Seismic Interpretation of a Complex Tectonic Environment, Northland Basin, New Zealand*

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Abstract

An extensive suite of 2D seismic data offshore western New Zealand was interpreted to elucidate the complex tectonic setting of this region and its impact on younger depositional systems. The seismic interpretation of the southern part of the Northland Basin was successful in evaluating the geological history of the basin, indicating that extensional faulting in the Late Cretaceous and Neogene was followed by uplift, creating the structural framework for the basin and determining the location of the accumulation of younger marine sediments. The basin exhibits many structural and stratigraphic features including normal faults, north-verging reverse growth faults, and igneous intrusions.

Introduction

New Zealand has been transformed by a unique and complex tectonic history. It has undergone three major tectonic events, including Paleozoic compression associated with Gondwana, Cretaceous extension with massive rifting, and the current compressional environment at the Indo-Australian and Pacific plate boundary along the east coast of North Island. This environment is further complicated by the presence of tectonic-associated volcanism. Off the western shore of New Zealand, this environment has resulted in the formation of many sedimentary basins including the Northland Basin and the Taranaki Basin. These are geologically young basins with the basement consisting of Early Cretaceous rocks. The boundary between the Northland Basin and the Taranaki Basin contains a foreland fold-thrust system that is characterized by syntectonic sedimentation, followed by extension. This study focuses on 2D seismic data covering the southern portion of the Northland Basin and the northern portion of the Taranaki Basin, located in the Tasman Sea southwest of Auckland (Figure 1). Seismic interpretation was performed to understand the tectonic history of the basin and its impact on younger depositional systems.

Seismic Data

The 2D seismic dataset used for this seismic interpretation was made available through the New Zealand Ministry of Economic Development. The dataset was acquired by Conoco in the 1990's and reprocessed in 2005. The marine survey was acquired with strike lines trending north-south and dip lines trending east-west with an approximate spacing of 2 km. For the purpose of this study, a total of 26 seismic lines from the survey were interpreted with the majority of them running in an east-west trend, orthogonal to the strike of the basin's major fault system. Nine strike lines run approximately north-south, acting as tie lines. Five wells are located within the southern portion of the study area, although only two contain publically available wireline data. Existing geologic information became sparse as the seismic interpretation was pushed northward through the complex basin. This placed some limitation on the accuracy of picking horizons across the entire study area, especially across syndepositonal faults.

Seismic Interpretation

The interpretation of the seismic data focused on the Northland Basin to examine its geological history. It was found that extensional faulting in the Late Cretaceous and Neogene was followed by uplift, creating the structural framework for the basin and determining the location of the later accumulation of marine sediments. Sediments within the study area exhibit structural features including growth faults, unique extensional features, as well as intrusive and extrusive igneous bodies. Many of these features are present in the two examples of interpreted seismic lines displayed in Figure 2 and Figure 3.

The majority of the faults in the basin were interpreted to be associated with extension. In the study area, four major faults were interpreted: three normal faults, with considerable displacement (Figure 4), and one reverse fault. A strong link was observed between the three extensional faults and the creation of considerable accommodation space in the eastern part of the basin that became the depocenter for Late Miocene and Pliocene sediments. The reverse fault was determined to be a north-verging growth structure associated with uplift in the western portion of the study area.

There are five areas interpreted to have experienced volcanism (Figure 5). They are associated with two types of volcanism: pillow basalts that extruded onto the ocean floor and intrusions within the sedimentary section. The majority of the igneous bodies are interpreted to be related to extensional faulting that occurred during the Miocene as three of them are located close to the major faults. It can be speculated that faulting resulted in zones of weakness utilized by intruding magmas formed in the backarc environment.

Overall, the structural features interpreted in the basin resulted in two distinct environments that focused the deposition of Neogene sediments, one to the east and one to the west. In the east, progradational units filled the basin resulting in westerly migration of the depocenter created by the three major extensional faults. Sediments in this part of the basin exhibit sigmoidal reflection patterns, from which we conclude that the Northland Basin was a relatively low-energy sedimentary regime. In the west, minimal deposition occurred due to the presence of a structural high.

Currently, the Northland Basin is located in a tectonically quiescent environment. All underlying structures have been completely filled by an influx of marine sediments resulting in the migration of the continental shelf westward and the creation of a “typical” continental margin with associated turbidites in the deeper-water settings. Recent sediments show the characteristics of this type of margin, with the development of many underwater channel systems that carry sediment loads away from the continental margin as described by Posamentier (2003).

Acknowledgements

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Reference Cited

Posamentier, H.W., 2003, Depositional elements associated with a basin floor channel-levee system: case study from the Gulf of Mexico: Marine and Petroleum Geology, v. 20, p. 677-690.

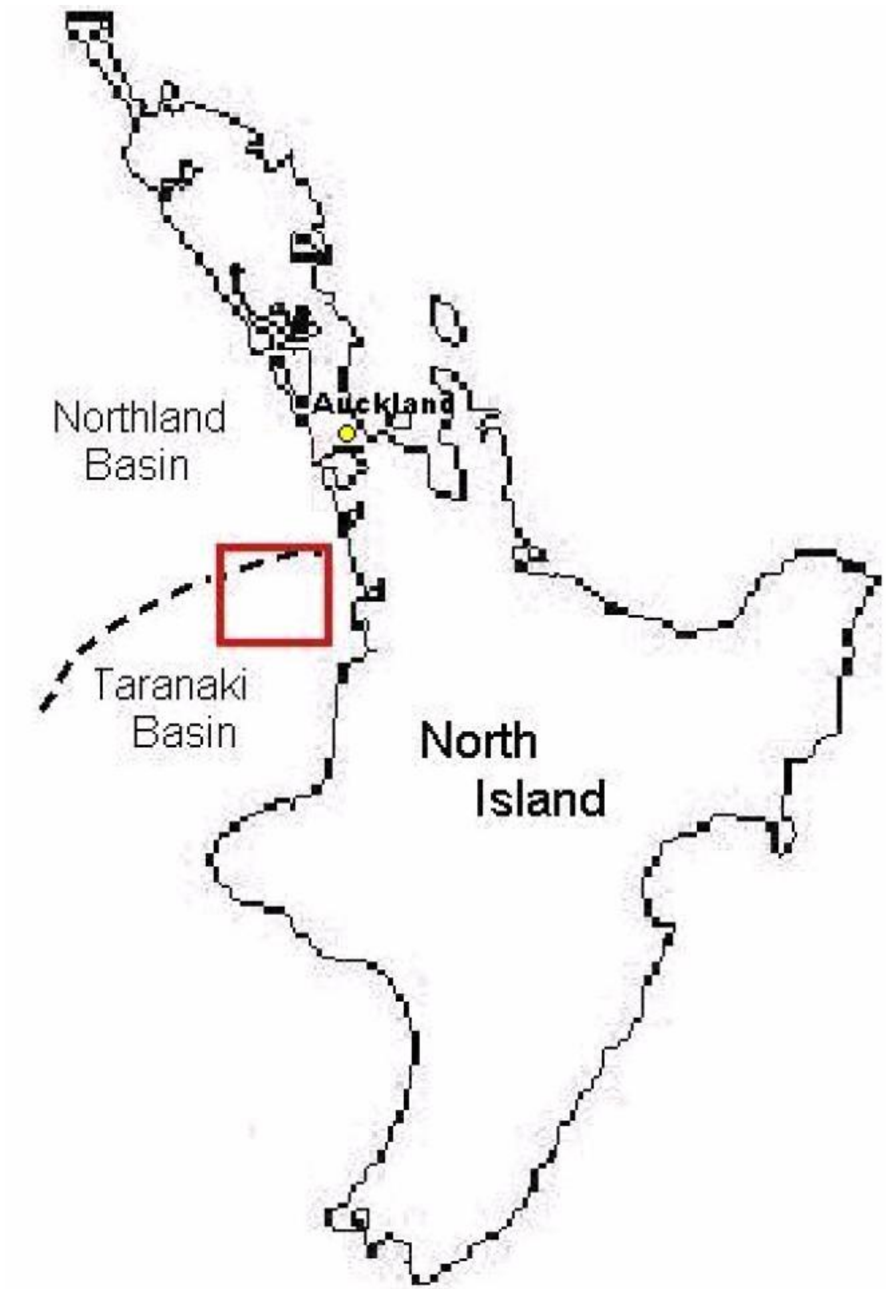

Figure 1. Study area and basin distribution offshore New Zealand.

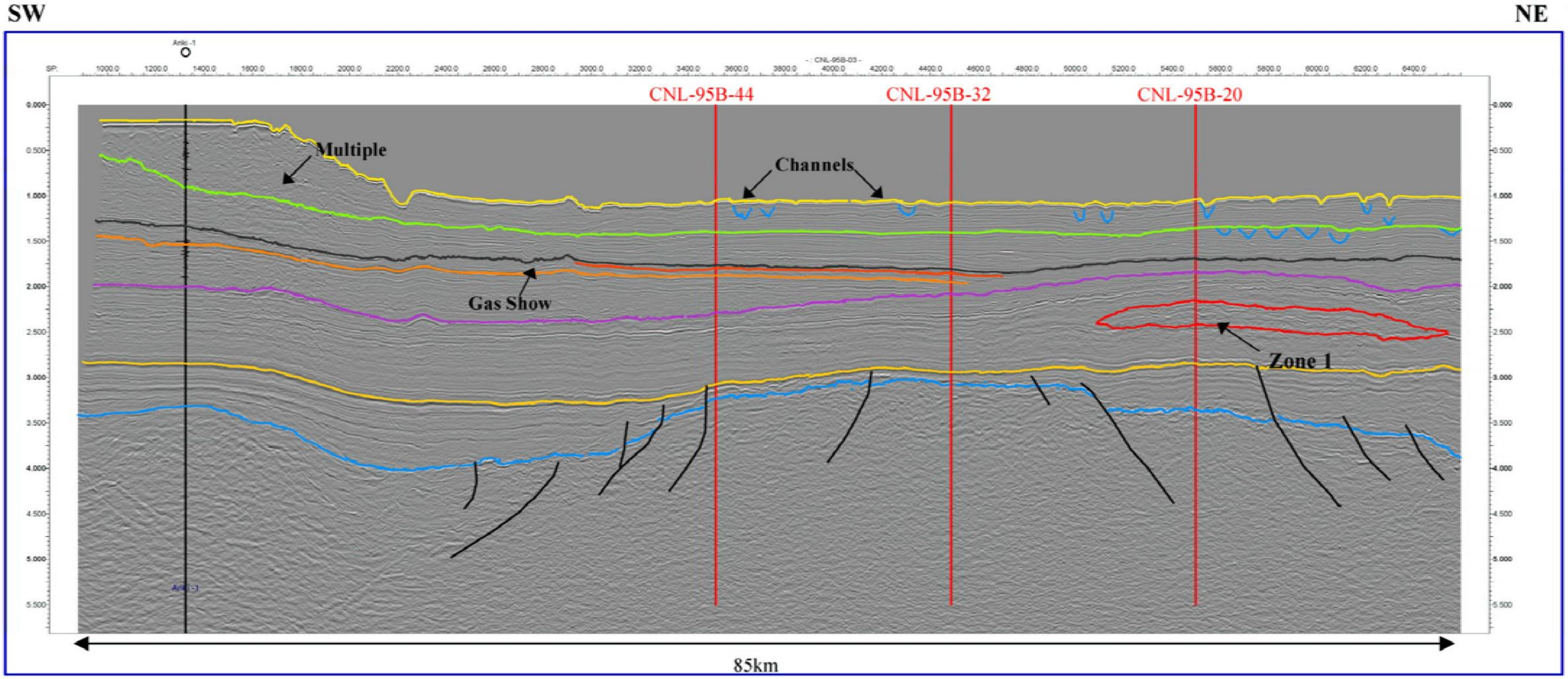

Figure 2. Seismic interpretation of one strike line in the western portion of the study area. Blue = Upper Cretaceous Pakawau Group; yellow-orange = Oligocene Tikorangi Formation; purple = Miocene Urenui Formation; orange/redorange/ red/black = Pliocene Giant Foresets; green = Recent sediments; yellow = ocean floor. Areas outlined in red are interpreted to be Miocene volcanics associated with the Mahoenui Formation.

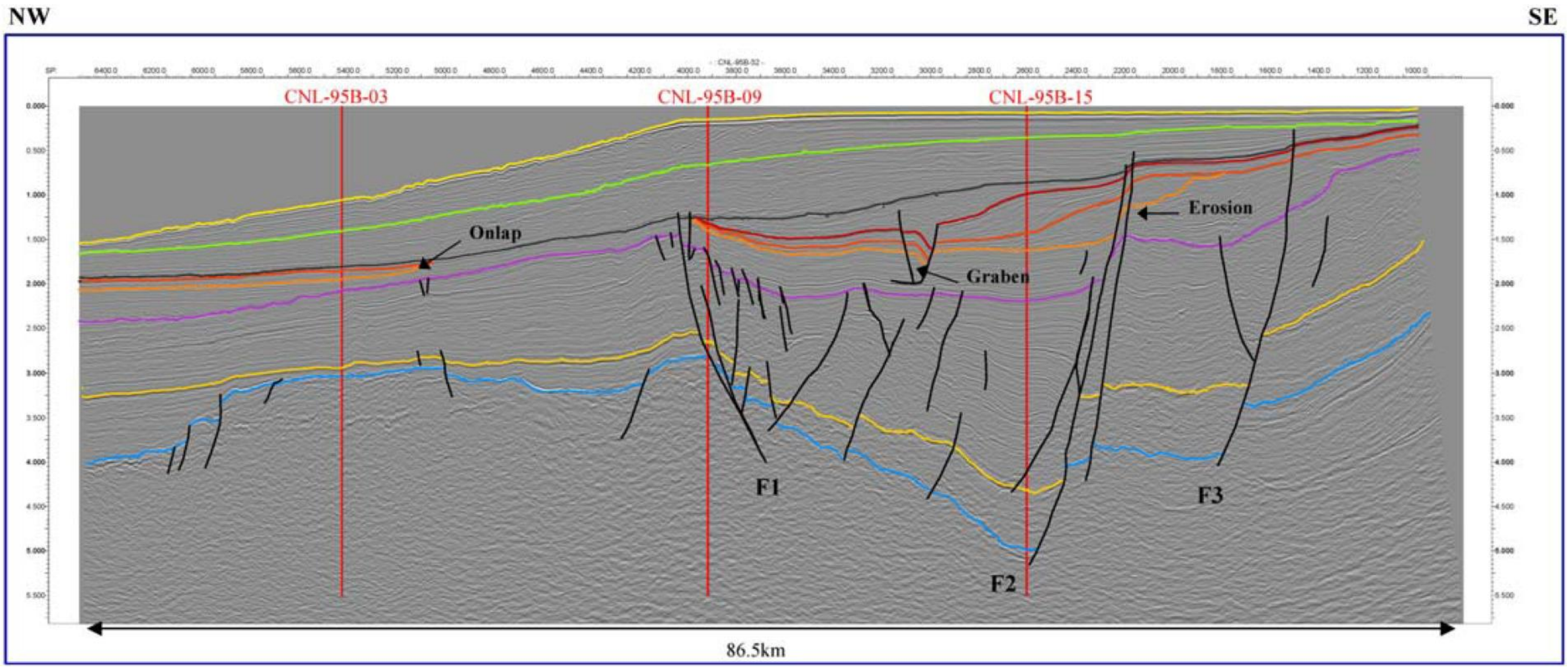

Figure 3. Seismic interpretation of one dip line in the center of the study area. See Figure 2 for horizon nomenclature.

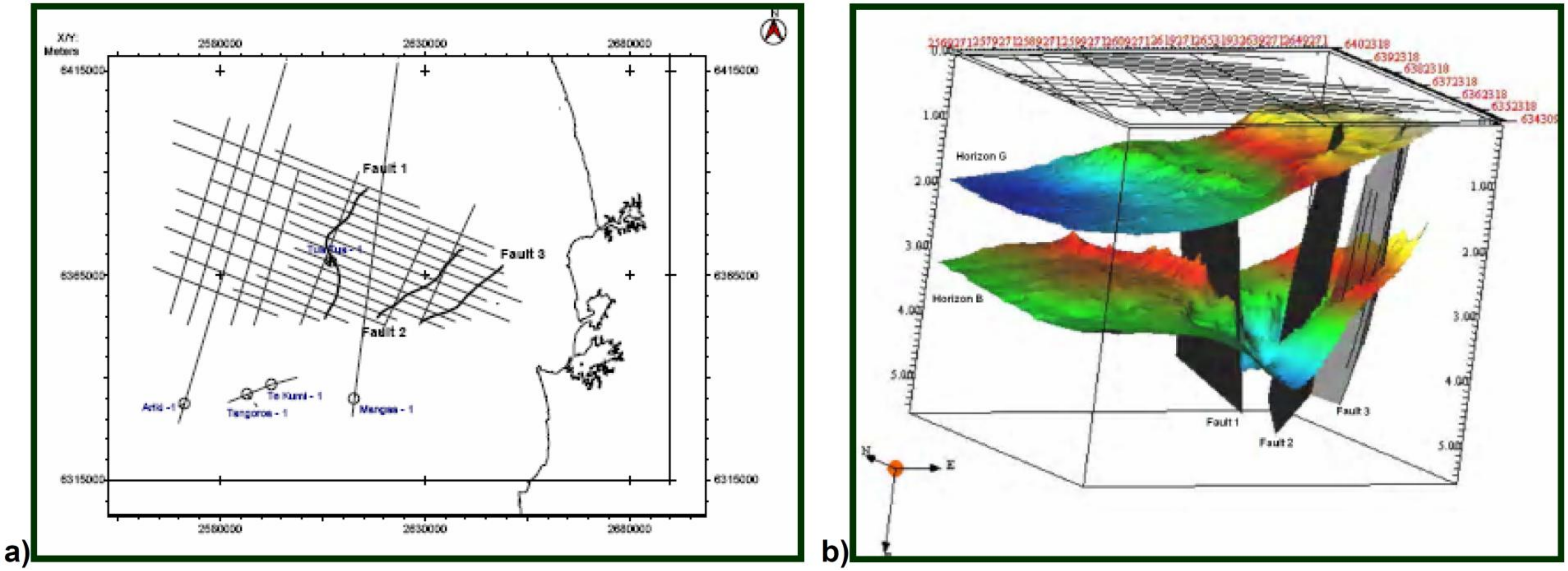

Figure 4. (a) Base map with three major faults associated with the extension in the basin. (b) Volume illustrating 3D orientation and extent of the three main faults.

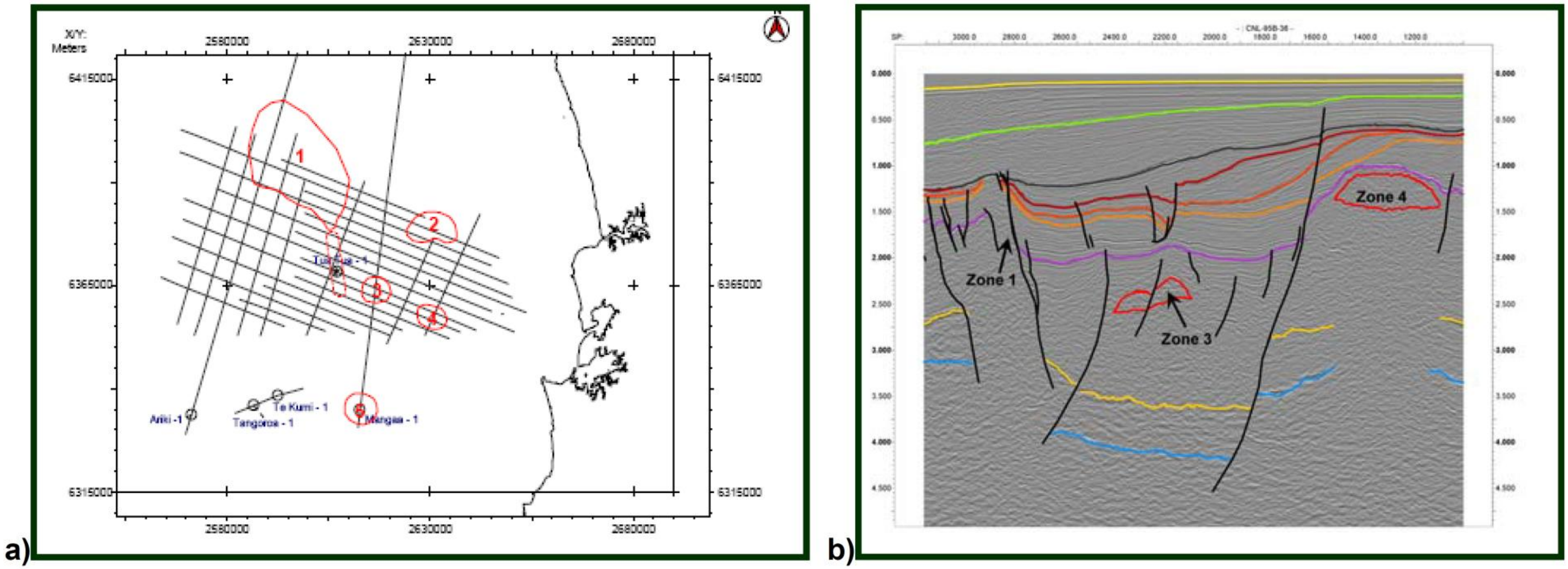

Figure 5. (a) Base map illustrating five areas containing igneous rocks. (b) Seismic interpretation of three of the igneous bodies.