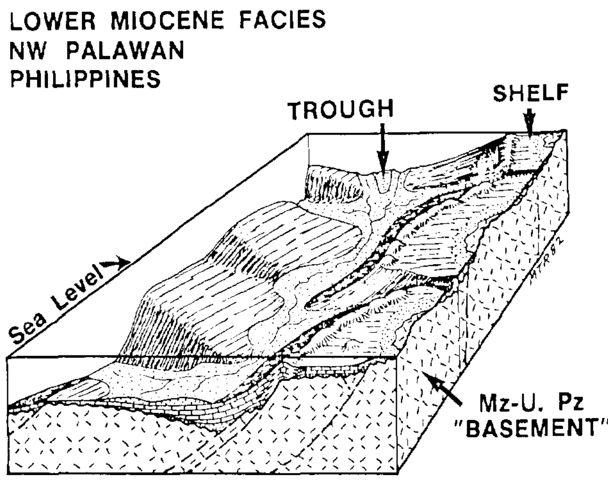
seal over the reef that protects internal reef components from additional submarine diagenesis. Consequently, some primary porosity remains intact, that, with continued submergence, may bypass meteoric diagenesis and still remains to become enhanced by late subsurface events.

Within core samples of Cretaceous and Miocene reefs, porosity created by late-stage dissolution is facies specific and predominantly moldic and enhanced primary (skeletal and interparticle). Submarine cements occlude some primary porosity in each reef facies. However, back-reef facies result in higher observed porosity because primary permeability allowed greater access for dissolving fluids. Stylolites that form and remain open within reef packstone-grainstone facies act as avenues for fluids that dissolve skeletal grains along narrow adjacent zones within the rock matrix. This late-stage dissolution can produce significant porosity where primary permeability is still preserved. Limited early submarine cementation inhibits burial compaction and acts to preserve porosity. Where stylolites extend into back-reef mudstone and wackestone facies, a higher percentage of impermeable muds and a limited amount of skeletal grains available for dissolution prevent development of significant porosity. Late-stage subsurface dissolution within reefal buildups, whether by widespread, pervasive fluid migration or as fronts along stylolite zones, is commonly facies-controlled by primary porosity and permeability characteristics. Thus, the distribution and degree of submarine cementation are important to both the early and late development of porosity in reef reservoir facies, even though sometimes for indirect reasons.



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Alternating Carbonate and Siliciclastic Deep-Water Facies in Tectonic Evolution of Northwest Palawan Margin (Philippines), South China Sea

Shifting Mesozoic and Cenozoic tectonic events controlled the deposition of thick alternating sequences of deep-water carbonate and siliciclastic sediments on the northwest margin of the North Palawan crustal block.

Highly deformed Jurassic to Lower Cretaceous rocks at the base of the section may have originated in a fore-arc region along the South China margin. This convergent margin shifted into a broad extensional region in the Late Cretaceous or early Paleogene. The Late Cretaceous through the early Eocene is generally a time of hiatus in the rock record, but rocks of this age may occur in half grabens under the northwest Palawan slope.

Late Eocene to mid-Oligocene dolomites and limestones were deposited in restricted to open marine environments as the rifted Mesozoic terrain subsided. During sea-floor spreading from the mid-Oligocene to early Miocene in what is now the central South China Sea, extensive carbonate deposition of reefs, platform lagoons, and deep-water sediments draped the trailing (northwest) edge of the southward-drifting North Palawan block. Over 1 km (3,300 ft) of diverse deep-water carbonate facies was deposited in an upper slope to basin setting. Turbidites were derived from reefal sources dominated by benthic forams, coral, and coralline algae. Mudstones formed by off-bank transport and settling of platform lagoon muds differ from normal pelagic deposits rich in planktonic forams. Deep-water carbonate units show a continual up-section decrease in abundance of reef- and lagoon-derived sediment and are abruptly overlain by deep-water siliciclastics.

Seismic profiles indicate late early Miocene tilting and partial emergence of the North Palawan block, during which clastic sediments prograded around and over relict carbonate platforms and deposited thick deep-water sequences on the northwest Palawan slope. These siliciclastics were deposited in submarine fan complexes as sand-rich middle to inner fan channels, outer fan lobes, and pelitic interchannel and interlobe deposits. After crossing the submerged carbonate terrain, turbidites were axially confined to a northeast-trending trough and formed a stratigraphic wedge several hundred meters thick against the slope of the relict platforms. Eroded shallow-water carbonate lithoclasts were commonly incorporated within siliciclastic turbidites. Turbidite sandstones are texturally submature feldspathic litharenites and subarkoses, and indicate a source terrain of quartzo-feldspathic sediments and metasediments, chert, volcanics, and acid-intermediate plutonic rocks. Petrologic studies thus support seismic and dip-meter interpretations that these sediments were derived from emergent pre-Tertiary rocks of the North Palawan crustal block.

Regional uplift in the middle Miocene was followed by mid to upper miocene subsidence, producing additional siliciclastic wedges on the northwest margin. The last regional uplift event, latest (?) Miocene, was characterized by wrench and reverse faulting. Miocene tectonism may have resulted from collisions of the North Palawan block with now adjacent terrains in the South Palawan, Mindoro-Panay, and North Sulu Sea regions. The northwest Palawan margin has been tectonically quiescent since the early Pliocene, marked again by carbonate deposition of reefs and flanking deep-water deposits.

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Pore Geometry: New Techniques for Quantitative Analysis

Accurate measurements and high resolution three-dimensional displays of pore geometry have been achieved using sophisticated optics, three-dimensional image analysis, and techniques of computer tomography. These new methods allow detailed analysis of low permeability pore structures with isolated secondary porosity. Examples under study include Cotton Valley tight gas sands, Smackover carbonates, and Whitestone limestone.

The procedure is to "serially section" rock samples, either by successive 2μm grindings or by microtoming brominated-epoxy/epoxy "double pore-casts." SEM images or photomicrographs of the sections are digitized, and these successive images are reconstructed into three-dimensional data sets. These data sets are then