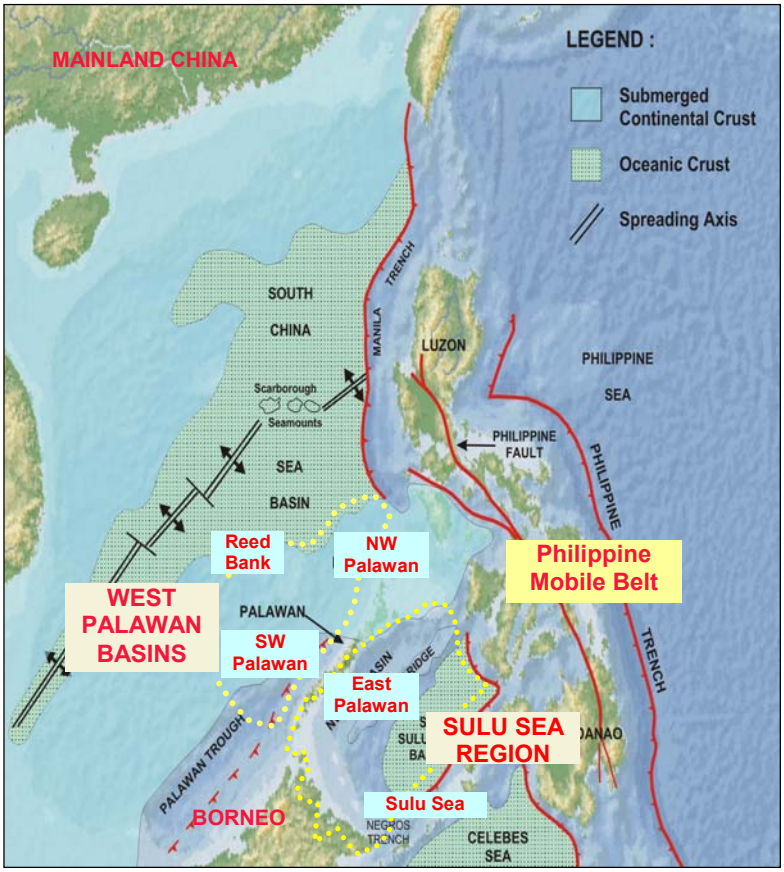
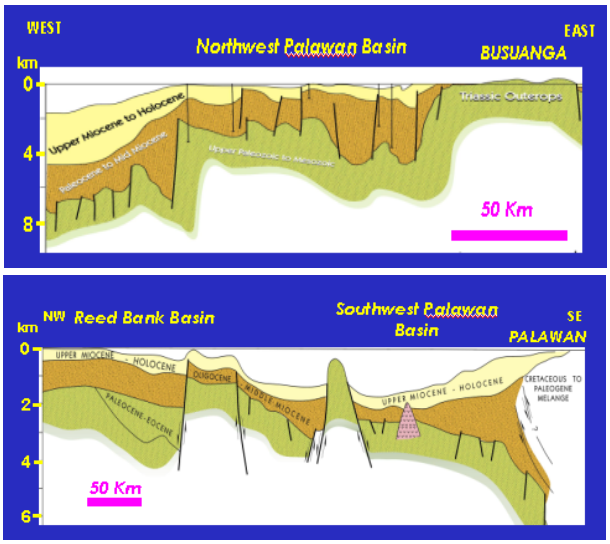
Petroleum Potential of West Palawan Basins and Sulu Sea Region



The Philippines is made up of two major tectonic units, namely, a) the stable rifted continental block to the west and b) the mobile Philippine arc to the east. The offshore West Palawan and the Sulu Sea region belong to the rifted block that separated from mainland China as a direct consequence of the opening of the South China Sea basin in the Oligocene. The block, considered an integral part of the Eurasian plate, is basically continental in nature except for marginal basins created along its edges.

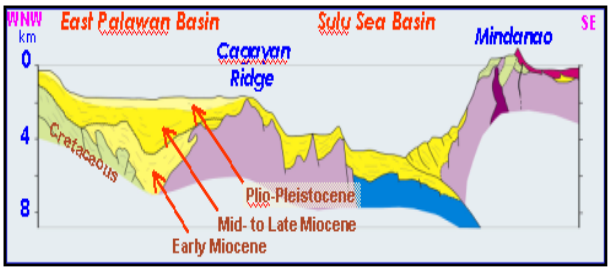
The offshore West Palawan consists of three sedimentary basins namely, Northwest Palawan, Southwest Palawan and Reed Bank. The Sulu Sea region is composed of the East Palawan and the Sulu Sea basins including the sub-basins of Balabac, Bancauan and Sandakan. The area of each basin ranges from 36,000 sq km to 92,000 sq km (Sulu Sea is bigger but it is partly covered by oceanic crust).

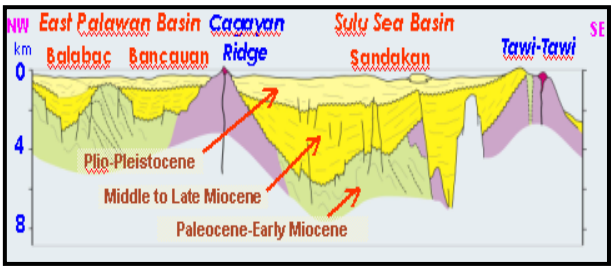
Basin Fill and Structure



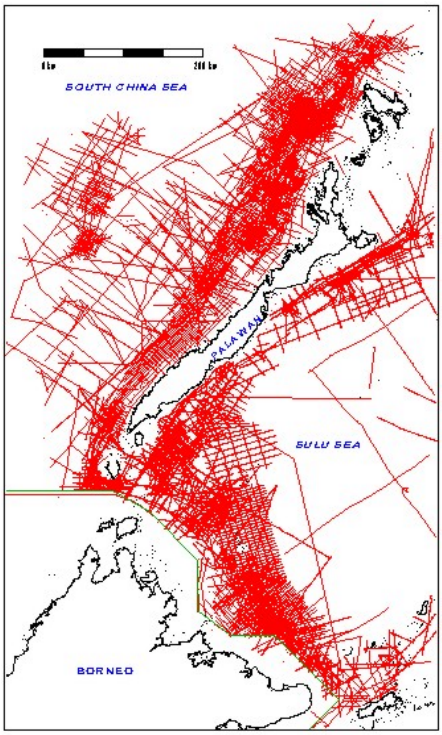
The NW Palawan basin is characterized by both extensional and compressional structures. The extensional features are parallel tilted fault blocks and intervening half-grabens. The basin has a sedimentary fill in excess of 10 km ranging from Late Paleozoic to Cenozoic in age. The SW Palawan basin is characterized by a thrust front and at least two major northeast-striking, northwest dipping master fault sets, believed to be transforms related to the opening of the South China Sea. These are offset by north-south striking, high angle faults. Basin fill is composed of

Upper Mesozoic to Quaternary marine clastic-carbonate sequences with up to seven km thickness, based on seismic evidence. The Reed Bank basin is a bathymetrically shallow portion located west of Palawan. It forms a plateau-like, stable block with many shoals and banks most of which are capped by present day coral reefs. The dominant regional structural pattern is characterized by differential subsidence and lateral tension. The area is deformed by extensional, antithetic, NE-SW to NNE-SSW faults dipping northwest and by small en echelon, NE-SW transtensional graben.



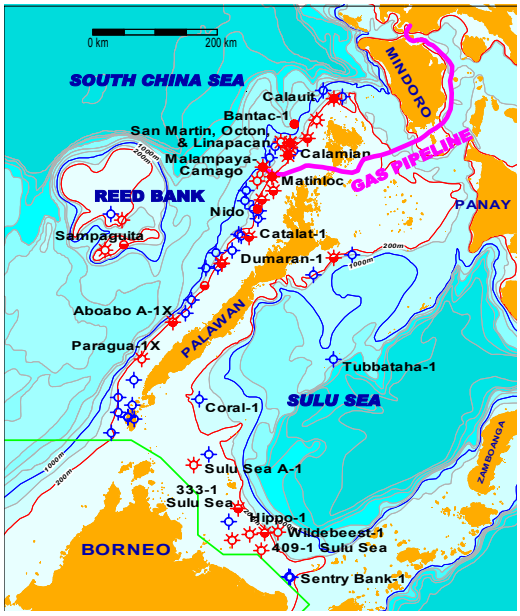


The basin fill of the Sulu Sea region consists of Tertiary marine sequence of clastic rocks resting on a Cretaceous to Paleogene basement. The Balabac and Bancauan sub-basins consist predominantly of shallow to deep marine sediment facies that are over five and three km thick, respectively. The Sandakan sub-basin, on the other hand, is covered by over nine km thick fluvial-deltaic facies. Basin deformation in the Neogene and younger section suggests extensional block faulting and subsequent wrenching. The underlying Paleogene section is generally highly deformed, possibly thrusted. Growth faults associated with fluvial-deltaic deposition formed rotational fault blocks in the Sandakan sub-basin.



Exploration and Drilling History

Petroleum exploration in the West Palawan started in the mid-1960's with the acquisition of 1,800 line-km 2D marine seismic data by Amosais Philippines in the SW Palawan basin. It was followed by the acquisition of about 7,200 line-km of seismic data acquired in the NW Palawan and Reed Bank basins in the 1970's. The first offshore petroleum well in the country, Pag-asa 1A, was drilled by Oriental Petroleum and Minerals Corporation in 1971. This was followed by the drilling of Calamian-1 well in the same year to test the Miocene clastics and carbonates in anticlinal fold and faulted monocline. With the introduction of the Service Contract System in 1973, petroleum contractors began acquiring 2D and 3D seismic data to complement their drilling programs. Seismic data acquisition from 1973 to



present amounted to 85,400 line-km 2D and 5,300 sq km 3D data. The extensive exploration program in the 1970's resulted in several oil and gas discoveries in the West Palawan basins. Nido-1 well, drilled by Philippine Cities Service, Inc. in 1976, was the first oil discovery in the NW Palawan basin. A total of 126 wells, composed of 96 exploration, 22 development, and 8 appraisal wells, were drilled in the West Palawan basins. Ninety-five of the 126 wells were drilled in the NW Palawan basin. Twenty-one are discoveries and six fields were developed for commercial production. To date, a total of 54 MMBO, 4 MMBC, and 67 BCFG were produced from the NW Palawan basin mostly from Miocene carbonate reservoirs.

Tubbataha-1 well was the first attempt to explore hydrocarbons in the Sulu Sea region. It was drilled in 1957 to test the Tubbataha reefs. Since then, a total of 18 wells have been drilled in the region, 7 in East Palawan and 11 in Sulu Sea. Eight of these wells have oil and gas shows. From 1965 to 2002, a total of 50,400 line-km of 2D seismic data including the most recent 5,900 line-km of WesternGeco have been acquired in the area. About 1,800 sq km of 3D seismic data was obtained by ARCO for the Hippo prospect in 1998.

Petroleum Potential

Source rocks and maturity

Eocene shales and Lower Miocene claystones in SW Palawan and Reed Bank are fairly rich in organic carbon with potential for oil and gas generation. Late Oligocene carbonates in NW Palawan are organically rich and capable of generating fair amounts of gas and oil at full maturity. The Paleogene syn-rift sedimentary unit assumed to comprise deep marine shales and marl with average 1.3 % TOC is also considered a potential source rock.

In the Sulu Sea region, principal source rocks are shales and siltstones of the Miocene section that have TOC values of up to 3 %. The successful flow of oil and gas from Miocene deltaic sands in the three offshore Sabah wells and oil and gas shows in the Philippine wells are evidences of hydrocarbon generation in the basin.

Reservoir

The Nido Limestone has been the main objective in the search for oil ever since the first oil discovery at Nido-1 in 1976. The reefal facies is the main reservoir with porosities of up to 22 %. The platform limestone often has good vugular and intercrystalline porosity. Proven clastic reservoirs include the Early Miocene Galoc sandstones overlying the Nido Limestone and the Paleocene-Early Eocene sandstone

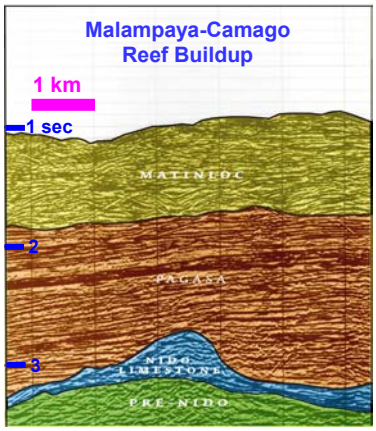
in the NW Palawan and Reed Bank basins, respectively. In the SW Palawan, non-commercial gas flowed from the Oligocene and Early-Middle Miocene sandstones and Pliocene sands.

Thick transitional marine to inner neritic Early to Late Miocene quartzose sandstone reservoirs primarily associated with deltaic facies developed along a broad northwest-southeast trend in the Sandakan Sub-basin in the Sulu Sea region. Measured porosities vary from 16 % to 35 %. The Middle Miocene reefal carbonate intersected at Sentry Bank Reef-1/1A in the Sandakan sub-basin proved to have an excellent reservoir with porosities greater than 20 % and permeability of up to 7 darcies.

Seal

The Early to Middle Miocene fine-grained sediments overlying the Nido Limestone is an effective regional seal. Intraformational fine clastics serve as an effective seal with sandstones in the West Palawan basins and the Sulu Sea region.

Petroleum plays



Proven stratigraphic plays in the NW Palawan include the Miocene reef complexes and turbidites. The established trap configuration in the Reed Bank area consists of Paleocene to Eocene deltaic channel sands in truncated and tilted fault blocks.

In Sulu Sea, potential hydrocarbon traps consist of anticlines, turbidites and possibly carbonate buildups.

Resource Assessment

The Philippine Petroleum Resource Assessment Project developed a petroleum resource classification system and established an inventory of Philippine petroleum resources. The results showed that the country's total risked petroleum resources is about nine billion barrels fuel oil equivalent (bfoe). More than half of these or about five billion bfoe is estimated to occur in the offshore West Palawan and Sulu Sea regions.