reflections that rise from the ocean bottom into the overlying water column as a result of natural gas seepage; (2) subbottom amplitude anomalies ("bright spots") that, when found along geologic structures, may indicate shallow hydrocarbon accumulations; (3) seismic smears, which are "turbid," chaotic, high-amplitude events that may indicate shallow, gas-charged sediments; and (4) seismic wipeouts, transparent zones commonly found below seismic smears or water-column anomalies indicating total reflection and/or absorption of seismic energy in an overlying zone of gas.

A high-frequency, high-resolution seismic reflection profile survey of the continental margin off northern Santa Cruz County, California, using both a 300-joule "uniboom" and a 1-kilojoule sparker has resulted in the detection of all four of these seismic anomalies. The shelf here is cut diagonally by the San Gregorio fault zone which marks the southeast boundary of the Outer Santa Cruz basin. Northeast of the San Gregorio fault, the shelf is dissected by the Monterey Bay fault zone. More than 100 water-column anomalies (gas seeps) have been detected, some of which rise over 50 m (160 ft) into the overlying water column. Most water-column anomalies correlate with subbottom geologic structures such as anticlines, faults, and truncated, tilted strata. Several subbottom amplitude anomalies, seismic smears, and seismic wipeouts have also been detected and correlated with structures. All these anomalies have been found in association with the middle Miocene Monterey Formation, the late Miocene Santa Cruz Mudstone, and the Pliocene Purisima Formation. Samples of natural gas have also been collected from a shallow