# CHAPTER 4

## Discussion

### 4.1. Structural style

There are early NNE-SSW trending faults associated with Late Cretaceous-Eocene half grabens. These are basement involved faults associated with rifting. During the post-rift stage there are more NE-SW to ENE-WSW trending faults and some reactivation of the NNE-SSW trends. Many of these post-rift faults do not appear to pass down into basement; hence they would not be conduits for magma in the crust, but maybe conduits for magma within the sedimentary basin. It is the NNE-SSW trends that would be expected to influence migration of magma at depth. However, there is no clear link between the three main igneous bodies (Fig. 3.9) and the syn-rift fault pattern. The NNW-SSE trend of the bodies lies oblique to the NNW-SSE trend of the faults. While there may be a relationship between faults and magma chambers at depth, it is not clearly revealed by seismic reflection data.

### 4.2. Volcanic activity

The relatively rapid post-rift basin subsidence means that where volcanic activity is prolonged the volcanic edifices build up vertically over a time-depth interval of about 1.5-2s TWT. This would be about 1.8-2.4 km height. This enables the growth of individual volcanic centres to be identified because they are separated by sedimentary rocks deposited during rapid subsidence. The age of the southern volcanic centre is about 8-2.5 Ma according to Giba et al. (2012). In this study the southern volcanic edifice can be subdivided into eight different centres that erupted at different times and/or different locations around the southern centre. Three smaller edifices (1, 8, 9, Fig. 3.14) are also present in the study area.

#### 4.2.1 Volcanism in the Northern Taranaki Graben

The belt of submarine stratovolcanoes occupies about 20% of the area of the northern Taranki Graben. They are primarily andesitic in composition, and have erupted lavas, lapilli tuffs, and given rise to volcanic slump breccias (e.g Giba et al., 2012). These deposits have been penetrated by some wells, and avoided by most exploration programs. In an adjacent 3D area one of the Miocene centres has been by drilled the well Kora-1 (Arco, 1988). The well is located in the Tasman Sea about 78 km north northeast of New Plymouth and 20 km south and 22 km southeast of the shell BP and Todd Tangaroa-1 and Ariki 1 wells, respectively. The location map for Kora-1/Kora-1A is given in (Fig. 4.3). The stratigraphic sequence penetrated consists of a thick section of Pliocene and younger claystones and other poorly consolidated fine grained sediments, overlying a relatively thick sequence of Miocene volcanics. This in turn is uncomformably underlain by Mio-Oligocene deep water Mahoenui claystones and siltstones, and Oligocene Te kuiti limostones and the underlying Eocene Tangaroa turbiditic sandstones of the Kaiata Formation. The complete stratigraphic sequence encountered in Kora-1 well is given in (Fig. 4.2). The well Tangaroa-1 which is located in the vicinity of the study area has penetrated the late cretaceous basement. Arco tested 668 b/d of 35 degree oil from Kora-1 (Oil and Gas Journal, 2001). This well was on the flank of the Kora stratovolcano, and had a deeper Eocene objective. The well demonstrated that in volcaniclastic reservoirs porosities could be as high as 30%, and permeabilites could reach 300 md. The main reason for a sub-economic accumulation was assigned to the seal. Hence volcaniclastic reservoirs are considered viable exploration targets, and may become more important as exploration matures in the basin.

### 4.3. Volcano growth mechanism

Volcano growth is governed by multiple stages of interplay between constructive and destructive processes. Constructive processes are dominated by the both surface (e.g. lava flows) and endogenous (e.g. dyke intrusion) build ups and destructive processes are dominated by the flank collapse (Anne et al., 2001; Kervyn et al., 2009). Submarine volcanoes as compared to their onshore counterparts are characterized by the net accumulation of sediments rather than net erosion (Jackson, 2012), so it is likely that any change on the internal seismic facies of the offshore volcanoes will relate to the constructional process (Magee et al., 2013). For example, prograding clinoforms and incised channels adjacent to the large edifices (i.e. edfices 6 and 7) in southern part indicate that the edifices were located proximally in a shallow marine depositional environment. Those edifices show onlap relationship with some of the reflectors indicate that they were partially submerged initially. Subsequently the relative sea level rose gradually controlled by the post rift subsidence, resulting complete inundation of these bodies. This observation is further supported by the draping of high amplitude, high to medium frequency, continuous reflections of postrift sediment packages (Fig. 4.1). While distal volcanism-related deposits (tuffs, tuffaceous sandstones) will not be easily distinguished from background sedimentation on seismic data, the more proximal deposits can be readily identified on the Parihaka 3D seismic. The most common external geometry are wedge-shaped, high amplitude reflection packages that thin passing away from the edifice. The bases tend to be parallel to the underlying sediments while the upper surface, which has a depositional slope away from the volcano, is onlapped by the basin sediment (see Figs). The reflectors of low and high amplitude can still be seen inside the wedge-shaped body indicate that the upper parts of the edifices are composed of both igneous and sedimentary (possibly pyroclastic) rocks. This interpretation is in line with the general facies models for submarine volcanogenic successions, which describes that sediments are commonly interbedded with the igneous material (Green and Short 1971).

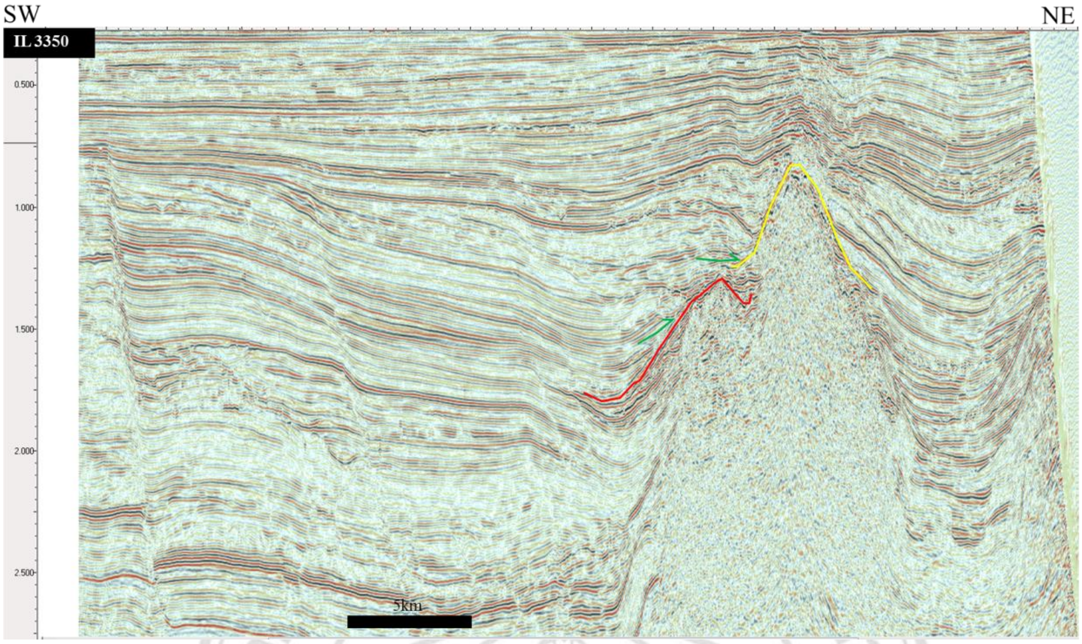


Figure 4.1 Figure 4.1 showing the onlap and draping of the strata

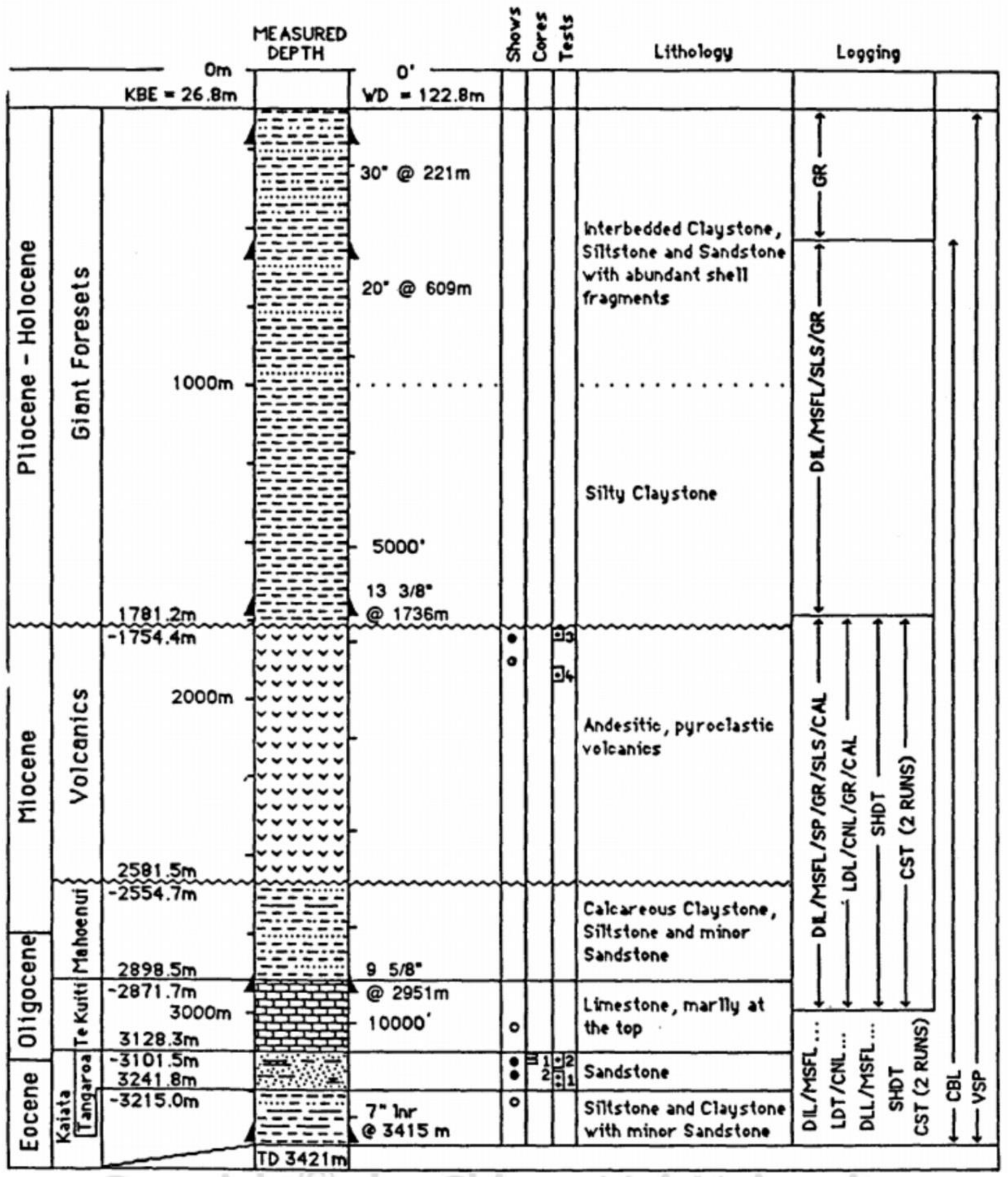




Figure 4.2 showing a stratigraphic column through Kora-1 well

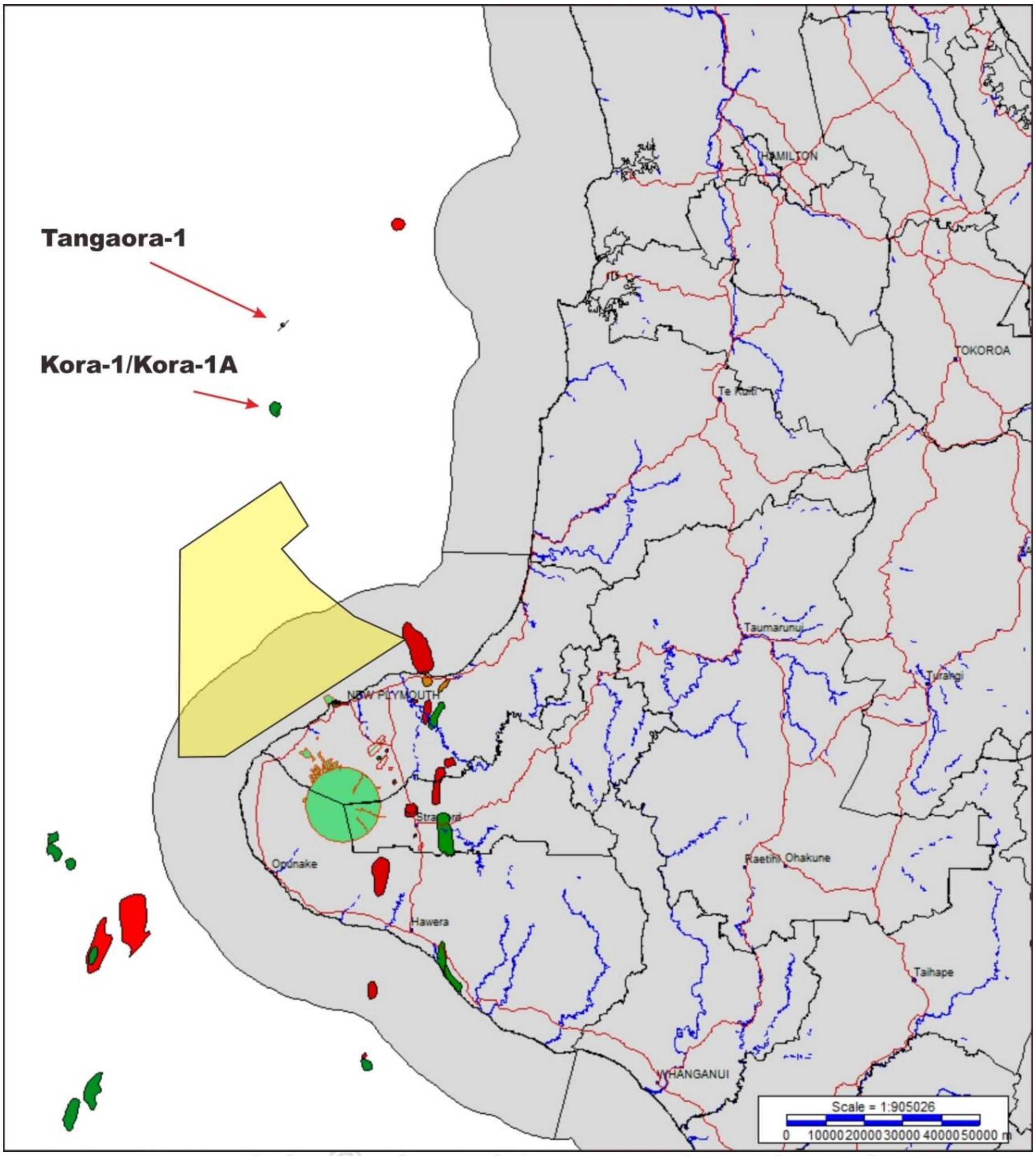




Figure 4.3 Location map for Kora-1 well alongwith the study area(yellow polygon represents study area)

#### 4.3.1 Examples from study area

##### 4.3.1.1 Edifice 1

Edifice 6 shows the parallel reflectors of high amplitude at its flanks which most probably due to the sediments shedding away from the volcano top. The little variation in the internal seismic facies (Fig. 3.20) of the edifice implies that many of the larger volcanoes grew by a proportional increase in summit height and basal diameter .This mode of growth is similar to the volcanic mound model proposed by (Vail et al. 1977, also see Magee et al., 2013). Intra-volcano seismic reflections that converge down-dip in the volcanoes indicate growth occurred through the preferential addition of material to the summit area and upper volcano flanks (Magee et al., 2013). These two models for the growth of the volcanoes involving increases in the height of summit are consistent with the interpretation that the majority of volumetrically important eruptions emanated from the summit area (Rossi, 1996). Near the flank of the edifice the relatively steep dips of the sediments way from the edifices is due to differential compaction, since the sedimentary fill of the basin will compact, while the predominantly igneous rocks of the edifices will not compact, or compact by a much lower amount.

##### 4.3.1.2 Edifice 2

Edifice 2(Fig. 3.16) has a very gentle slope ranging from 6-12° suggesting that it has shield like morphology (Schofield and Totterdell, 2008). These morphometric parameters have been compared with (i) shield volcanoes imaged on seismic reflection data from offshore western India (Calvès et al.,2011); and (ii) small, terrestrial shield volcanoes (e.g. Rossi,1996; Grosse et al., 2009) by Magee et al., 2013 and a depression on top of edifice suggests crater development and caldera collapse.

### 4.4 Effect of igneous intrusions on paleoenvironment

The reflection pattern around the northern edifice shows onlap of the reflections with a clinoform morphology onto the edifice during the Late Miocene. Near the edifice are local erosional surface are developed due to it being a persistent high. Passing away from the edifice seismic unit 5 shows constant thickness and remains unaffected by the edifice. One of the units onlapping the upper part of the Southern volcanic edifice complex is the Giant Forsets Formation, which as its name suggests is composed of prograding forests, but is also affected by many channels and incised valleys. These features have been imaged on H4 (Figs. 3.42, 3.43). They tend to trend NE-SW to ENE-WSW and appear to be developed independently of the volcanic centres. However locally around the Southern volcanic complex more radial, and N-S trending channels are present (Fig. 3.45) indicating the local influence of the centres deflecting the channels. Small, local radial drainage patterns from the volcanic centres have also been imaged (Fig. 3.42).

**1.5 Onshore volcanoes**

There is only large volcanic mountain (Mount Taranki) located onshore on Taranaki peninsula. It has a height of ~1700 m (Fig. 3.28) which is higher than all the edifices measured offshore. The maximum dip of its flank measured is 22° which is equal to some of the edifices measured offshore. These are typical dimensions for a stratavolcano. In contrast shield volcanoes, associated with more basic lavas, tend to dip less than 5 °. The other two volcanoes measured onshore are very small having a maximum heights of 800m and maximum dips of 17°. Comparison with the offshore volcanoes suggests that the offshore volcanoes tend to preserve well because they are characterized by accumulation of sediments rather than net erosion (Jackson, 2012). Mount Taranaki (volcano 1, Fig. 3.28) is much taller than the edifices measured offshore although the diameters of the largest offshore volcanoes is similar to the steeply dipping part of Mount Taranaki. This is because for the young onshore volcano the perfect volcanic peak is preserved. For the older volcanoes either destruction of the peak during eruption, or by erosion would reduce the slope and height from the youthful example seen at Mount Taranaki to the edifices observed in the subsurface. The older eroded onshore volcanoes (Fig. 3.28 volcanoes 2 and 3) exhibit dimensions and geometries much more in line with the offshore edifices (Fig. 4.4).

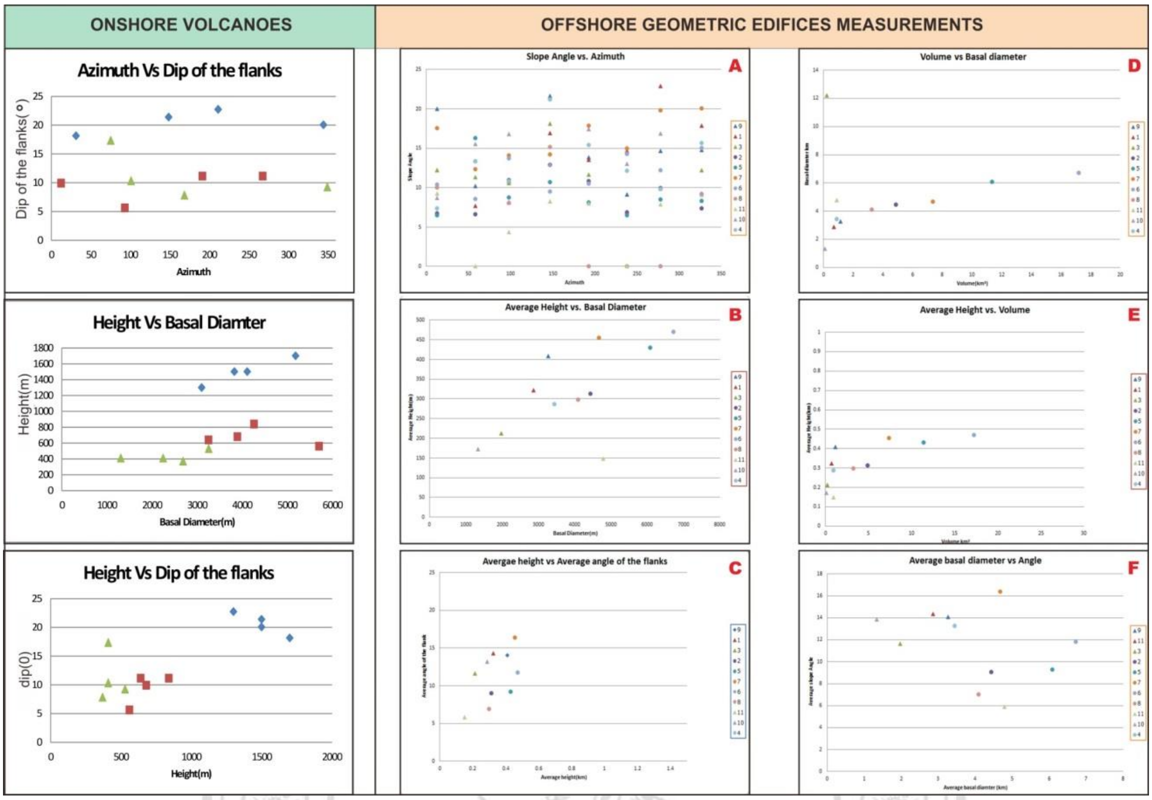


Figure 4.4 A graph showing the comparison with onshore and offshore volcanoes