

EOCENE TO RECENT STRUCTURAL HISTORY OF ONSHORE TARANAKI, WITH REFERENCE TO THE MAIN PLAY STYLES

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Abstract

Detailed seismic interpretation in onshore Taranaki PPL's 38083, 38084, 38702, 38706 and 38707, has resulted in the recognition of a multiphase history of deformation. Three major structural episodes have been identified.

Mid Eocene extensional activity along NE and ENE trending faults has been recognised between Stratford and Kapuni. Fault throws of up to 400 m are apparent.

Oligocene to Late Miocene compressional activity formed the major north-south trending structural features in central and eastern Taranaki. This episode is made up of three components. In the Oligocene, foreland basin subsidence commenced and was associated with growth of monoclinial flexures. Compressional activity reached maximum intensity in the Early Miocene when a number of folds and two thrust zones were formed. The Tarata Thrust Zone to the west is typified by thin-skinned detachment tectonics involving only Tertiary sediments. The Taranaki Fault Zone involves thrusts of both Tertiary material and imbricate slices of Mesozoic basement. Compressional activity continued in the Mid to Late Miocene period with formation of inversion structures and continued growth of folds.

Pliocene to Recent extensional activity with associated wrench movements formed complex fault patterns including negative flower structures, especially in central and western Taranaki. Fault throws of up to 750 m have been observed. Contemporaneous uplift and tilting of Taranaki Peninsula resulted in regional dips of up to 4°.

Each of the three episodes has contributed to the formation of structural closures. The principal closure-forming events are the Oligocene-Miocene compression and the Pliocene to Recent extensional-wrench faulting. These two episodes, either individually or in combination, have formed most of the known structures. However, the Eocene faulting and the late tilting are important for some prospects.

Introduction

The Taranaki Basin, located on and offshore along the western side of New Zealand's North Island, has been the focus of the petroleum exploration industry in New Zealand since 1865, when digging around the Moturoa seep began (McSweeney, 1989). Since then, exploration activity, more particularly the drilling of wells and interpretation of seismic data, has led to major advances in understanding the geology of the basin. As a result, a number of regional syntheses of the geology have been published, such as Pilaar and Wakefield (1978); Knox (1982); Palmer (1985); Thrasher (1989); King (1989) and Palmer and Bulte (1991). For background information on the basin as a whole and on the stratigraphy, the reader is referred to these.

This paper is limited in scope to the onshore Taranaki Peninsula and addresses the structural styles and development in some detail, with reference to particular prospects and leads. Structures developed in the Cretaceous-Paleocene sequence are not covered as these are generally beyond the

reach of drilling. The paper draws on seismic interpretations conducted by NZOG over the period 1989-91 in onshore Taranaki Petroleum Prospecting Licences 38083, 38084, 38702, 38706 and 38707 (Figure 1). Some observations from elsewhere have also been included.

In addition to standard seismic interpretation, two other techniques have been used to develop the structural interpretations presented in this paper. Forward seismic modelling using Daniel Geophysical software was used for resolving complex thrust geometries along the Tarata Thrust Zone and the Taranaki Fault Zone. Cross-section balancing was also used to help refine the interpretations in these areas.

Major Structural Features

In a regional context, Taranaki Peninsula is located mainly on the Urenui Platform, an elevated structural block separating the north and south Taranaki grabens. The major structural features in the onshore Taranaki Basin are shown in Figure 2. The diagram is a composite and shows structures present

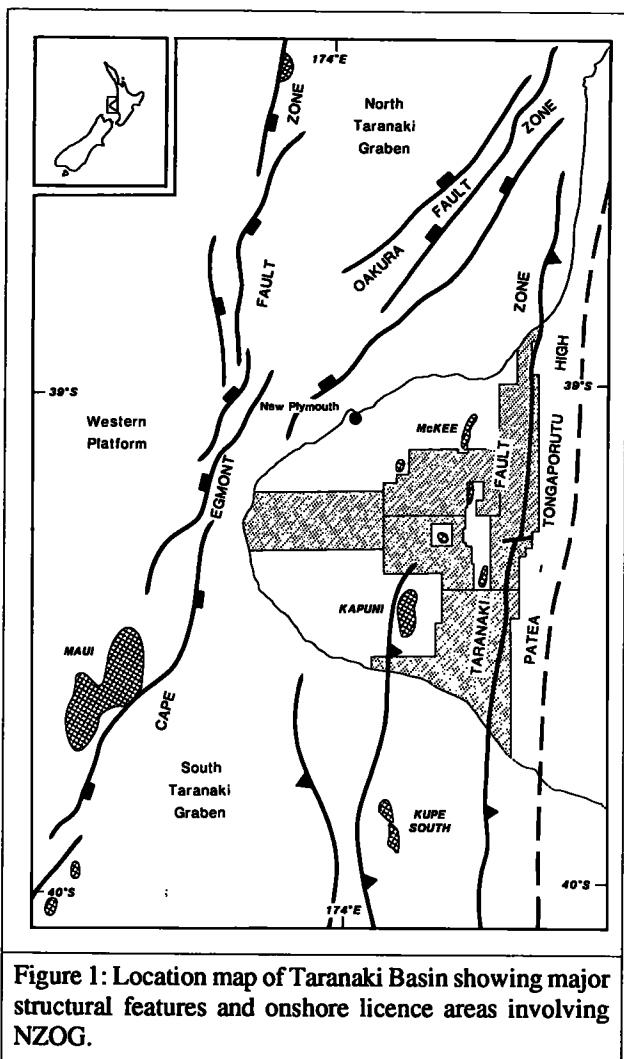


Figure 1: Location map of Taranaki Basin showing major structural features and onshore licence areas involving NZOG.

at various levels in the stratigraphic sequence, i.e. it is not a representation of the regional structure at a particular level. These features include:

- (i) The Taranaki Fault Zone in the east, is a thrust belt which forms the eastern margin of the Taranaki Basin. It defines the western edge of the Patea-Tongaporutu High, a north-south trending block of shallow Mesozoic basement (Mills, 1989).
- (ii) The Tarata Thrust Zone, 15 km further west, is a complex zone of thin-skinned detachment tectonics. The basal detachment surface is ultimately rooted in the Taranaki Fault Zone to the east. Two major transfer fault zones, the Totara and Toko faults, subdivide the Tarata Thrust Zone into segments with different structural configurations. The Tarata Thrust Zone dies out to the south in the vicinity of the Waihapa Anticline.
- (iii) A series of broad, generally north-south trending anticlines and synclines lie to the west of the Taranaki Fault Zone. These include the Waihapa Anticline, the Mangahewa Anticline, the Stratford Anticline, the Manaia Anticline and the Rahunu Anticline.
- (iv) A series of NE-trending wrench-fault zones to the east and northeast of Mt Taranaki have cut the Stratford Anticline into a series of discrete structures.
- (v) A broad, relatively unstructured area lies to the west of the Manaia Fault and has a strong regional dip to the south.
- (vi) Western Taranaki is an area of intense extensional-wrench faulting. This area has structural affinities with the

offshore North Taranaki Graben and underwent rapid subsidence in the Pliocene to Recent period while the eastern and northern parts of Taranaki Peninsula were being uplifted.

Outline of Structural History

Seismic data provides definitive evidence of a multiphase history of structural growth in onshore Taranaki. In this study, three distinct structural episodes have been identified within the Eocene to Recent period.

During the Mid Eocene and extending into the Late Eocene, extensional activity resulted in vertical movements on normal faults. The evidence for this episode is a series of ENE to NE-trending faults which offset intra-Kapuni Group (Mid Eocene) seismic reflectors, but do not cut the top Kapuni reflector (Eocene/Oligocene boundary).

From the Oligocene through the Miocene, there was a compressional period. This initially involved regional subsidence and tilting related to development of the Taranaki Foreland Basin. Thrusting along two zones and folding followed. The evidence for the timing of this episode is based both on seismic evidence of growth (thinning on to positive structures) in addition to recognition of unconformities representing significant time gaps in wells located on structures of this type.

In the Pliocene, the tectonic environment changed to extension with a strong wrench component. Over the Pliocene to Recent period this has resulted in widespread formation of normal faults, which in many cases are grouped together in the form of negative flower structures (Harding, 1985). These structures are clearly quite young as all units up to seismic datum (sea level) are cut by them, without any indication of differential structural growth. Growth therefore postdates the earliest Pliocene.

The three structural episodes identified are best illustrated by means of actual examples. Four structural prospects from areas operated by NZOG in onshore Taranaki have been selected. Their locations are shown on Figure 2.

Structural Examples

Tipoka Structure, located in western Taranaki (Figure 2), is an example of extensional-wrench faulting formed during the Pliocene to Recent episode. The structure is illustrated in Figs. 3A and 3B. Figure 3A is a time structure contour map at top of the objective Moki C sands (Early Pliocene). Figure 3B is a NW-SE oriented seismic section running in the dip direction across the Tipoka Fault block.

The overall structural form is a series of intersecting, NE-striking, listric, normal faults. These are largely confined within the Miocene-Pleistocene sequence and generally sole out above 2.5 sec Two Way Time (TWT). Their ultimate relationship with deeper structure is unclear. The Tipoka Fault dominates the structure and has vertical displacement reaching a maximum of 600 msec TWT (about 750 m) at top Moki C sands. Maximum horizontal offset in the plane of section (i.e. dip-slip) is approximately 800 m. Well ties, at Tipoka-1 on the downthrown side of the fault and at Burgess-1 immediately north of the area shown on the map, provide confirmation of the seismic picks.

A series of lesser antithetic faults are present on both footwall and hanging walls sides of the Tipoka Fault. The footwall antithetics help create structural closure to the north. The major faults shown on Figure 3A generally die out rapidly along strike. For example, displacement on the

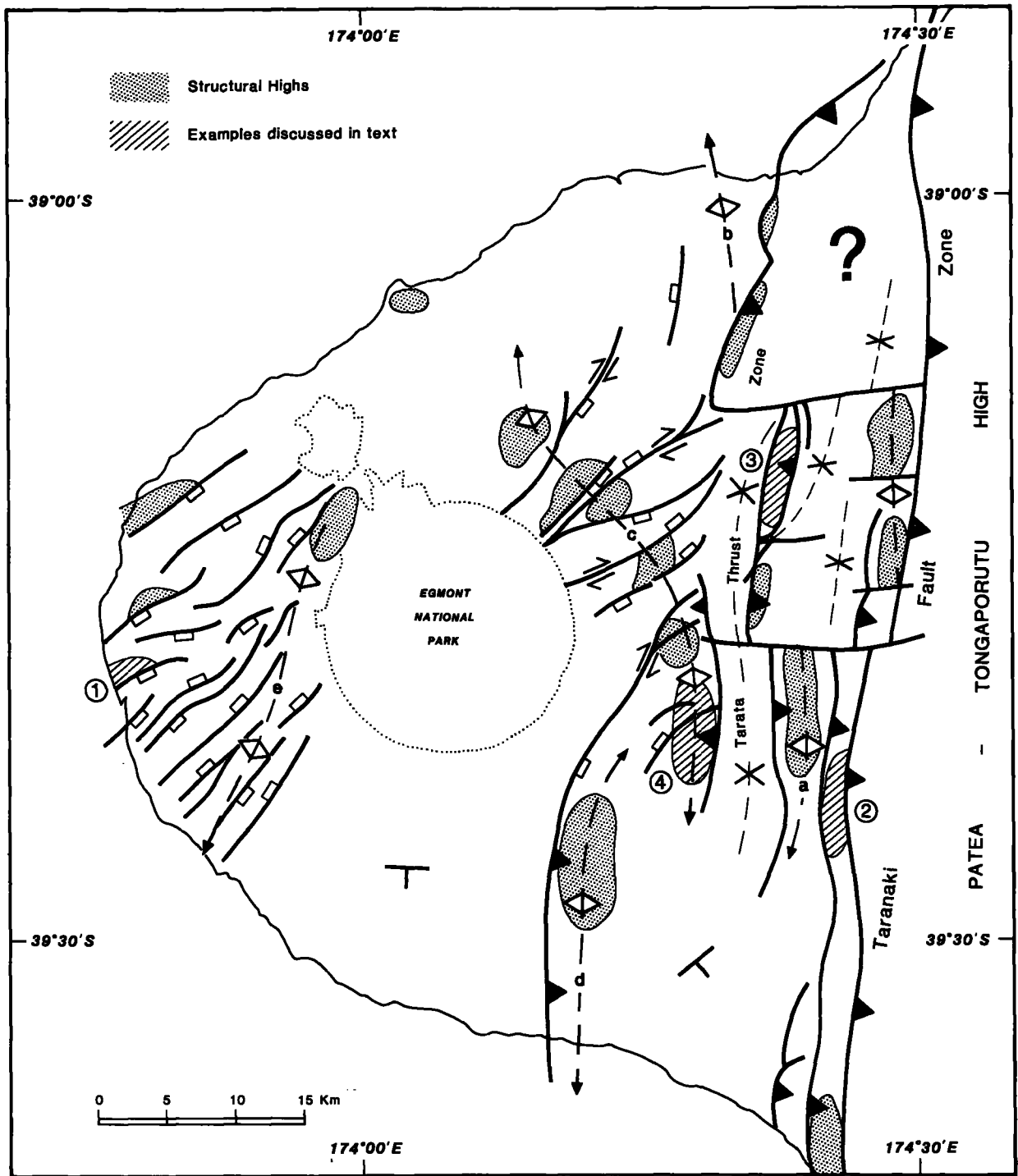


Figure 2: Regional setting of onshore Taranaki. The shaded areas are identified structural highs at various levels in the stratigraphic sequence. East of Egmont National Park they are at Late Eocene-Early Miocene levels. West of Egmont National Park they are at Late Miocene-Early Pliocene levels. The numbered structures are examples given in the text: 1) Tipoka; 2) Hu Road; 3) Tariki and 4) Cardiff. The Anticlines: a) Waihapa; b) Mangahewa; c) Stratford; d) Manaia and e) Rahotu.

Tipoka Fault decreases from 750 m to zero within 2.5 km. However, the displacement is taken up en-echelon by other faults. Such rapidly changing throws are typical of faults involving a significant component of wrench movement. Dramatic changes in thickness of the Mid Pliocene and younger units across the Tipoka Fault indicate that most structural growth occurred from approximately Mid Pliocene to about Early or Mid Pleistocene.

Hu Road Structure, located on the Taranaki Fault Zone (Figure 2), is an example of thrusting involving basement. The structure is typical of the thrust features along the footwall of the Taranaki Fault Zone in onshore Taranaki and is illustrated in Figs. 4A and 4B. Figure 4A is a time structure contour map at top Tikorangi Limestone. Intra basement structure has been omitted from the map for simplicity. The overall structural form is a north-south striking zone of

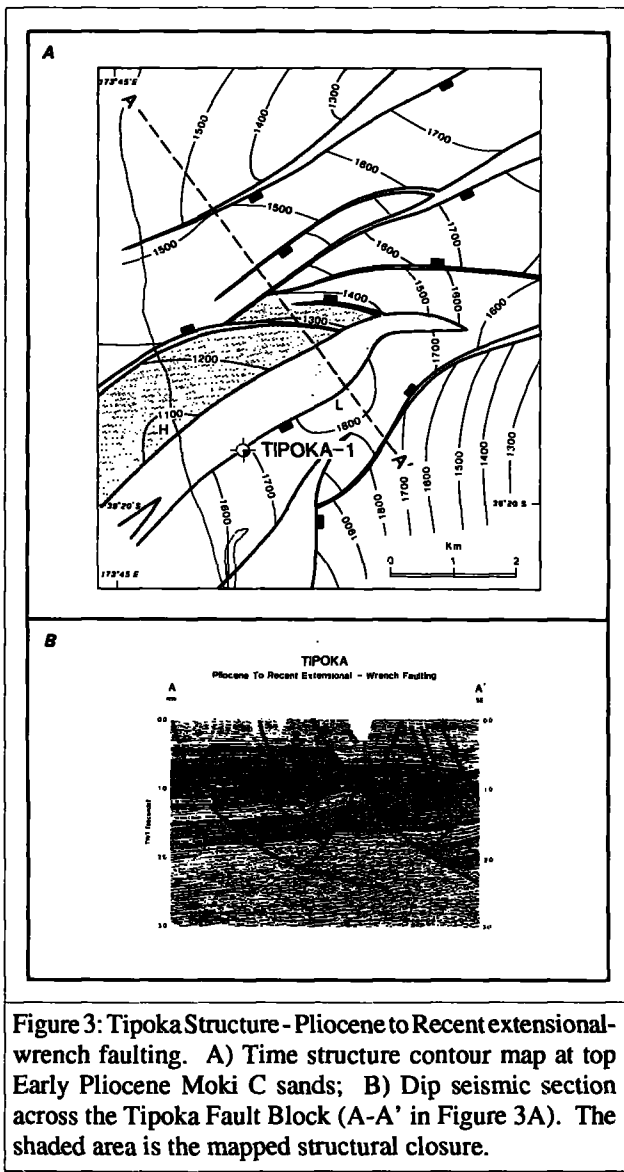


Figure 3: Tipoka Structure - Pliocene to Recent extensional-wrench faulting. A) Time structure contour map at top Early Pliocene Moki C sands; B) Dip seismic section across the Tipoka Fault Block (A-A' in Figure 3A). The shaded area is the mapped structural closure.

imbricate thrust slices which have moved from east to west along east-dipping thrust faults. The upper thrust slices are entirely of basement. The zone of Tertiary thrust slices is between 1 and 5 km wide. Figure 4B is an east-west seismic line running perpendicular to structural strike. Information from adjacent seismic lines along strike has been projected on to the eastern end of this section.

The wells Rotokare-1 and Pukearuhe-1 and some seismic lines provide good evidence that bedding in the basement sequence dips to the east. The thrust faults appear to have formed parallel to bedding within basement. In contrast, bedding within the structurally underlying thrust slices of Tertiary sediments generally dips at 5° to 40° to the west. These Tertiary slices are bounded by continuous thrust ramp segments which cross-cut bedding, there being few obvious flat or bedding-parallel segments.

Across the structurally lowest thrust fault on Figure 4B, the top Tikorangi reflector has been offset significantly less than the top Kapuni event. Despite this, the intervening Oligocene sequence thickens slightly to the east across the fault. In addition, there is noticeable flexure of the top Tikorangi reflector. This geometry suggests that thrust faulting was preceded by development of a fault-propagation fold.

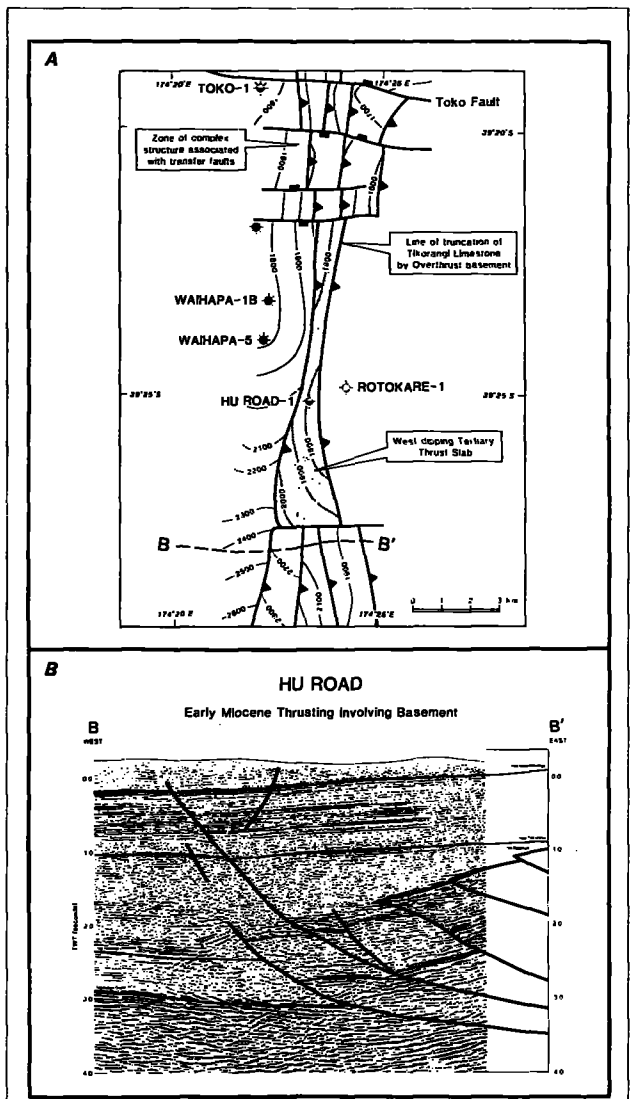


Figure 4: Hu Road Structure - Miocene thrusting involving basement. A) Time structure contour map at top Tikorangi Limestone; B) Dip seismic section across the Taranaki Fault Zone south of Hu Road (B-B' in Figure 4A), showing the main basement thrusts and frontal Tertiary thrust blocks. Shaded area is the structural closure at Hu Road.

Figure 4A shows that the thrust belt is broken into segments along strike by transfer faults. They are well developed in an area north of Hu Road Structure. The Toko Fault is the most prominent and well defined. There are often abrupt changes in structural configuration across these transfer faults. The leading edge of the frontal basement thrust is offset by up to 1-1/2 km and the number of Tertiary thrust slices often changes. These faults can be important in providing strike direction closure. It is suggested that they act as a structural accommodation mechanism analogous to the transfer faults now widely recognised in extensional tectonic terranes. The existence of these east-west transfer faults is strongly suggestive that the Early Miocene thrusting involved simple east-west compression with no significant wrench component.

The timing of activity along the Taranaki Fault Zone can be clearly demonstrated on the seismic data. Eastward thickening of the top Tikorangi - top Kapuni interval from

the west, across the thrust blocks in the east, is evidence of Oligocene subsidence of the Taranaki Foreland Basin due to tectonic loading further east. Thrusting in the vicinity of the Hu Road Structure therefore post dates deposition of the Tikorangi Limestone (Waitakian) and can be dated as mainly Altonian (Early Miocene) in age. However, in some places further north, significant movements persisted into the Tongaporutuan (Late Miocene).

The fault shown cutting through the Mid Miocene to Pliocene sequence on Figure 4B is a normal fault which adjoins an older thrust fault at depth. This indicates Pliocene to Recent reactivation of an Early Miocene thrust fault plane with reversal of movement sense in an extensional environment.

The third example, the Tariki Structure, located on the Tarata Thrust Zone (Figure 2), illustrates thin-skinned detachment and associated thrust. It is shown in Figs. 5A and 5B. Tariki is a complex compressional feature of similar age to the Hu Road Structure, but is considerably different in style. The map shown in Figure 5A is a time structure contour map over the northern part of Tariki Structure at the top Tikorangi Limestone. The map shows only the highest thrust slice as well as the autochthonous area to the west. The map illustrates that Tariki is a NNE-striking, west-dipping, fault-bounded slab of about 2 to 3 km width. There are a number of well developed transfer faults at Tariki. A complex transfer fault zone shown at the northern edge of the map, the Totara Fault Zone, separates Tariki from the McKee Structure to the north. Both Tariki and McKee Structures plunge towards this fault zone. Figure 5B is an east-west seismic line across the northern extension of Tariki in PPL 38706. The southern part of the structure lies within the Tariki Mining Licence.

The structural interpretation shown in Figure 5B is the end result of an extensive seismic modelling project using recently reprocessed seismic data. This interpretation differs significantly from previous interpretations by Haines (1990); and by Palmer and Bulte (1991). A number of wells provide both structural and velocity control. The modelling process involves the construction of a depth model based on the initial interpretation of the seismic section. According to the observed interval velocities from adjacent wells and the appropriate densities, a pseudo-stack was generated using Daniel Geophysical software. The pseudo-stack was compared with the observed stack and the depth model was then modified accordingly. This process was reiterated until a satisfactory fit between the pseudo-stack and the observed stack was achieved (Figure 5B). During this process some refinements were made to the interpretation by section balancing using the line length method.

In 2D profile, Tariki can be described as a reverse thrust structure, with a vertical relief in excess of 600 msec TWT. The appearance of Tariki is complicated by the presence of minor imbricate reverse thrusts beneath the main thrust mass and by the conjugate thrust fault cutting the upper part of the structure. Although most of the thrust faults dip to the west, the tectonic transport direction was from east to west, as it is throughout the Tarata Thrust Zone. The basal detachment surface appears to be in the Mangahewa Coal in the upper part of the Kapuni Group (Late Eocene).

Tariki lies above a prominent monoclinial flexure formed during the Oligocene. This early flexure is illustrated on Figure 5B by the rapid eastward thickening of the Oligocene

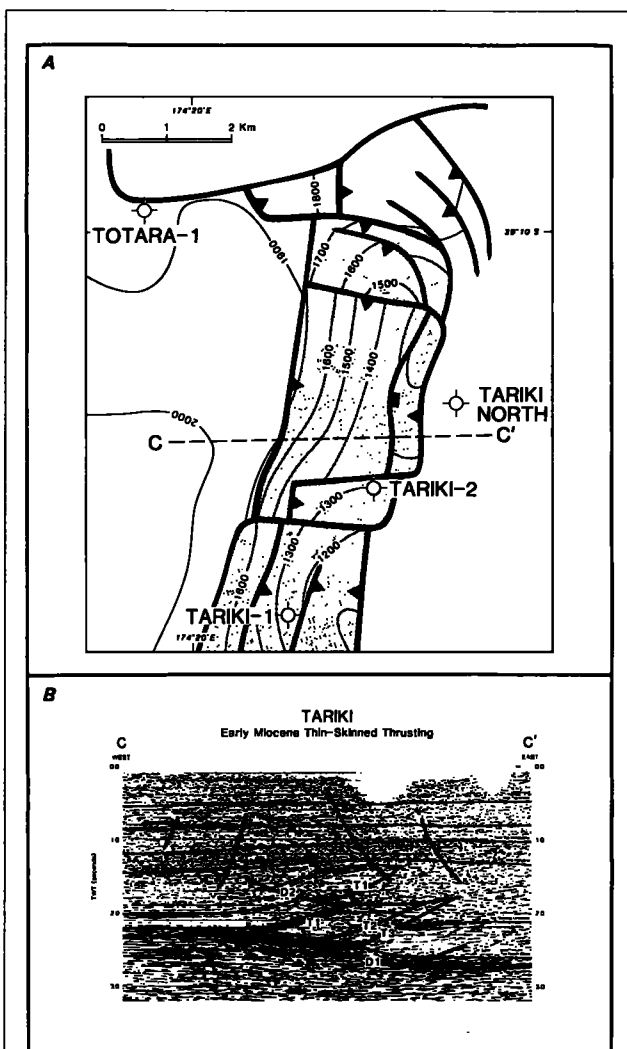


Figure 5: Tariki Structure - Miocene thin-skinned detachment thrust. A) Time structure contour map at top Tikorangi Limestone showing the bounding thrusts and transfer faults; B) Dip seismic sections across the Tariki Structure (C-C' in Figure 5A) showing: the main detachment thrust (D1), secondary thrust (D2) and reverse thrusts (T1, T2 and T3).

section between top Tikorangi and top Kapuni reflectors. The geometry of the Tariki Structure was controlled by this pre-existing flexure. It is considered that, as the basal detachment propagated to the west to the monoclinial flexure, a zone of weakness developed at the foot of the flexure. This was probably due to high concentration of stress and resulted in development of a west-dipping passive thrust (Figure 5B, T1). The west-moving detached slab then became a wedge and drove the passive thrust upwards. As the wedge-shaped, detached slab moved further to the west up the monoclinial flexure, it progressively steepened the passive, reverse thrust plane. At a certain stage in this process the amount of energy required to form a new reverse thrust plane became less than the energy required to continue driving the existing reverse thrust slab upwards. Thus, a second (and later a third) reverse thrust was developed at the foot of the monoclinial flexure as shown in Figure 5B, T2 and T3.

Structural growth at Tariki took place mainly during the Early Miocene Altonian stage. Some mild compressional activity persisted into the Late Miocene, as is illustrated by

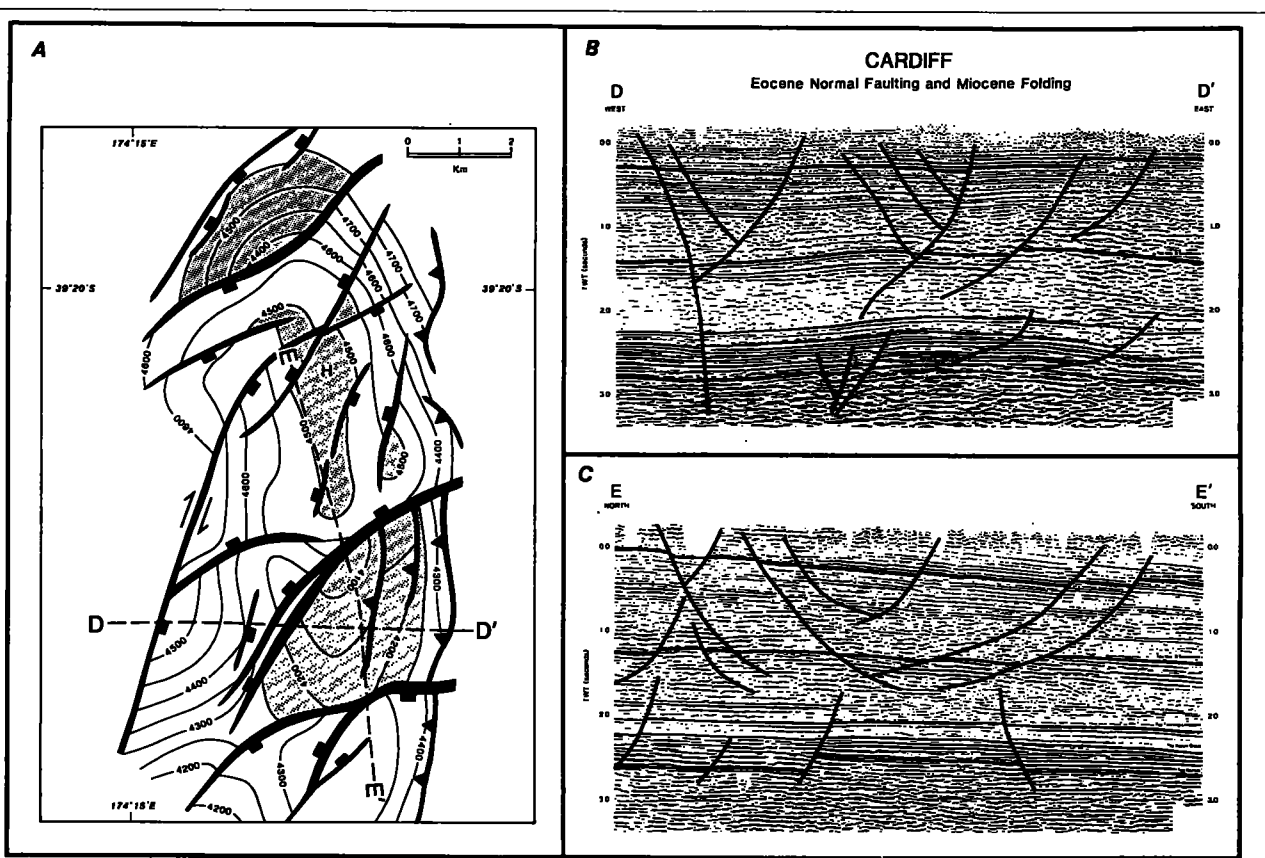


Figure 6: Cardiff Structure - Eocene normal faulting and Miocene folding. A) Depth structure contour map at top Mid-Eocene Kapuni K3 sands. Shaded areas are mapped structural closures; B) Dip seismic section across the Cardiff Structure (D-D' in Figure 6A) showing the anticlinal form in the Eocene to Upper Miocene sequence. Typical negative flower structures formed during the Pliocene to Recent extensional-wrench episode are also shown; C) Strike seismic section along the Cardiff Structure (E-E' in Fig 6. A) showing Eocene normal faulting and Pliocene to Recent tilting.

the flexure of the Mid and Late Miocene horizons above the thrust complex.

Cardiff Structure, located at the southern end of the Stratford Anticline in PPL 38707, is the most complex of the four examples. All three episodes have been involved in forming Cardiff, including reactivation of earlier faults during the latest episode. Figure 6A is a depth structure contour map over Cardiff at top Kapuni K3 sands, a Mid Eocene fluvial sandstone unit which forms the main reservoir zone at adjacent Kapuni Field. Figs. 6B and 6C are seismic sections across Cardiff in the dip (east-west) and strike (north-south) directions respectively.

Cardiff is a composite fault closure on a low amplitude, north-south trending anticline. Figure 6B shows that the anticline itself is well developed within the Eocene through Upper Miocene sequence, but is not present in the conformably overlying Pliocene sequence. This indicates that compressional activity ceased before the Pliocene. The steep eastern limb of the anticline is cut by a series of reverse faults and shows evidence of both Oligocene and Early Miocene fold growth.

Figure 6C illustrates that in the axial direction, Cardiff has the form of a horst block in the Kapuni Group sequence. The northern bounding fault of the block has over 200 msec TWT of offset at top K3 sands, equivalent to over 400 m. The seismic picks defining this fault throw are tied to wells to the north and south at Stratford-1 and Kapuni-8 respectively. Thinning of the Mid to Late Eocene Kapuni K2

sequence across the horst block, indicates the timing of fault movement. Horst block formation therefore pre-dates the folding episode. This phase of extensional faulting appears to have ceased during the Late Eocene and was followed by a period of relative tectonic quiescence in the Latest Eocene.

Figure 6A illustrates the complexity of the fault pattern at Cardiff. Three generations of faulting appear to be present. The normal faults active during the Eocene are most prominent as they involve the largest vertical offsets. These faults strike ENE to NE and effectively break the anticline into a series of separate closures. Some segments of these early faults have been reactivated in the Pliocene to Recent episode. The reverse faults, on the eastern limb of the structure, strike parallel to the anticlinal axis and were formed concurrently with the folding (Oligocene-Miocene).

A series of NNE to NE-striking faults which splay and intersect with the other fault sets, are of Pliocene to Recent age. These are also well illustrated in Figure 6B. In this section, the Miocene-Pliocene sequence is cut by clusters of normal faults which form upwardly splaying patterns. In some cases, one or more master faults persist downward into the Kapuni Group. These fault clusters constitute negative flower structures and are indicative of an extensional-wrench environment (Harding, 1985). Further north in the Inglewood area, negative flower structures are instrumental in forming closures in Miocene turbidite sands (Moki and Mt Messenger Formations). In western Taranaki, faults of this same vintage display dextral horizontal offset.

Pliocene to Recent tilting in onshore Taranaki is best illustrated in Figure 6C. This regional tilting in the Pliocene sequence is important in forming structural closure. Prior to tilting, the Cardiff Structure lacked closure to the south. The tilting also resulted in a strong regional variation of seismic velocity which distorts the structural configuration mapped in travel time.

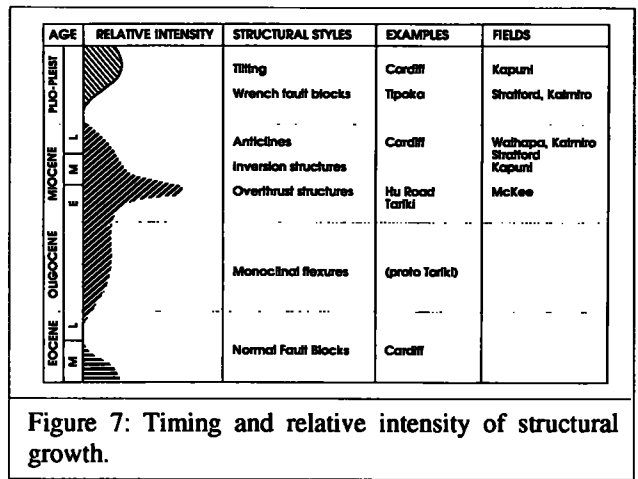
Synthesis and Conclusions

The four examples described above were selected so as to illustrate a representative cross-section of the structural styles in onshore Taranaki. Figure 7 presents a synthesis of the structural history indicated from these examples and elsewhere. The relative intensity of the three structural episodes is shown in the figure in diagrammatic form with shaded areas of varying width.

The Eocene extensional episode resulted in formation of fault-block structures in the Kapuni Group, such as at those at Cardiff and Stratford. So far, faulting of this age has only been recognised in central Taranaki. The significance of these faults, as trap-forming faults in the Kapuni K3 sands, is unknown and will depend on the level of permeability in the fault-juxtaposed Kapuni K2 sequence.

Compressional tectonics, from the Oligocene through Miocene period, resulted in formation of a wide variety of structural features in onshore Taranaki. Mild compression during the Oligocene, associated with foreland basin development, resulted in growth of north-south trending monoclinial flexures, which are widely developed in eastern Taranaki. During the climax of compression in the Early Miocene, intense thrust movements took place on the Taranaki Fault Zone along the eastern margin of the basin. Deep rooted thrusts from the Taranaki Fault Zone extended to the west and formed the basal detachment of the Tarata Thrust Zone. At the same time some of the Oligocene flexures grew into true anticlines (Stratford Anticline at Cardiff), some became the locus of thin-skinned thrust complexes (Tarata Thrust Zone) and others became inactive. This deformation was a consequence of significant east-west shortening. The amount of shortening is in the range of 5 to 10 km, possibly more. Within the zone of compressional deformation there were significant variations along strike in the rate and amount of shortening as well as differences in the geometry of structures formed. These variations were accommodated by the development of transfer faults. The Toko and Tarata faults are the two most important.

The compressional episode continued, at reduced intensity, through the Mid and Late Miocene. Inversion structures and localised reverse faulting occurred in this period, but folds were the principal structural style formed.



The Manaia Anticline, on which the Kapuni Field is located, is a high relief inversion structure formed by the uplift and folding of a buried Late Cretaceous half-graben.

The compressional episode formed most of the structural closures recognised in onshore Taranaki. Many fault-closed structures associated with thrusts have been drilled. The McKee, Tariki and Ahuroa fields are all located on overthrust slices along the Tarata Thrust Zone. A few sub-thrust fault closures along the Taranaki Fault Zone have been drilled, so far without success (e.g. Hu Road-1). A number of closures associated with anticlines have also been drilled with successes at Kapuni, Kaimiro, Stratford and Waihapa.

During the Pliocene, the tectonic environment changed and an episode of extensional wrench faulting began. This phase continues to the present. Zones of intense, generally NE-trending faults, were formed, many of which include prominent negative flower structures. During this episode high amplitude fault-block closures were formed in western Taranaki, where the intensity of faulting was greatest. In eastern Taranaki, in addition to new wrench-fault zones, many earlier faults were reactivated. These include both Eocene extensional faults and Miocene thrusts, with reversal of vertical movement sense in the latter. In some places, Pliocene to Recent fault systems cross pre-existing anticlines subdividing them into numerous subsidiary fault-closures (e.g. Kaimiro, Ngatoro and Stratford). In such cases, the wrench-fault systems provide an important vertical migration pathway for hydrocarbon charging of shallow Miocene reservoirs. In addition, during the Pliocene to Recent period, uplift and tilting significantly modified the configuration of many existing structures, especially in southern Taranaki (Cardiff and Kapuni). This resulted in regional dips of up to 4° in Pliocene sediments.

References

- HAINES, A.J., 1990: Waveform modelling of deep reflections from complex strata at Tariki, New Zealand, using an F-K domain propagator method. *Physics of the Earth and Planetary Interiors* 59: 153-169.
- HARDING, T.P., 1985: Seismic characteristics and identification of negative flower structures, positive flower structures, and positive structural inversion. *The American Association of Petroleum Geologists Bulletin* 69: 582-600.

- KING, P.R., 1989: Polyphase evolution of the Taranaki Basin, New Zealand: Changes in sedimentary and structural style. *Proceedings of the 1989 New Zealand Oil Exploration Conference, Ministry of Commerce (1990), 1*, 134-150.
- KNOX, G.J., 1982: Taranaki Basin, Structural style and Tectonic setting. *New Zealand Journal of Geology and Geophysics* 25: 125-140.
- MCSWEENEY, A., 1989: Petroleum wells in New Zealand 1865-1989. Second edition: Petroleum and Geothermal Unit, Energy and Resources Division, Ministry of Commerce, Wellington.
- MILLS, C., 1990: Gravity expression of the Patea-Tongaporutu High and subsequent model for the Taranaki Basin Margin. *Proceedings of the 1989 New Zealand Oil Exploration Conference, Ministry of Commerce (1990), v.1*. 191-200.
- PALMER, J., 1985, Pre-Miocene Lithostratigraphy of Taranaki Basin, New Zealand. *New Zealand Journal of Geology and Geophysics* 28: 197-216.
- PALMER, J. AND BULTE, G., 1991: Taranaki Basin, New Zealand. in *Active Margin Basins*, Edited by K.T. Biddle, *AAPG Memoir 52*: 261-282.
- PILAAAR, W.F.H., & WAKEFIELD, L.L., 1978: Structural and stratigraphic evolution of the Taranaki basin, offshore North Island, New Zealand. *Australian Petroleum Exploration Association Journal* 93-101.
- THRASHER, G.P., 1989: Tectonics of the Taranaki Rift. *Proceedings of the 1989 New Zealand Oil Exploration Conference, Ministry of Commerce (1990) 1*: 124-133.

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