Seismic Interpretation and Basin Analysis of the Longford Sub-basin

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Abstract

The Longford Sub-basin in northern Tasmanian is a continental rift initiated during the Late Cretaceous to early-Palaeocene, associated with the break up of Australia and Antarctica. The basin is approximately 100km (axial length) by 30 km and formed due to NE-SW extension. Recently acquired seismic data, was used in conjunction with well logs and potential field data to provide a new view of the stratigraphy and structure of the basin.

The Longford Sub-basin consists of major NW-SE faults and minor NE-SW faults. The major western boundary fault dips between 60^0 and 70^0 to the NE. The basin includes a western graben and a half-graben in the east. The western graben formed at the onset of rifting followed by a later development of the eastern half-graben. A series of NE trending transfer faults were active during initial extension. This caused strike of basin forming faults to change and were later reactivated initiating the formation of the half-graben.

Seven seismic sequences have been recognised within the Longford Sub-basin and a new stratigraphic framework is proposed. The basin fill consists of a basal Palaeocene to early-Eocene coal-rich lacustrine facies, a mid-Eocene lacustrine facies and a late Eocene fluvio-lacustrine sequence. Initial basin fill was restricted to the north of the western graben and was synchronous with subsidence. Mid-Eocene volcanism deposited through discontinuous basalt flows. Faulting at this time resulted in connection of the western and eastern sub-basins for the first time. By the late-Eocene, the lacustrine sedimentation was replaced by a fluvial dominated depositional environment.

There are few drill holes that penetrate to the basement but two-way-time structure contour maps derived from the seismic allow reconstruction of the basement surface. The structural history of the basin has lead to the identification of potential petroleum plays. These plays prospectively lie in a dome in the western graben, and in transfer zones and tilted blocks near Hummocky Hills.

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Chapter 1 Introduction

1.1 Background

The Longford Sub-basin is the largest onshore Tertiary basin in Tasmania. The Sub-basin is considered to have formed under the same event that produced the Bass Basin (Matthews 1989). During the pre-Late Jurassic a major left lateral strike-slip fault was initiated along the southern margin of Australia, extended through the Otway Basin and to the west of Tasmania (Willcox 1990). A branch of this strike-slip zone passed through the Bass Basin and into northern Tasmania, resulting in the formation of the Tamar Graben and southern extension, the Longford Sub-basin.

1.2 Location and Physiography

The Sub-basin is situated in central northern Tasmania (Figure 1.1 & 1.2). The Sub-basin is oval-shaped, comprising an area of approximately 950km^2 and a NW axial length close to 100km^2 (Direen 1995).

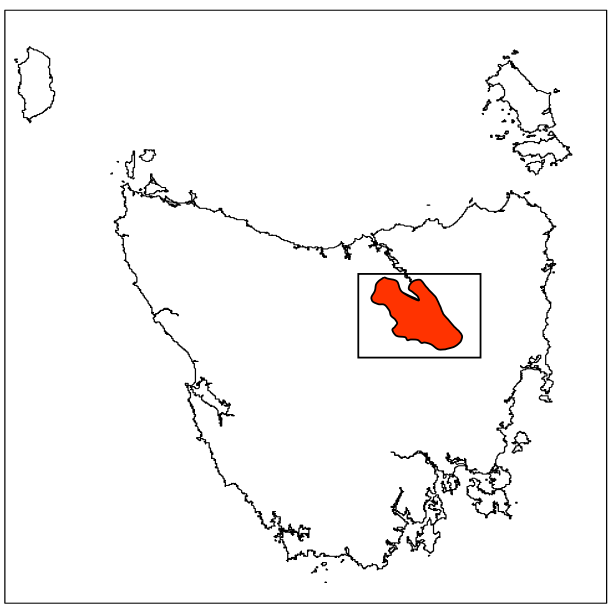

Figure 1.1: Location Map

The Longford Sub-basin extends from Launceston and Quamby Brook in the north, to Poatina and Conara in the south. The western limit trends along the foothills of the Great Western Tiers and the eastern margin is represented/drawn at Ben Lomond (figure 1.2).

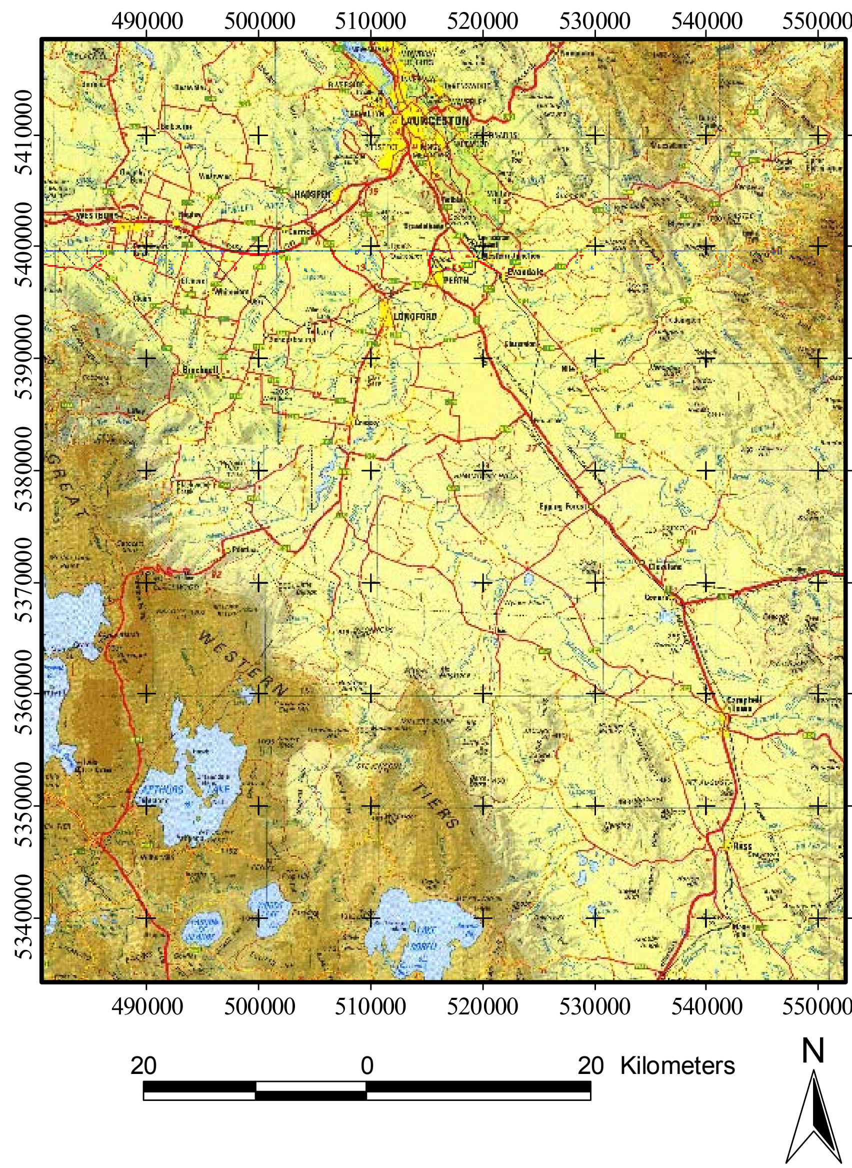

Figure 1.2: Detailed location map of the study area

The physiography of the Sub-basin consists of relatively flat, open plains and low lying hills that support extensive agriculture. The exceptions are Hummocky Hills and Mt Arnon that form central ridges. In contrast, heights in excess of 1000m and 400m ASL occur at the western and eastern margins respectively.

1.3 Aims

The purpose of this study was to create preliminary interpretations of seismic lines over the Longford Sub-basin, consisting of three-dimensional stratigraphic and structural modelling of the basin.

Specific aims involve:

- Calibrate the seismic to provide Two Way Time (TWT) structure maps.
- Recognise stacking patterns and produce a new stratigraphic framework based on seismic reflection characteristics.
- Apply the stratigraphic framework to the entire basin following a better understanding of the vertical and lateral extent sequences.
- Determine depositional environments and nature of basin fill from seismic reflection.
- Map major faults, determining geometry, timing and control on deposition.
- Produce a TWT structure contour map of the basement, and
- Evaluate the economic potential.

1.4 Datasets Used

- Great South Land Minerals (GLSM) acquired 12 migrated seismic profiles containing 275km of data down to 5 sec (TWT) over the Longford Sub-basin (figure 1.3).
- Bureau of Mineral Resources magnetic intensity dataset of Tasmania.
- The Geoscience gravity survey. The residual Bouguer anomaly has had additional infill by GSLM over the Longford Sub-basin.
- Over 200 drill holes enter the basin. Wells of particular interest were oil prospecting, uranium and water investigation holes (Matthew 1983; Appendix 1, 5 & 6.) Geophysical data run on oil prospecting hole (OP1) is referred to extensively.
- The seismic interpretation software used in this project is Kingdom Suite+ 7.0. This program, together with ER Mapper 6.1, Arc View 3.2, Corel Draw 8.0 and Microsoft Power Point, was employed to generate images.

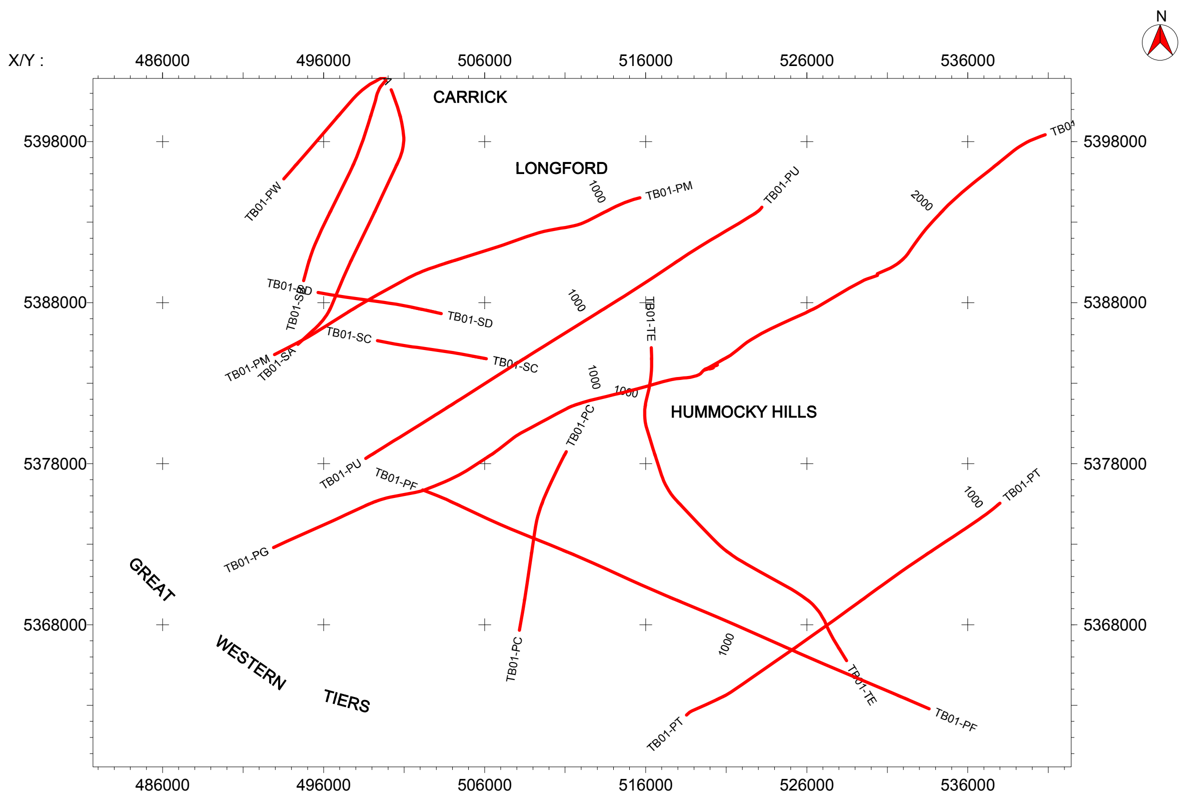

Figure 1.3: Seismic coverage over the Longford Sub-basin.

Chapter 2 Regional Geology

2.1 Introduction

The Longford Sub-basin overlies the relatively complex Palaeozoic and Mesozoic rocks of Tasmania. Limited occurrences of these older rocks appear within the basin, confined to the SW margin around the Great Western Tiers. This chapter outlines the geology of the study area (figure 2.1) and previous sub-divisions of the Tertiary stratigraphy.

2.2 Stratigraphy

Proterozoic - Cambrian

Proterozoic-Cambrian rocks occur in a window beneath younger cover. They occur SW of the basin near O'Connor Peak and Little Billop. The rocks are part of a large continuous volcanic belt that outcrops extensively in western Tasmania and is referred to as the Dundas Element by Seymour and Calver (1995). These are possible correlates of the Crimson Creek Formation (Crawford 1991; Forsyth et al. 1995). The rocks consist of slate, phyllite and basic volcanic rock (tuffs) with minor limestone beds (Matthews 1983). Matthews (1983) reported Precambrian dolomite at Brumby's Creek, with Cambrian quartz sandstone and minor conglomerates occurring NW of the Sub-basin at Beaconsfield.

Ordovician - Devonian

Ordovician-Devonian rocks outcrop extensively to the NE of the Sub-basin, but occurrences are reported within the study area. The early Ordovician-early Devonian Mathinna Group consists of a micaceous quartz-wacke turbidite sequence and mudstone sequence. Devonian batholiths intrude the Mathinna Group.

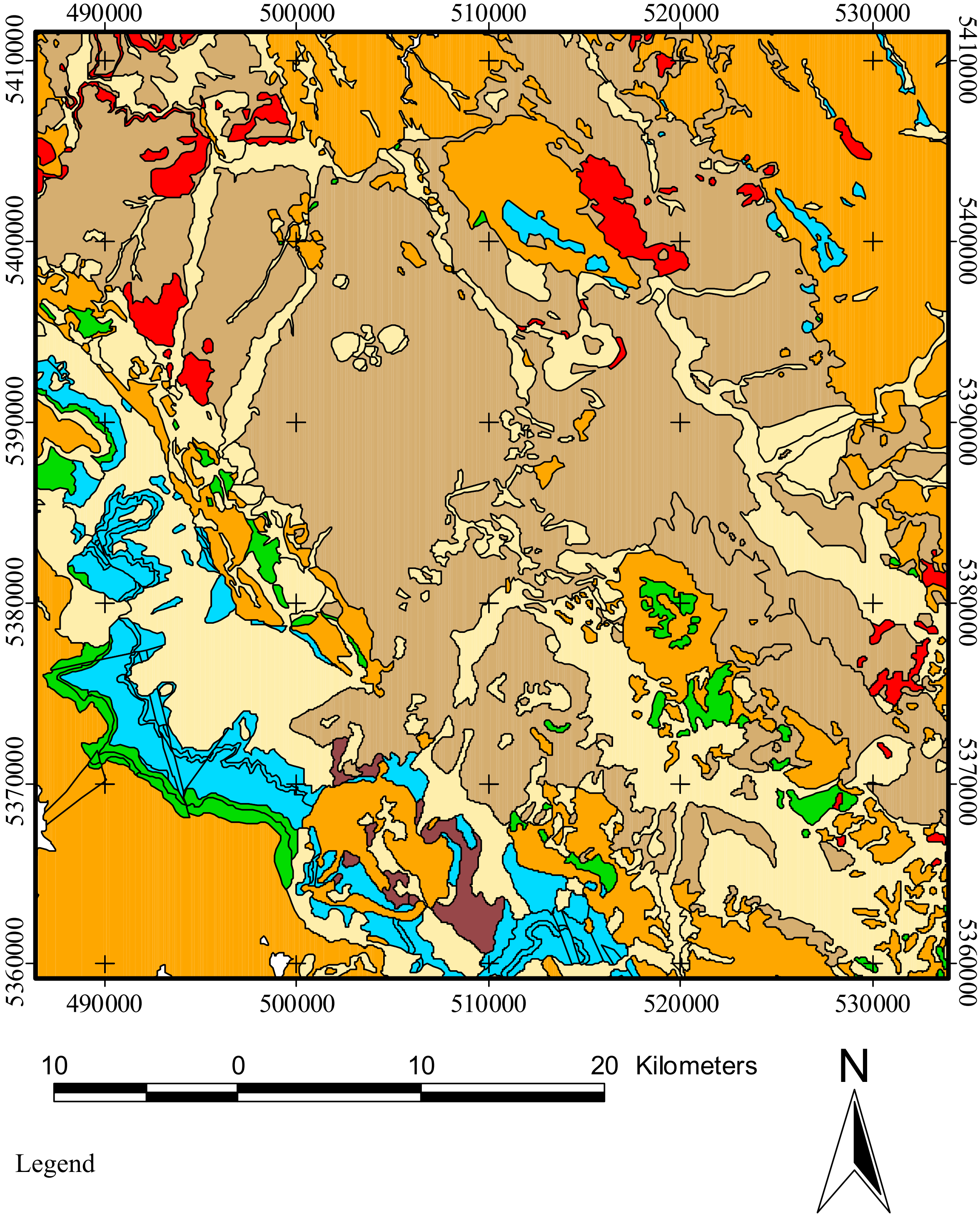

Figure 2.1: Geology map of the Longford Sub-basin

Permian – Triassic

These rocks are referred to as the Parmeener Supergroup, which can be subdivided into the Lower and Upper Parmeener Supergroup. The Lower Parmeener consists of a Lower Permian glaciomarine, and freshwater sequence, as well as an Upper Permian freshwater succession. These rocks unconformably overlie Precambrian to Devonian rocks. The basal unit consists of a tillite overlain by a glaciomarine sequence of: mudstone, pebbly mudstone, pebbly sandstone with minor limestone and Tasmanite oil shale. The freshwater sequence of the Lower Parmeener consists of sandstone with coal measures (Pike 1973). A late transition back to a glaciomarine environment produced a pebbly mudstone, pebbly sandstone and limestone succession (Forsyth et al. 1995). Best exposures occur along the escarpment of the Great Western Tiers and isolated areas to the north.

The Upper Parmeener Supergroup consists of uppermost Permian-Triassic freshwater sediments. This sequence disconformably overlies Lower Parmeener sediments. The Triassic sediments comprise well-sorted, cross-bedded quartz sandstone in the lower section, and dominantly lithic sandstone, shale and sub-economic coal seams, in the upper section (Matthews 1983). Triassic dolerite outcrops at Hummocky Hills.

Jurassic

Jurassic dolerite forms the margins, central ridges and immediate basement to most of the Longford Sub-basin. At least two major dolerite sheets outcrop around and within the Longford Sub-basin (Longman & Leaman 1971). Direen (1995) proposed as many as four dolerite sheets may occur around the Longford-Sub basin.

Tholeiitic dolerite occurs as sills, dykes and shallowly or steeply transgressive intrusions within the Parmeener Supergroup sediments (Leaman 1971; Matthews 1983). Large areas of outcrop cap the Tiers to the west, to the east at Deddington, and at Hummocky Hills and Mt. Arnon inliers within the basin.

Tertiary

The Tertiary sediments of the Longford Sub-basin disconformably and unconformably overlie the Mesozoic Parmeener Supergroup and Jurassic dolerite. Tertiary sediments reach a known maximum thickness of 793m in the north of the Sub-basin. Lithologies present are coarse to fine grained sandstone, siltstone, shales, gravels, conglomerates and lignite beds.
Volcanism was prevalent during the mid to late Tertiary producing a variety of basalts.

Over the last 50 years numerous studies on the stratigraphy have been undertaken, with only limited basement data. Such studies by Sutherland (1971), Matthews (1983), and Direen (1995) have resulted in different lithostratigraphic classifications.

2.3 Previous Work

Sutherland (1971) describes the geological relationships and petrology of Tertiary volcanics within the Tamar Graben. Although his investigation was concentrated to the north, he made considerable reference to the Longford Sub-basin. Sutherland divided the basin into pre-, inter- and post-volcanic sediments. The pre-volcanic package consists of Palaeocene to Upper Eocene lacustrine sediments. The inter-volcanic package is mid-Eocene to Miocene volcanic dominated unit with contemporaneous clay, sand and gravel deposition. The post-volcanic package is a Pliocene to Pleistocene fluviatile unit. This unit is distinguished from underlying packages only by laterites, talus, soils and aeolian sands. Sutherland (1971) described the lavas of the area as alkali olivine-basalts, with minor tholeiitic and alkaline olivine-basalts.
Matthews (1983) described the basin fill as predominately terrestrial Palaeocene to Eocene sediments. By this time palynological data had become widely available, replacing the age assumptions in the earlier investigations by Carey (1947) and Sutherland (1971).

The model of deposition for the majority of the basin history was interpreted by Matthews (1983) as lacustrine, similar to Johnson (1875) and Carey (1947). Matthews (1983) noted the occurrence of coarse sands, gravel and conglomerates. He went on to describe the depositional environment as a dominant lacustrine setting with intermittent fluviatile stages, which were influenced by subsidence and volcanism.

Matthews (1983) sub-divided the Tertiary stratigraphy as follows:

- Palaeocene to Eocene; clay, sand and lignite
- Mid-Eocene to Pliocene; basalts, clay and sand
- Pliocene to Pleistocene; laterites, soils and aeolian dunes

Using uranium prospecting holes, Direen (1995) questioned the lacustrine model, suggested by earlier authors and favoured a fluvial system on an extensive floodplain. He suggested a fluvial sequence from the Palaeocene to Holocene. Direen's interpretation appears reasonable for the upper 150m section of the basin that he investigated, but its extrapolation below this depth was not based on data.

2.4 Structural Geology

Major NW trending faults have greatly controlled Tertiary deposition of the Longford Sub-basin. It is probable that the Longford Sub-basin formed on much older lines of weakness (Baillie 1989). Basin margin faults are recognised as the Tiers Fault in the SW and the Hadspen Fault in the NE (Longman 1966; Longman & Leaman 1971). In the NE of the basin, the Longford and Pateena Faults parallel either side of the Hadspen Fault, but it appears unclear if, or which of these structures has controlled Tertiary deposition. In the north of the basin faulting is poorly understood, whereas in the south, faulting appears to be complex (Direen 1995). Figure 2.2 is a map of previously interpreted faults.

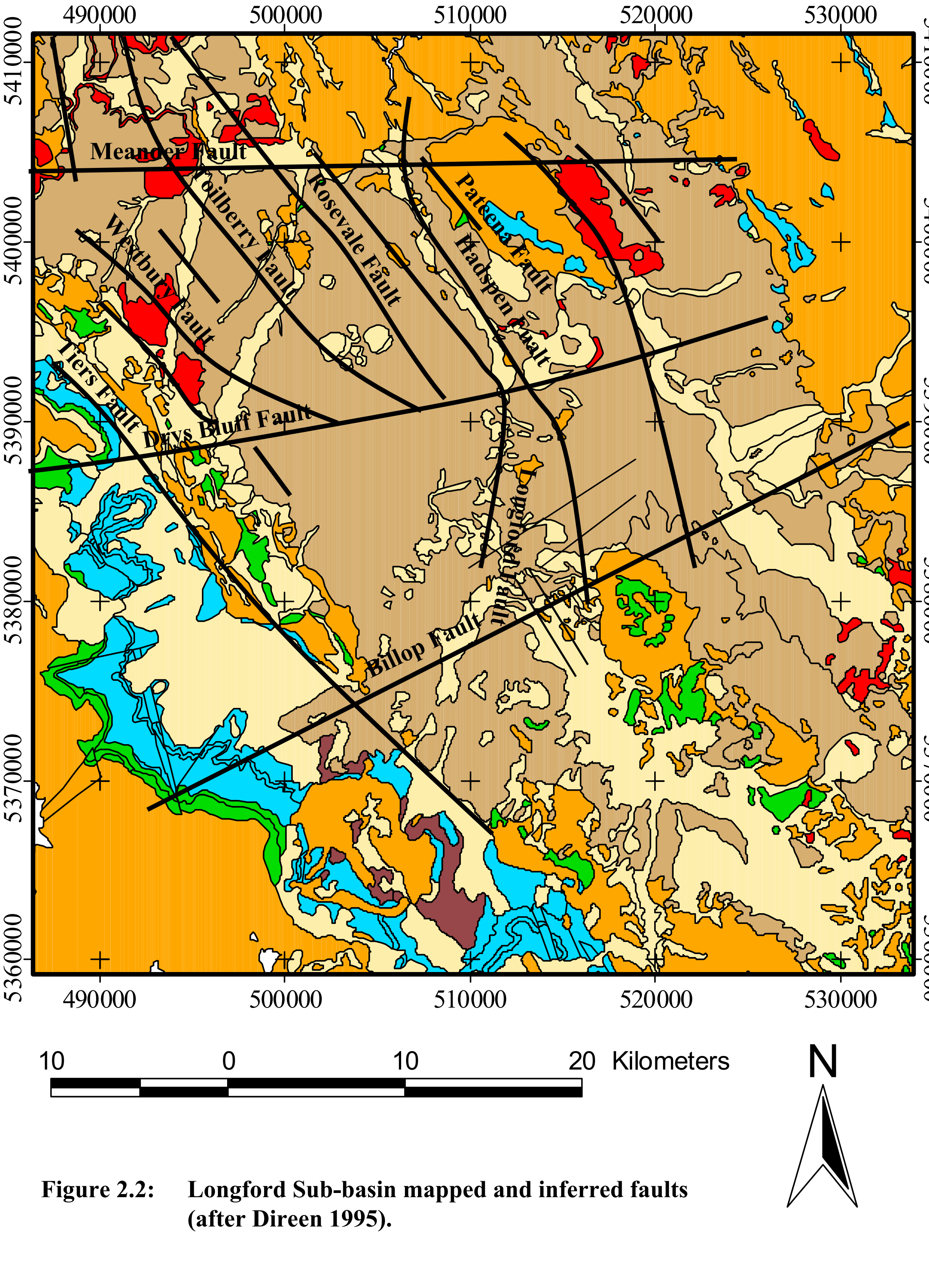

Figure 2.2: **Longford Sub-basin mapped and inferred faults (after Direen 1995).**