

Petroleum Basins

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New Zealand basin overview

There are eight sedimentary basins with known or potential hydrocarbons onshore and underlying the continental shelf of New Zealand, as well as several deepwater basins within its Exclusive Economic Zone. Commercial and sub-commercial discoveries, abundant potential source rocks, thick Cretaceous-Cenozoic sediments, and numerous hydrocarbon seeps and shows in exploration wells all indicate that petroleum generation and migration has and is taking place in many of these basins.

The petroleum systems hosted in several of the country's basins have many common characteristics because the stratigraphic distribution of potential source, reservoir, and seal rocks generally follows a similar pattern. However, the diversity of tectonic environments in New Zealand has produced differences in maturation and migration history.

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New Zealand's Petroleum Systems

Tectonic development of New Zealand basins

All New Zealand's prospective sedimentary basins are younger than Early Cretaceous and most are composite basins, exhibiting multiple evolutionary phases and sediment deposition. Basin evolution can generally be divided (from oldest to youngest) into rifted margin, passive margin, and convergent margin episodes that reflect the broad plate tectonic development of the New Zealand sub-continent.

The break-up of Gondwana from the mid-Cretaceous, and spreading in the Tasman Sea in the Late Cretaceous and Paleocene, initially led to the formation of rift basins and the deposition of terrestrial sediments that now form the predominant source rocks in many basins. The early Paleogene was a period of comparative tectonic quiescence, basin development was characterised by regional post-rift thermal subsidence, and widespread marine transgression leading to the deposition of shoreline sands followed by marine silts and muds. These transgressive shoreline systems contain important productive and potential reservoir rocks, while overlying silts, muds and carbonates form good seals.

In the Middle and Late Eocene, sea-floor spreading to the southwest of New Zealand marked the initial stages in the development of the present-day Australian-Pacific plate boundary in the region. Pacific Plate subduction began to impinge upon northern New Zealand from the mid-Oligocene. As subduction progressed through the Early Miocene, regional subsidence was accompanied by reverse faulting along the eastern margin of the Northland and Taranaki basins. Back-arc extension and local volcanism ensued, and has continued to the present day.

During the Neogene, the Alpine Fault evolved to become the primary focus of dislocation between the Pacific and Australian plates in the New Zealand region, with more than 450 km of dextral strike-slip motion on the fault since the Early Miocene. Since the Middle Miocene, relative plate motion has become more oblique and the rate of convergence has accelerated, resulting in increasingly rapid uplift, erosion and sedimentation, and widespread basin inversions. Deformation associated with this tectonism has produced many structural traps.

Source rocks

Most of New Zealand's current hydrocarbon production is sourced from terrestrial and marginal marine rocks of Late Cretaceous to Eocene in age within both syn-rift and transgressive coastal plain settings. Biomarkers indicate marine influences in Cretaceous and Paleocene rocks, and there are marine rocks with source potential in laterally equivalent basinal settings.

Reservoirs

Potential reservoir rocks are present throughout the stratigraphic record. The most productive reservoir rocks are in Paleogene transgressive shoreline systems and a variety of facies belts within Neogene clastic depocentres. Oligocene and Early Miocene limestone with high fracture permeability is a prolific oil reservoir in the Taranaki Basin. Hydrocarbons are also produced from Miocene and younger deepwater sandstone turbidites in Taranaki, and similar Neogene slope and basin floor fans are found in many other New Zealand basins. Late Cretaceous transgressive shoreline sands are viable but untested reservoirs. In the East Coast region, Pliocene-Pleistocene coquina limestone has favourable reservoir characteristics.

Seals

Seals are abundant in all potential petroleum basins and overpressures, indicative of fluid confinement within the stratigraphic sequence, are often encountered during drilling operations. Seal rocks in most basins are widespread marine mudstones that were deposited during both the passive margin transgressive phase and the regressive convergent margin phase. Oligocene and Early Miocene limestones, that were not fractured during Neogene tectonism, may also provide seals in many basins.

Overburden

In general, there are two important periods of sediment deposition that resulted in substantial burial. Late Cretaceous rifting produced grabens several kilometres deep that rapidly filled with sediments. Hydrocarbon generation began in the deepest of these basins during the late Cretaceous and early Tertiary.

A second phase of rapid sedimentation occurred in many basins during the Neogene when the development of the plate boundary through New Zealand caused rapid uplift and erosion. Very high Neogene sedimentation rates, in excess of 1000 m per million years, have occurred in some basins. For example, deposition of the Giant Foresets Formation in the Taranaki Basin increased the overburden thickness by as much as 2000 m over much of the basin in just 3 million years. The volume of the Giant Foresets Formation is greater than the present day volume (above sea level) of the New Zealand landmass.

Traps

All commercial hydrocarbon accumulations encountered in New Zealand to date are in structural traps formed in the Neogene. In the Taranaki and East Coast basins the most prospective traps include thrust-controlled anticlines, overthrusts, inversion structures and normal fault-bounded blocks. Other leads include pinch-outs and drape-folds on high standing basement blocks, which are common in the Northland and Great South basins. In the East Coast region, where smectitic mudstones are common, diapiric structures may also form traps.

Generation, migration and accumulations

Thermal modelling studies predict that over most of New Zealand the present day depth of source rocks for oil expulsion requires burial of more than about 4000 m. Some hydrocarbons were possibly expelled in the deepest parts of basins as early as the Late Cretaceous, but in many basins the present day mature kitchen areas are essentially confined to areas where there has been significant Neogene deposition. In general, deepest source rocks comprise type III terrestrial sources, and younger overlying rocks are type II marine sources.

Migration paths from source rocks to reservoirs are poorly understood in New Zealand basins. In basins where there has been a lot of deformation, there is uncertainty about the importance of faults as pathways for hydrocarbons.

In most basins, generation, migration and entrapment of hydrocarbons took place in the Tertiary. The critical moment for the petroleum system of various accumulations, when all prerequisite geological factors for the charging of traps begins, is predicted to have been during the Eocene and Oligocene for the Great South, West Coast and Western Southland basins, and during the Neogene for all other basins.

Prospectivity

All of New Zealand's production so far has been from the Taranaki Basin, the country's most explored and commercially successful hydrocarbon province. However, the basin is only moderately explored compared with basins world-wide, and there is considerable scope for further commercial discoveries as demonstrated by recent exploration successes.

The rest of New Zealand is severely under-explored, and most sedimentary basins have the potential for commercial hydrocarbon discoveries. Many untested structural closures are potentially larger than the giant Maui field in the Taranaki Basin.

As exploration and research programmes advance, understanding of New Zealand's sedimentary basins and their petroleum systems continues to evolve. The important geological elements and the timing of generation, migration and accumulation of hydrocarbons are now broadly understood, enabling a more methodical approach to identification and appraisal of prospects. Coupled with increasing levels of exploration over recent years, this has led to an enviable success rate for wildcat drilling and a recent commercial discovery success rate of one in three in Taranaki Basin. Ongoing exploration can be expected to lead to further finds here and in other basins.

[Northland Basin](#)

New Zealand's Northland petroleum sedimentary basin

[Taranaki Basin](#)

New Zealand's Taranaki petroleum sedimentary basin

[Wanganui Basin](#)

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New Zealand's West Southland petroleum sedimentary basin

[Northland Basin Map](#)

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[Taranaki Basin structural styles](#)

Taranaki Basin structural styles