CHAPTER 1

Introduction

Mapping of the igneous features, both extrusive and intrusive, from 3D seismic reflection data (Parihaka) from Taranaki Basin offshore New Zealand provides insight into the intensity and movement of volcanic activity in the Taranaki basin. The 3D Parihaka survey images a series of sub-marine volcanoes, both intrusive and extrusive bodies are well preserved. This study aims at documenting the internal architecture, their emplacement history, distribution, intensity and their possible impact on sedimentation. The area is affected by thin skinned and thick skinned normal faults with the basement faults trending NNE-SSW, while other faults confined to the sedimentary section trend NE-SW. The Taranaki Basin is situated on the western margin of the New Zealand continental landmass, and occupies a large portion of the present day western shelf. Three phases of deformation have been identified in the basin as follows: Late Cretaceous to Paleocene (~84–55 Ma) extension was followed by Eocene to Recent (~40–0 Ma) shortening, and Late Miocene to Recent (~12–0 Ma) extension (Stern and Davey, 1989; King and Thrasher, 1992, 1996; Giba, 2010), with coeval compression and extension occurring in the south and north, respectively. Spatial variations in the tectonic regime from north to south across the basin are related to an evolving subduction zone, east of New Zealand (Giba et al., 2010). The onset of andesitic volcanism in the Northern Taranaki basin began ~16 Ma ago and migrated towards the south (Giba et al., 2010). The Taranaki Basin has up to 10 km of sedimentary section (Holt and Stern, 1994). Rifting during Late Cretaceous to early Paleocene generated localised faulting and subsidence, and was followed by regional passive thermal subsidence during the Eocene. An extensive crustal-scale down warping event (wavelength ~150 km) was triggered by foreland thrust loading along the Taranaki Fault during the Oligocene-Miocene. This regional down warping of continental crust created accommodation space which in turn was infilled by the extensive Giant Foreset Formation during the Plio-Pleistocene. This study focuses on using 3D seismic data to define the structural trends of the study area, map igneous features, and determine their relative timing, distribution, seismic signatures, and their interactions with the sediments in the study area.

1.1 Study Area

The study area is located in the Taranaki Basin, which is a wide sedimentary basin located on the western side of the North Island, New Zealand (Figure 1.1). The Taranaki Basin stretches over ~100,000 km^2, with the majority of the basin residing offshore at water depths ranging from 50-250 m. The Taranaki Basin has a one and half century old history of oil and gas exploration, and is still the only hydrocarbon-producing region in New Zealand. There have been many significant discoveries since the 1950s, including the Maui and Kapuni fields. The Taranaki basin contains 15 producing fields at present and several more discoveries are under development or considered as sub-commercial. Despite the fact more than 400 wells have been drilled in the basin, still it is rated as relatively under-explored in terms of oil and gas exploration.

The immediate site of the study area is the south-western termination of the North Taranaki Graben. (Figure 1.1). It is ranked as an under-explored region with high potential of oil and gas exploration by the New Zealand Petroleum and Minerals (NZPAM, 2013).The late Miocene Mohakatino and Manguri Formations lie at the base of its stratigraphic section (King and Trasher, 1996). The sub-marine andesitic volcanism gave rise to Mohakatino formation which occurred during 16 Ma to 2 Ma. It contains tuffaceous and volcaniclastic sand, muds and silts. The Manganui Formation stretches all across the Taranki basin and is defined as a deep water hemiplegic succession.

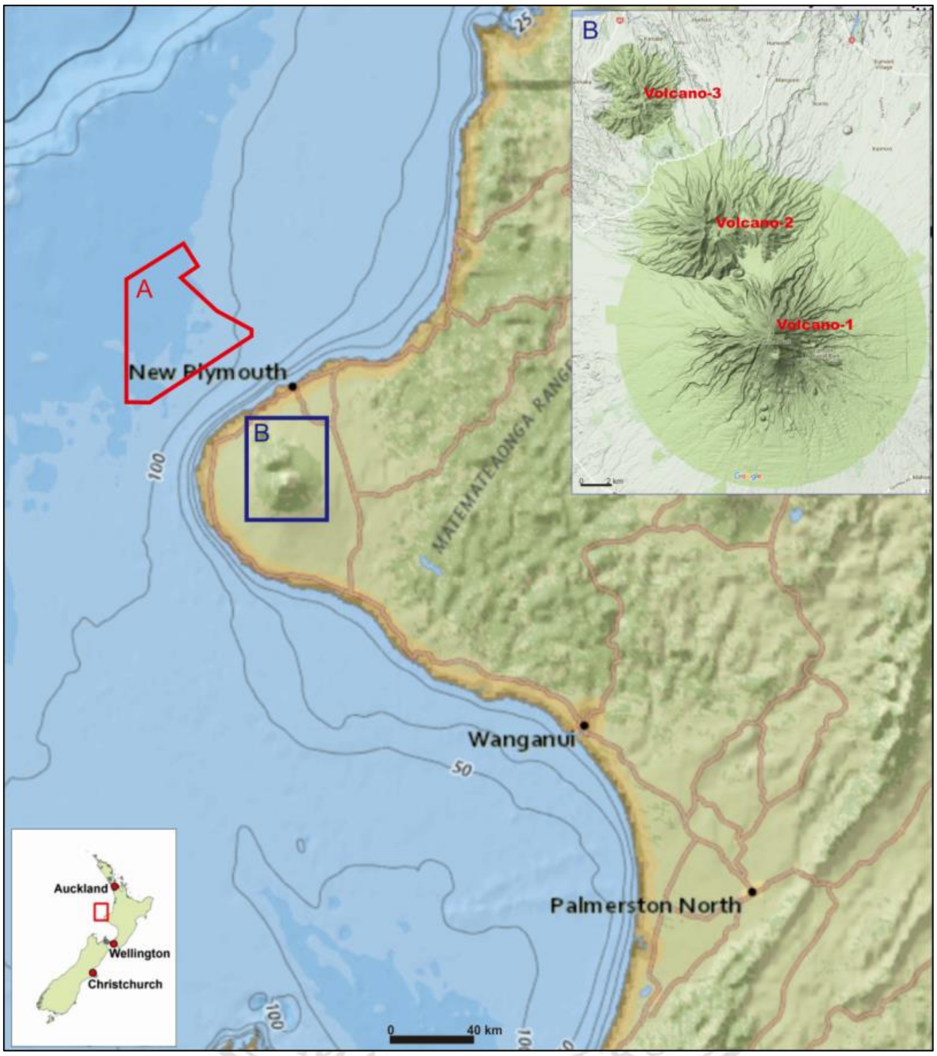

Figure 1.1 Location of the Study Area (A), Parihaka 3D-Seismic Survey, Offshore, New Zealand, Index map taken from ngdc.noaa.gov (B) location of the onshore Volcanoes (Figure taken from Google Earth, 2015).

1.2 Research Objectives

The objectives of this study are:

1. Mapping of the igneous features(distribution, internal architecture)
2. Mapping of the horizons
3. Constraining the structural events
4. Reviewing the tectonic history
5. Quantification of the igneous features from seismic and as well as the onshore volcanoes located on the Taranaki peninsula
6. Establishing the impact of intrusions on sedimentation

1.3 Rational

Volcanoes have long been attracting research activity and there have been considerable efforts to map the internal architecture of the igneous features, their style of emplacement, their shape and their impact on surrounding sediments. Their emplacement history tells about the intensity and movement of the volcanic activity. The distribution of volcanics in the sedimentary basin poses a real challenge for the petroleum exploration and also for the volcanic researchers who want to understand the seismic feature of the volcanic edifices, which still remains the challenge. Although previous researches have explained the internal architecture of volcanoes in some other geological e-g Irish Rockall Basin, Voring and More basins but in Taranaki basin there has been little effort to study the seismic signatures of volcanic feature, their emplacement style and quantify their dimensions and compare them with other volcanoes.

1.4 The Geological Setting and Tectonic History of the Taranaki Basin

1.4.1 The Location of the Taranaki Basin on Region Scale

New Zealand lies on the boundary between the Australian plate to the west and the Pacific plate to the east (Figure. 1.2). These two plates form two large, oppositely dipping subduction zones demarcated by a major oblique strike slip fault. The Pacific Plate is subducting underneath the Australian plate at the west-dipping Hikurangi subduction margin located to the east of the North Island. On the other hand, the Australian Plate is subducting eastward underneath the Pacific Plate at the Puysegur Trench to the SW of the South Island. The crustal-scale, transform Alpine Fault extends over 900 km along the western edge of the South Island and accommodates the complex interactions of these two subduction zones. The Taranaki Basin developed as a complex mixture of foreland and extensional basins (Stern & Davey, 1990). An episode of extension and subsidence during the Late Cretaceous to Early Eocene was followed by compression and foreland subsidence from the Late Eocene to Recent. Intra-arc extension from Late Miocene to 2 Ma, and back-arc extension from 2 Ma to Recent occurred in the north and middle of the basin. An evolving subduction zone to the east of New Zealand caused the spatial variations in the tectonic regime from north to south and explains this coincident compression (Giba et al., 2010).

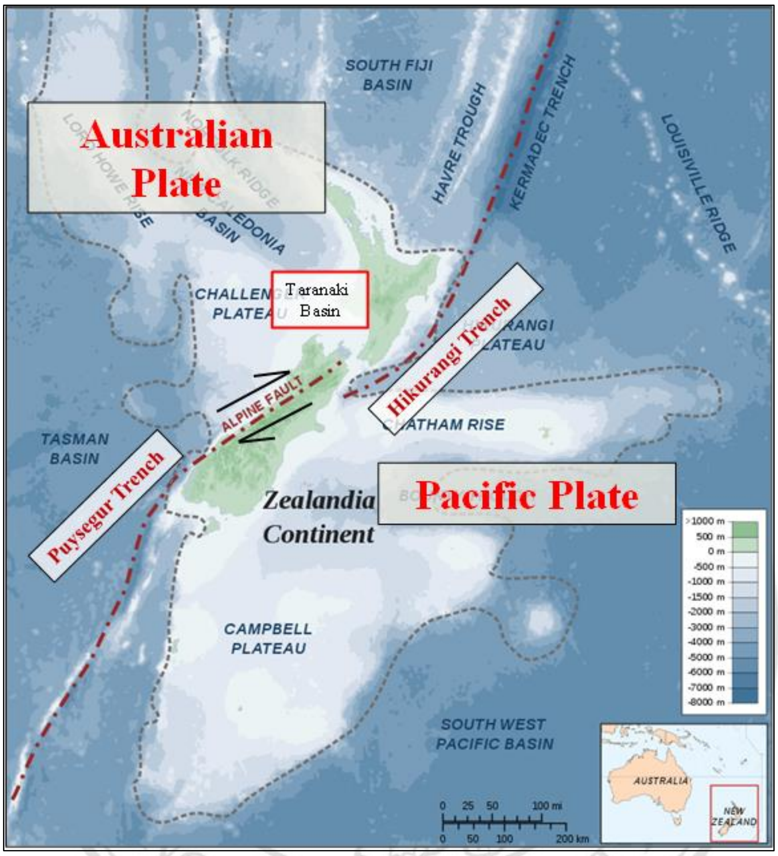

Figure 1.2 Structural elements map of the New Zealand Continent. Plate boundaries are marked by the maroon dot-dash line. Elevation/Water depths are indicated by varying shades of green and blue. Figure is modified from https://en.wikipedia.org/wiki/Geology_of_New.

The Taranaki Basin is a thick Cretaceous-Cenozoic sedimentary wedge, bounded to the east by the Taranaki Fault. The major part of the Taranaki basin resides offshore on the western edge of New Zealand's continental landmass. The Taranaki Basin comprises two main structural elements (Figure. 1.3). The Eastern Mobile Belt is defined as a broad, N-S elongate region, highly faulted band of deformation having a complex tectonic history. While the Western Platform is a stable, ~150 km wide shelf containing ~5000 m of relatively simple, unfaulted sedimentary section. The Eastern Mobile belt can further be divided into three parts: Northern, Central and Southern. The northern and central parts of the Eastern Mobile Belt are known as the North Taranaki and Central Grabens respectively. These two Grabens are under an extensional regime while the southern area, called the Southern Inversion Zone, is under a compressional regime. The North Taranaki Graben which is the immediate site of this study, is a ~80 km wide faulted depression possessing up to ~11 km of sedimentary section. The Paleozoic metasedimentary basement rocks overlie the basin and basaltic plutons of Devonian, Carboniferous and Cretaceous age have intruded into the basin (Muir et al., 2000).

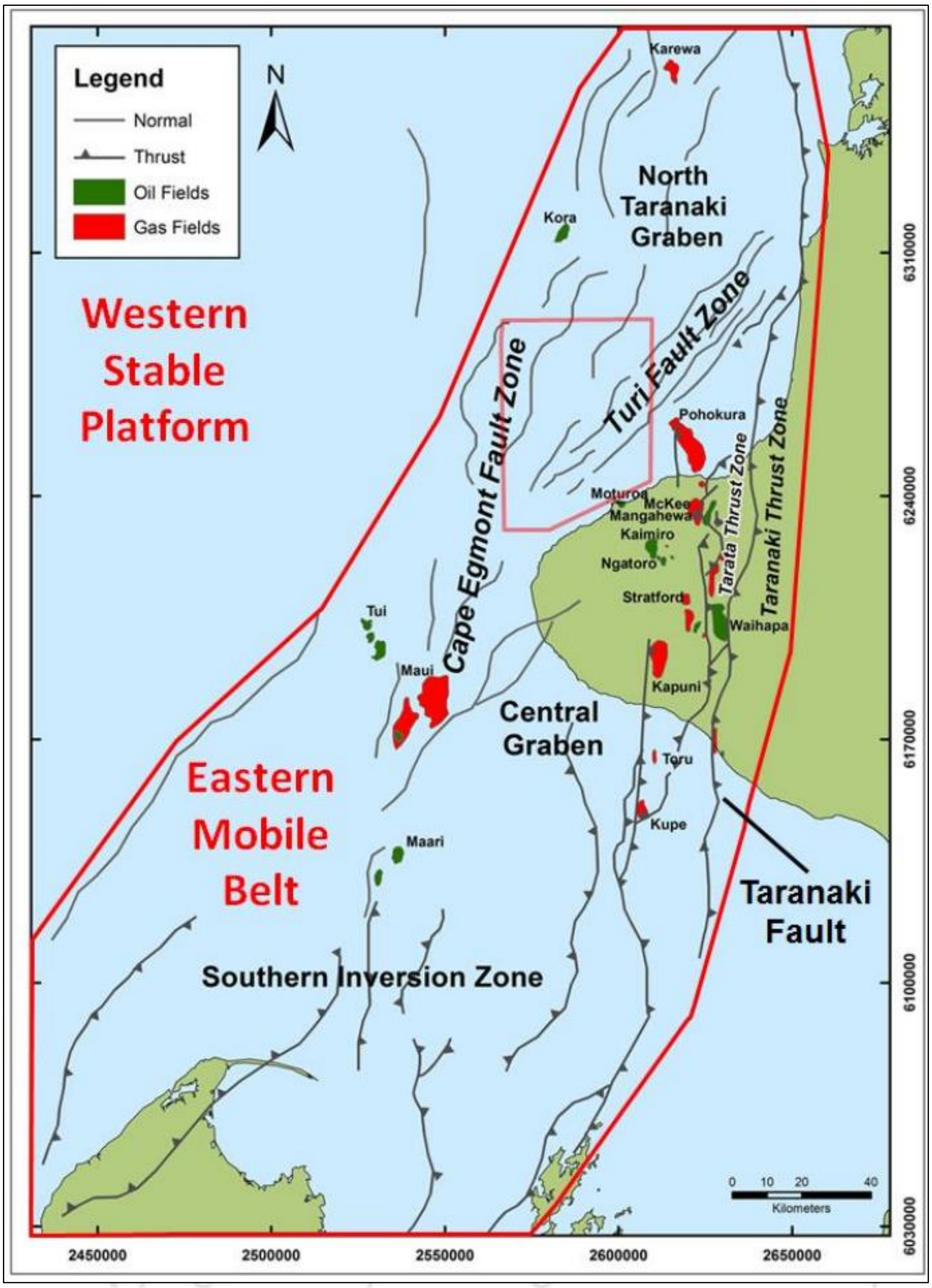

Figure 1.3 Structural element map of the study area (Modified from Aaron, 2014)

1.4.2 North Taranaki Graben

The North Taranaki Graben is an elongate, NE-SW triangular, extensional feature bounded to the east and west by the NE-striking Turi Fault Zone and the NNE-striking Cape Egmont Fault Zone respectively. The North Taranaki Graben is located offshore to the N-NW of the Taranaki Peninsula and differs from the rest of the Taranaki basin in tectonism and subsidence history. Biostratigraphy indicates that during Late Miocene to Early Pliocene the North Taranaki Graben was at lower bathyal (1000-1500 m) water depths unlike the majority of the basin which was between upper bathyal and shelfal water depths (50-600 m) (King & Thrasher, 1996).

The North Taranaki Graben varies from the conventional back-arc model in some aspects despite being considered as Back-arc extensional feature (King & Thrasher, 1996). The Turi and Cape Egmont Fault Zones were under an extensional regime during the Late Miocene to dominantly Pliocene, with a southward migration of faulting and coincident andesitic volcanism. Andesitic volcanism of the Mohakatino Volcanic Centre began at ~16 Ma, followed by normal faulting which began in the northernmost Taranaki Basin at ~12 Ma (Giba et al., 2010). Normal faulting and volcanism have a common causal mechanism and spatio-temporal correlation, still none of the process dominates the timing, location or activity rate of the other (Giba et al., 2013). The clockwise rotation of the Hikurangi subduction margin to the east has caused the graben to open progressively in a fan-like fashion (Giba et al., 2010). The southwards migration of the southern termination of extension was geologically instantaneous 100-150 km episodes at c. 12-8 and 4 Ma (Figure 1.4).

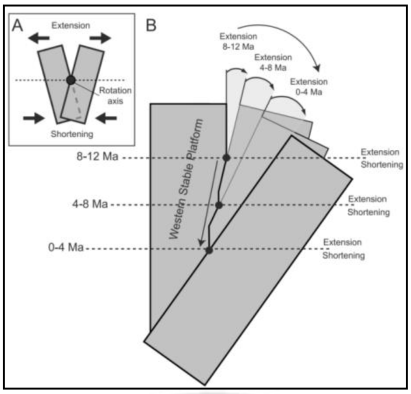

Figure 1. 4 A schematic diagram from the structural evolution the Taranaki basin, (a) shows the map view of two crustal blocks that roate about a vertical axis due to extension in the North and shortening in the South. Source: Giba et al., (2010).

The hinge point between extension and compression currently is located close to the Maui Field, SW of the Taranaki Peninsula. The episodic southwards migration of extensional tectonics during the Late Miocene-Pliocene caused extension within the North Taranaki Graben of 1-3 km, with the major period of extension commencing during the Pliocene. Extension of up to 2km has been accommodated on the Cape Egmont Fault Zone and Turi Fault Zone, proximal to the study area.

The Cape Egmont Fault Zone which is ~N-S oriented, 15-20 km wide and marked by a left stepping, en-echelon fault pattern, exhibits large dip slip movements that tend to be concentrated on single east-dipping faults at any one location (Nodder, 1993). These fault-segments do not appear to accommodate much, if any, lateral movement despite being an en-echelon fault system. The reactivation of Cretaceous basement faults at non-optimal orientations is believed to have given rise to this en-echelon pattern (Giba et al., 2012).

The Turi Fault Zone consists of several NE-SW striking, quasi-linear dip-slip faults (King & Thrasher, 1996). Movement within the fault zone tends to be spread across stacked, sub-parallel faults which each take up a small portion of the total extension and progressively step basement and the overlying sedimentary section down to the NW. The Mohakatino Volcanic

Centre is a series of more than 20 individual submarine andesitic stratovolcanoes and associated intrusive volcanic complexes which trend NNE/SSW along the central axis of the North Taranaki Graben (King & Thrasher, 1996). Three intrusive complexes are present within study area.

1.5 Taranaki Basin and Volcanism

The Taranaki Basin is located at the southwestern end of a swath of arc-related volcanism and rift faulting that extends southwards from the South Fiji Basin (Fig. 1.5 a). Volcanoes and faults in the basin are mainly located offshore west of New Zealand's North Island within the continental crust of the Australian Plate (Fig. 1.5). The basin Andesitic volcanoes associated with subduction along the Hikurangi margin define a broad NE–SW-trending zone that, for at least the last 16 myr, was oriented approximately parallel to the strike of the subducting plate (Seebeck, 2013) and extends northwards from New Zealand into the South Fiji Basin. Within this zone a general east and southeastward younging of volcanism has been interpreted to record changes in the geometry of the subducting plate(Fig. 1.5) (e.g. Balance, 1976; Brothers, 1984; Kamp, 1984; Hayward et al.2001; Booden et al. 2011; Seebeck 2013).

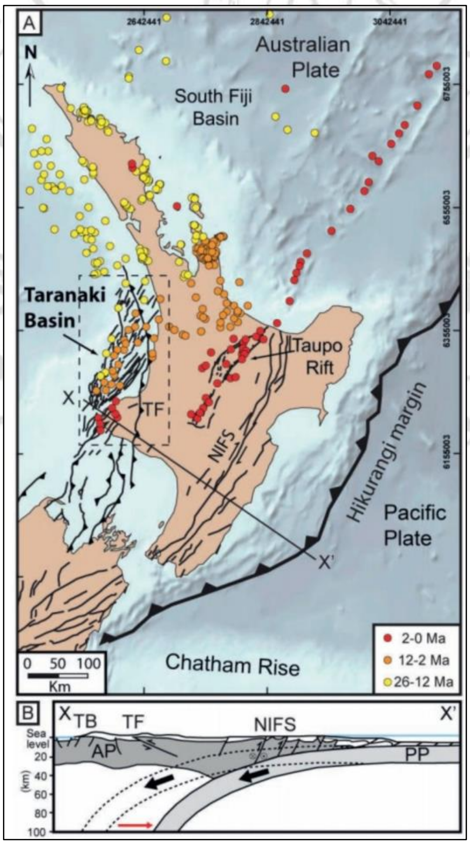

Figure 1.5 Map showing the Hikurangi subduction margin and the North of New Zealand. The locations of the faults are shown in black and the ages of the subduction related volcanic centers are denoted by circles (b) Schematic section across the Hikurangi subduction zone (Giba et al., 2013).

The net effect of changes in slab geometry and upper plate rotations is that active volcanism and normal faulting in North Island are now concentrated in the Taupo Volcanic Zone and the southern part of the Taranaki Basin. Rifting and arc volcanism in the Taranaki Basin both commenced in the Miocene (volcanism c. 19 Ma and faulting c. 12 Ma) and migrated southwards to replace an earlier, Late eocene to early Pliocene (c. 40–4 Ma), phase of contractional deformation (king & Thrasher 1996; Stagpoole & Nicol 2008; Giba et al.2010). Volcanism in the basin started in the Miocene, about 7 myr earlier than the beginning of rifting, and continues today with eruptions of Mt. Taranaki (Giba et al., 2013). A chain of mostly submarine and inactive stratovolcanoes occupy the centre of the basin, are oriented in an approximately NNE–SSW direction and appear to coincide in space with a Late Cretaceous to early Tertiary rift. Volcanic centres are mostly cone shaped with maximum diameters from 2 to 40 km in map-view (Giba et al., 2013). A seismic section showing volcanic edifices along with horizons (ages) mapped by Giba et al., (2013) tied with the well is shown in (Fig. 1.6).

The volcanoes have low-to high-k calc alkaline basaltic to rhyolitic compositions commonly associated with subduction-related volcanism and are consistent with an arc origin related to the subducting Pacific Plate (King & Thrasher 1996). Normal faulting started in the north at c. 12 Ma, with contemporaneous volcanic activity in the same area marked by the formation of additional volcanic centres. At c. 8 Ma the distribution of normal faulting in the basin extended towards the south, with a sympathetic southward migration of thrusting and shortening (Giba et al., 2013). At the same time, the locus of volcanic activity migrated southwards, with most Miocene volcanoes being located within the Late Miocene and Late Cretaceous to early Tertiary rifts. In the early Pliocene (c. 4 Ma) the region of basin extension again broadened rapidly southwards to include the southern part of the Taranaki Basin immediately west and SW of the Taranaki peninsula (Giba et al., 2013).

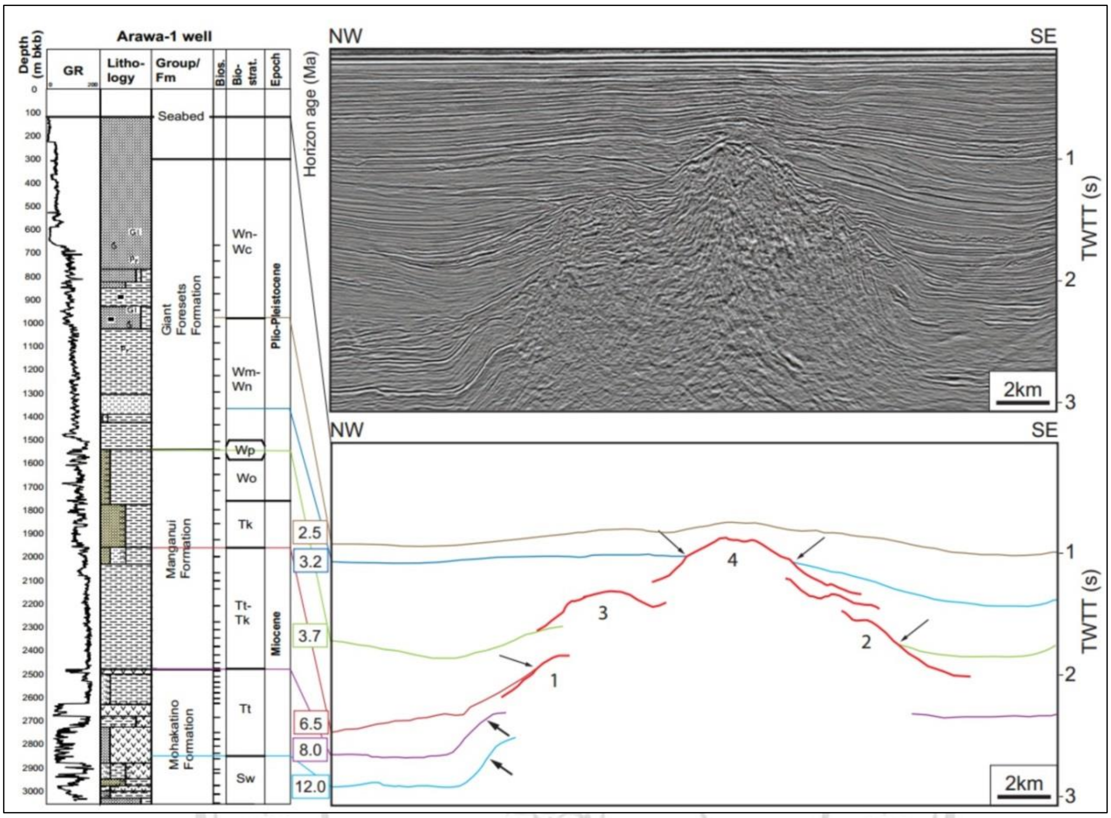

Figure 1.6 shows the sesmic view of the volcanics mapped by Giba et al., 2013 and tied with the Arawa-1 well.

1.6 Structural History of the North Taranaki Graben

The western margin of the North Taranaki graben is bounded by the Parihaka Fault. The fault has a length of approximately 50 km and a complex 3D geometry. It consists of up to five separate seismically-resolvable segments with lengths varying from 8 to 15 km. The fault trace is near-continuous on Late Cretaceous horizons, strikes north-south to NNW–SSE and has undergone vertical displacements (i.e. throws) of up to 1800 m., whereas the fault encompasses four main en-échelon segments with varying strikes of about north-south to NE–SW on Early Pliocene younger horizons (Fig. 1.7 c, d & 4) and has undergone vertical displacements of up to 1450 m (Giba et al., 2010).

The fault segments of post Miocene, which are hard-linked (i.e. physically linked) with the basement fault at depth, are segregated by resolvable relays with separations (i.e. the strike-normal distance between relay bounding faults) of between ~500 and 2000 m. Morgans, (2006) and Giba, (2010) investigated growth patterns associated with a relay ramp between segments I and II of the Parihaka Fault zone. They determined that growth began around 3.7 Ma, syn-kinematic strata exhibited consistent growth patterns and demonstrated that maximum fault lengths were established rapidly after about 0.3 Ma, i.e. less than 10% of the fault history.

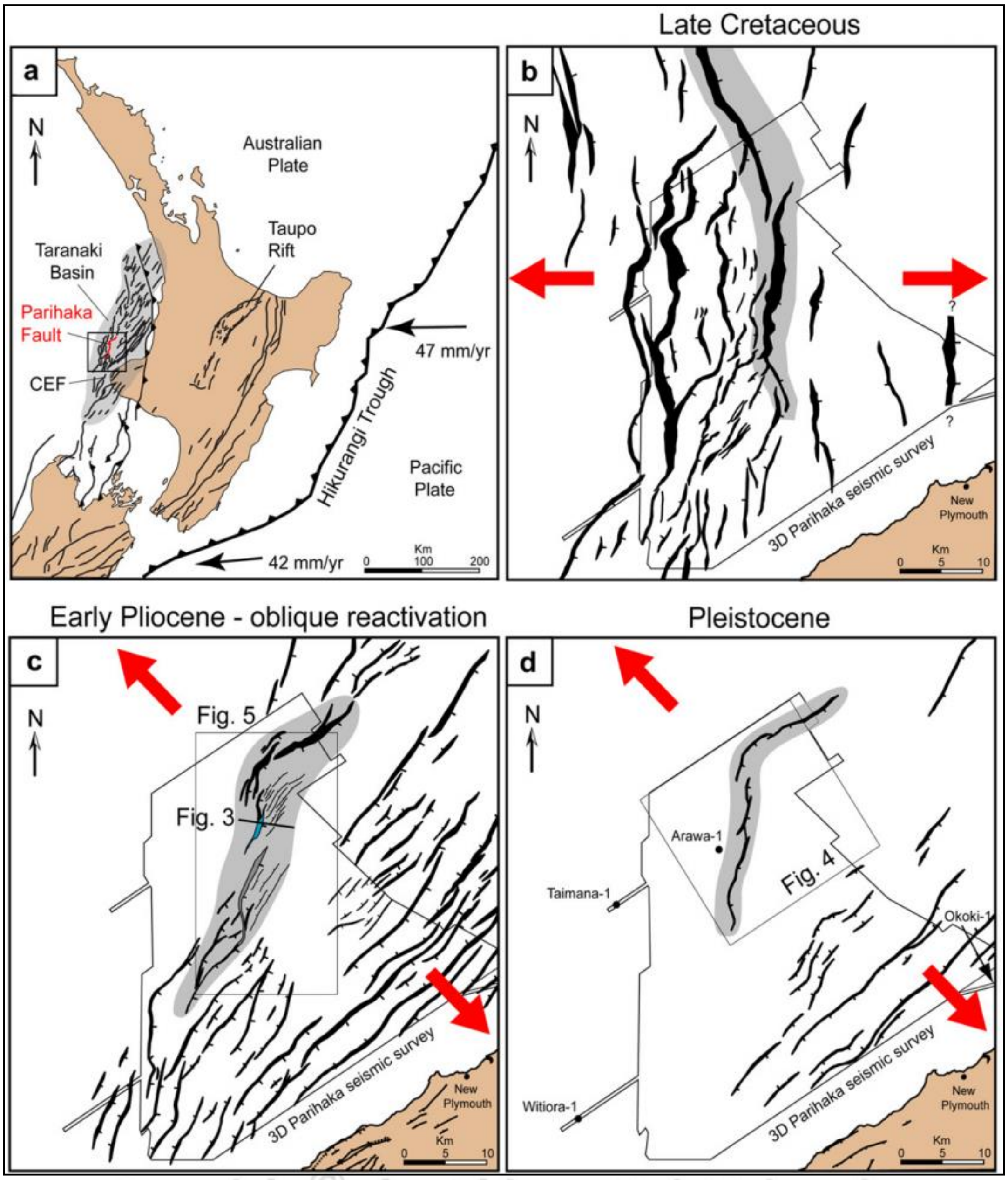

Figure 1.7 a) showing the plate boundary setting of the North Island, New Zealand. It shows the location of the Taranaki basin and the Parihaka fault in the back arc region of the Hikurangi subduction zone. b—d) maps depicting the temporal evolution of the western margin of the central Taranaki basin. Black polygons denote the active normal faults of Late Cretaceous (a), b, Pliocene, (c), and Pleistocene (d). Grey polygons enclose parihaka fault (Giba et al., 2010).

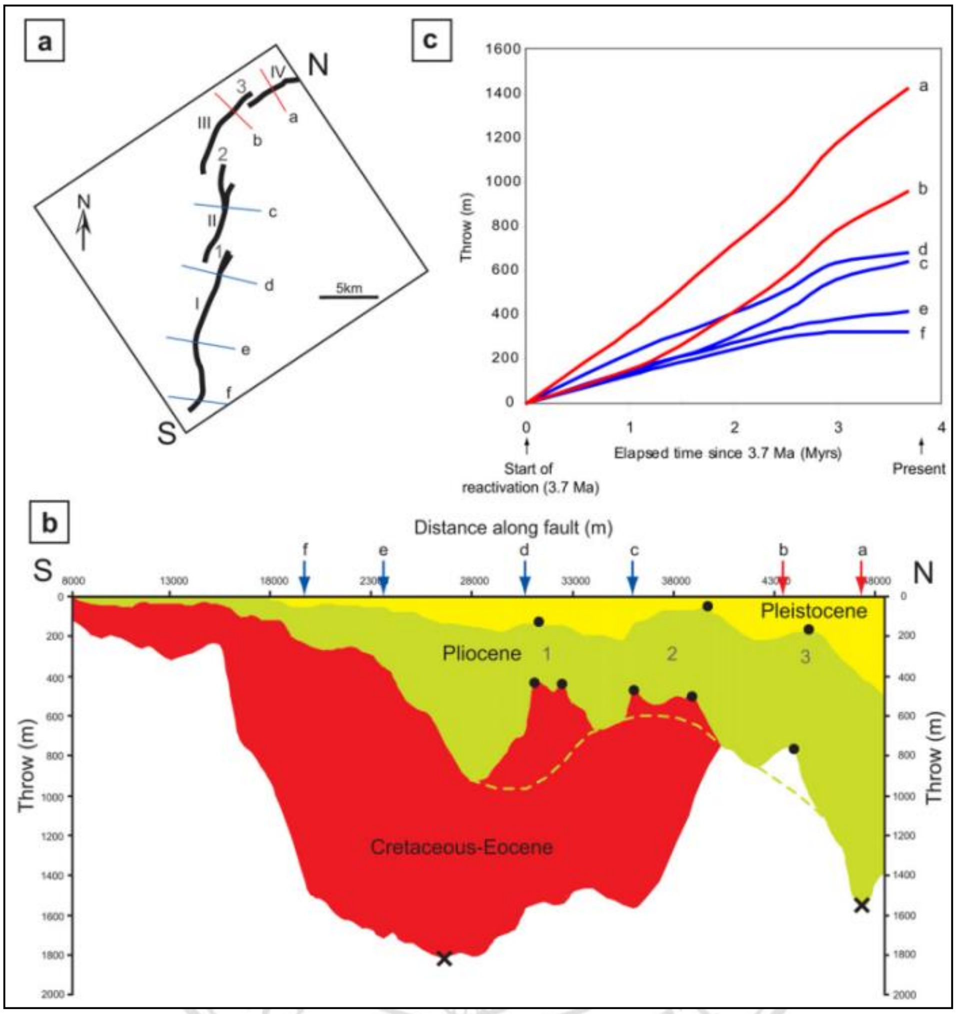

Figure 1.8 Displacement analysis of the Parihaka fault. a) map view of the segmented fault trace at Pleistocene level, b) displacements along the fault that durign Late Cretaceous-Eocene, Pliocene and Pleistocene are denoted by red, green and yellow, respectively. Maximum and minimum displacements are indiacted by crosses and filled circles respectively. Minima displacement coincide with the locations of relay zones(indicated by grey numbers). Figure used from Giba et al. 2010.

1.7 Stratigraphy

The sedimentary section within the Taranaki Basin can be divided into four units affected by four distinct tectonic regimes (Fig. 1.9). These are broadly:

1. Late Cretaceous syn-rift sequence.
2. Paleocene-Eocene late-rift and post-rift transgressive sequence.

3. Oligocene-Miocene foredeep and distal sediment starved shelf and slope sequence and Miocene regressive sequence.
4. Plio-Pleistocene regressive sequence.

The tectonic evolution of the Taranaki Basin is explained in "Setting and Tectonic History" Nascent rift sub-basins across the south and east of the Taranaki Basin were initially infilled by Late Cretaceous terrestrial sands, muds and coals of the Rakopi Formation (Thrasher, 1991). In the northern Taranaki Basin discreet N-S oriented sub-basins were infilled during this time. These carbonaceous sediments form the primary source rocks of the petroleum system in the basin. Progressive subsidence within the sub-basins allowed a marine transgression which swept southwards from the open embayment in the northwest basin (now Deepwater Taranaki Basin). Terrestrial in-fill deposits of the Rakopi Formation were overlain by marginal and fully marine units of the North Cape Formation (Thrasher, 1992a; Wizevich et al., 1992). Together, the Cretaceous-aged sediments form the syn-rift sequence known as the Pakawau Group.

Extension slowed during the Paleocene-Eocene and rifting on sub-basin bounding faults diminished. Post-rift relaxation of the lithosphere produced basin-wide subsidence, generating accommodation space and allowing a marine transgression to flood the basin. Rift sub-basins were infilled with sediment and inactive bounding faults were buried beneath an influx of sediment. Up to 2500 m-thick sequence of non-marine, paralic and marine sediments was deposited, with an open embayment in the north of the basin, to the NW of the present day location of the study area (King & Thrasher, 1996).

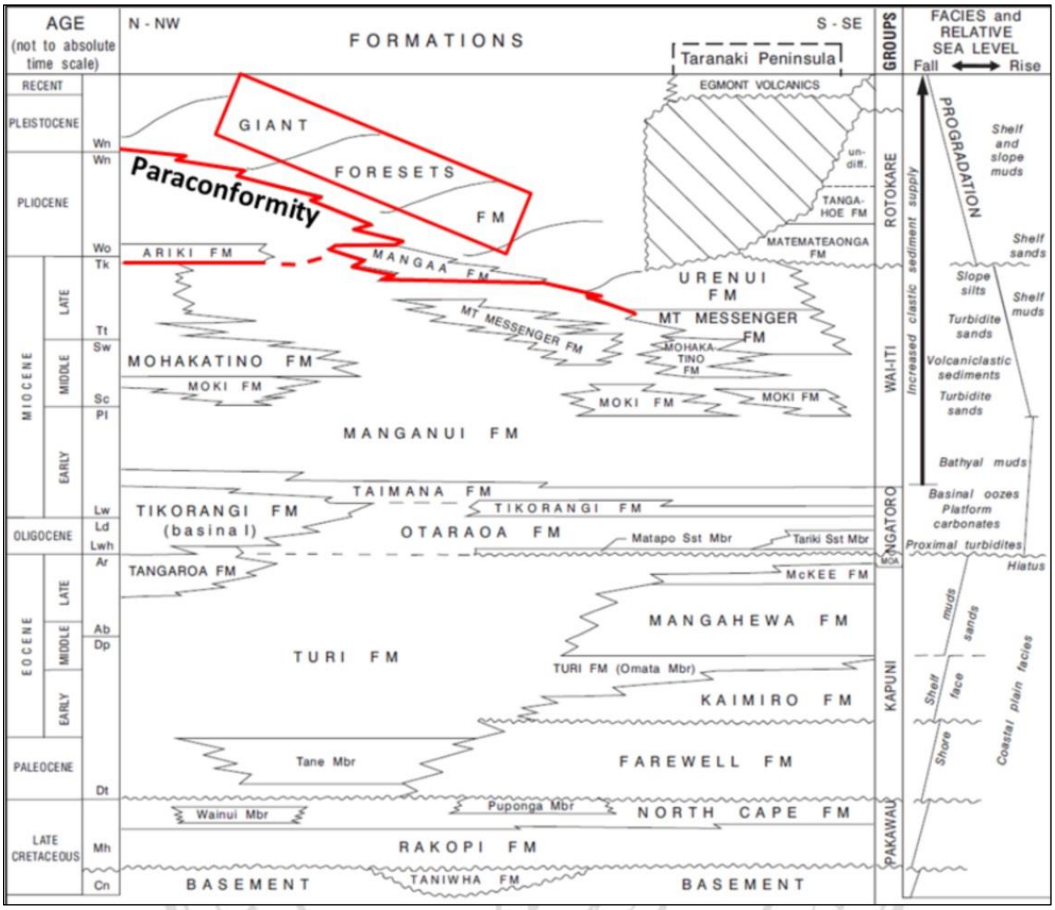

Figure 1.9 Stratigraphic column of the Taranaki basin (modified from King and Trasher 1996 and Aaron 2014).

The northern basin was dominantly marine, while the southern basin experienced non- and marginal–marine conditions, with the shoreline position oscillating periodically, but generally migrating southwards through the Eocene. The interbedded coastal plain and marginal marine conditions known as the Kapuni Group were gradually overlapped by the fully marine, fine-grained sediment of the Moa Group. These inter-fingered sedimentary packages are important source, reservoir and seal components of the Taranaki petroleum system. As the New Zealand continental landmass continued to subside during the Oligocene, subaerially exposed landmasses were diminished and a regional marine transgression took place (King, 2000). Sediment sources were depleted and sediment-starvation was common across most of the continental shelf. This created conditions, which were conducive to widespread deposition of shelfal carbonates. The Tikorangi Formation is a regionally extensive, up to 240 m thick, Oligocene-aged siliciclastic-carbonate to carbonate limestone unit that has correlative units across several New Zealand sedimentary basins (Hood et al., 2003). The northern Taranaki

Basin sat at shelf-upper bathyal depths during this time, with an open embayment to the NW of the study area.

Compression and uplift of the New Zealand landmass from the Mid-Late Miocene to the south and east of Taranaki provided an influx of clastic material, infilling the eastern foredeep depression (Kamp et al., 2004). Up to 2000 m of rock uplift in the central North Island as well as compression along the Alpine Fault generated an influx of clastic sediment to the adjacent King Country, Wanganui and Taranaki Basins (Guilford & Stern, 2004). An initial period of progradation during the Mid-Miocene to early Pliocene in the King Country, Wanganui and southern Taranaki Basin was followed by second phase of shelf progradation from the mid-Pliocene-Pleistocene in the central and northern Taranaki Basin (Hansen & Kamp, 2004b). The migration of sediment was blocked on the basin's eastern margin by the Patea-Tongaporutu and Herangi Highs (). Sediment was instead directed along the Toru Trough from the south. More than 3500 m of sediment was deposited, particularly in the east of the Taranaki Basin where foredeep subsidence was most pronounced, during the Oligo-Miocene. Sediment was reworked from the proto-coast to bathyal marine depths (200-1500 m), which prevailed across much of the basin during the initial period of regional contraction. Multiple discrete submarine turbidite deposits formed during the Miocene, creating some of the Taranaki Basin's reservoir units (e.g. Mount Messenger Formation) (Mills, 2002).

Extension in the northern basin from the Late Miocene onwards created a depression that has continued to capture sediments since the Earliest Pliocene. Large volumes of sediment sourced from the uplifted landmass to the east and south were preferentially funnelled into the depression, starving areas in the north and west of the basin. Kilometer –scale clinoformal beds known as the Giant Foresets Formation (GFF) rapidly prograded the shelf edge to the north and northwest. By the late Pliocene, the rate of sedimentation outpaced the rate of extension within the North Taranaki Graben. Deposition of the GFF within the North Taranaki Graben outpaced subsidence by ~3 Ma, overtopping the graben footwalls and prograding the shelf break to the N/NW.

1.7.1 Stratigraphy of North Graben

The North Taranaki Graben has a distinct tectonic history for the period Late Miocene Recent, which generated localised bathyal water depths and a distinct sedimentary section within the graben. The genesis of the North Taranaki Graben began with the onset of volcanism at ~16 Ma and extensional faulting at ~12 Ma. At the base of the North Taranaki Graben stratigraphic section are the Late Miocene Mohakatino and Manganui Formations which are present in the onshore and northern offshore Taranaki Basin (Fig. 1.9).The Mohakatino Formation is tuffaceous and volcaniclastic sand, mud and silt unit related to sub -marine volcanism that occurred in the graben from ~16 Ma to ~2 Ma. The Manganui Formation is a deep-water hemipelagic mudstone succession which is widespread across much of the Taranaki Basin.

A paraconformity sits directly above the Mohakatino/Manganui Formations across a large portion of the North Taranaki Graben accounting for up at least 1.5 Ma of missing time in places (Fig. 1.9). This highly condensed or missing section was caused by a period of sediment starvation across large parts of the northern Taranaki Basin. Non-deposition has been connected to the capture of thick accumulations of sediment within the King Country and Wanganui basins east and south of the North Taranaki Graben respectively (Kamp et al., 2004). The sedimentary sections in the study area at the location of Arawa-1 and Taimana-1 do not contain the paraconformity; however these wells are technically located on the graben margin (Diamond Shamrock Exploration, 1984 ; ARCO,1992). The Ariki Formation is a calcareous marl unit that straddles the paraconformity in the North Taranaki Graben. The formation is named for a marl first described within Ariki-1, though it has since been observed in several other wells (e.g. Wainui-1, Tangaroa-1, and Te Kumi-1). The formation has a strongly calcareous character and a distinctly high planktic percentage. The formation is a condensed, terrigenous sediment-starved unit deposited at bathyal depths (King & Thrasher, 1996).

Overlying the paraconformity is the Mangaa Formation, which is a basin-floor sandstone unit. The formation is a turbidite package of fine to very fine grained sandstones with thicknesses up to 600 m over two main intervals within Mangaa-1, where it was first described (King & Thrasher, 1996). The unit has wedge geometry, thinning to the NE along the graben axis. Seismic profiles indicate that the formation was deposited from south to north during the Early Pliocene and represents the initial sedimentary infill of the North Taranaki Graben following the hiatus (Hansen & Kamp, 2004a).

1.8 Literature Review

1.8.1 Investigation of the spatio-temporal relationship between normal faulting and arc volcanism on million-year time scales

The spatio-temporal evolution of normal faulting and submarine volcanism during the Mid-Miocene to Recent (<16 Ma) in the Taranaki Basin, New Zealand, provides insights into the processes driving rifting and volcanism. Submarine volcanoes in the Taranaki basin have been blanketed by the high sedimentation rates which led to the preservation of the volcanic edifices. Volcanic activity migrated south wards. This gradual migration of the volcanic activity in the Taranaki basin was ascribed to the continuous steepening and SE rollback of the subducting pacific plate. (Giba et al., 2013).

1.8.2 Interactions between the prograding giant foresets formation and a subsiding depocentre

The Pliocene-aged Giant Foresets Formation has closely interacted with the faults bounding the North-Taranaki Graben. A sub-basin named the Arawa Sub-basin is a fault bounded depocentre which subsided during the Pliocene, attracted the volumes of sediment across the Parihaka Fault (Aaron, 2014) within large-scale channels. The sedimentary features showed the transport direction varies between NE and SE. The controlling factor of sediment redirection is faulting along the Cape Egmont Fault Zone and subsidence within the North Taranaki Graben. (Aaron, 2014).

1.8.3 Volcano growth mechanisms and the role of sub-volcanic intrusions

Temporal and spatial changes in Volcano morphology and internal architecture can determine eruption style and location. A 2D seismic reflection data was used in the Ceduna Sub-basin, offshore southern Australia to analyse 56, pristinely preserved Volcanogenic mounds and a genetically-related network of sub-volcanic sills and laccoliths. (Magee et al, 2013). Their study focused on deformation patterns preceding volcanic eruption.

1.8.4 Seismic reflection imaging and controls on the preservation of ancient sill-fed magmatic vents

Two-dimensional seismic reflection data from offshore southern Australia image a series of 2-3 km wide 50-800, high, sub-circular, middle Eocene age mounds. The mounds are interpreted as the seismic expression of submarine volcanic events. These are considered to be the oldest example ever documented. These vents are pristine and are well preserved because of their sub-marine environment of emplacement (Jackson, 2012).

1.8.5 Seismic characteristics and distribution of volcanic intrusions and hydrothermal vent complexes in the Vøring and Møre basins

Intrusive complexes and associated hydrothermal vents were mapped on a regional 2D seismic reflection dataset and one 3D seismic survey the in Voring and More basins. Their study focused on the mapping of sheet intrusions and their findings suggest that sheet intrusions are saucer-shaped in un-deformed basin segments. Their width becomes larger with increasing emplacement depth. The vent complexes are located above sills and were formed as a direct consequence of eruption of gases from sills (Planke et al., 2005).

1.8.6 Volcanic Gas Reservoir Characterization

Internal architectures are used to define the relationship among geological units in space and time. Internal architectures of volcanic rocks was defined based on gas reservoir development and the compositional features such as the genetic relationship, occurrence sequence, superposition relationships as well as the geometry and size of architectural units at various levels from Volcanic formation to volcanic edifice, volcanic massif, volcanic lithofacies and volcanic lithology (Ran et al., 2014).

1.8.7 The potential role of igneous intrusions on hydrocarbon migration, West of Shetland

The potential impact of the extensive sequence of igneous intrusions in the Faroe–Shetland Basin was evaluated by (Rateau et al., 2014). They analysed the spatial relationship between sills and hydrocarbon occurrence. They also recognized fractured sills which have been charged by gas. They undertook the study of different processes which derives the petro-physical characteristics of sills. They provided a series of general conceptual models dealing with hydrocarbon migration and igneous compartmentalization within sedimentary basins, which may be applied not just to the Faroe–Shetland Basin, but to other sedimentary basins anywhere in the world if it gets proven (via well data or other methods) that the intrusions are impacting the petroleum system. The finding of their study suggests that magmatic intrusions may act both as barriers and/or carriers for fluid flow/hydrocarbon migration. In basins where sills act as barriers it causes compartmentalization in both the source and reservoir rock intervals. In areas where hydrocarbon migration takes place along the saucer–shaped sills the result is concentration of migration above the tips of the sill, with little concentration above the central portion.