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Architecture and Evolution of the Kingoonya Palaeochannel System

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CONTENTS

PLATES

PREFACE

During July 2001 to December 2003, palaeochannel studies related to the Harris Greenstone Belt (HGB) Program in the Gawler Craton of South Australia investigated the geophysical and geological expression of palaeochannels and related mineralisation in both transported and residual regolith and its relationship with palaeodrainage landforms. The palaeochannel project was undertaken as one of four study modules of the HGB Program: Tectonic Synthesis, Landscape Evolution, Remote Sensing and Mineral Potential. These modules will assist exploration in the HGB and provide fundamental data for increasing knowledge of geological processes and landscape evolution within this important region. The HGB region was chosen because it has strong affinities with well known gold and nickel producing regions but has been under-explored because it is largely covered by regolith, including palaeochannels.

The principal objective of the HGB Program is to develop geoscientifically and technically efficient procedures for mineral exploration through a comprehensive understanding of the geological processes within the HGB. This requires comprehensive investigations of the basement, tectonic, sedimentary, transported and residual regolith development, and landscape evolution and their effects on the surface expression of concealed mineralisation. The numerous gold, base metal and uranium deposits and/or prospects in the area provide an excellent opportunity to examine, map and sample prospective units, and to investigate the mineral potential of a few areas of significant mineralisation currently outlined in the HGB region.

The investigations were based on palaeochannel research methods that have been successfully applied in the deeply weathered northwestern Gawler Craton, of which some knowledge was already available in the published literature. The research was highly successful with complex palaeochannel patterns being delineated using methods based on remote sensing, and geophysical, geological, computer-modelling, and sedimentological applications. The success of the palaeochannel research project has benefited from the cooperation of all research modules in the HGB program, and from a new impetus to extend similar research in other parts of the Gawler Craton (i.e., the Central Gawler Craton Gold Project commencing in 2004).

Baohong Hou (Palaeochannel Project)
Michael Schwarz (Program Leader)

January 2004

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Most figures and tables were drafted by the author and some figures (e.g., 3D geological sections) and images (e.g., topographic contours, DEM) were generated by the Publishing Services and Spatial Information Services Branches of PIRSA. *Lyn Broadbridge* (PIRSA) processed samples for palynology and PIMA II. *Steve Hore* (PIRSA) processed data and provided comments on gravity. *Alan Mauger* (CRC LEME, PIRSA) processed data and provided comments on remote sensing images and spectral geology. *Domenic Calandro* and *Andrew Shearer* (PIRSA) provided comments on most geophysical results. *David Gray* (CRC LEME, CSIRO) processed EVS/MVS 3D modellings and provided comments on palaeomorphology. *Andrew Burtt* (PIRSA) helped with GIS processing. *Liliana Stoian* (PIRSA) processed data and provided stratigraphic suggestions based on palynology. I greatly appreciate the many detailed discussions and valuable suggestions on various aspects of the study from *Neville Alley* (CRC LEME, PIRSA), *Marc Davies* (PIRSA), *Paul Rogers* (CRC LEME, PIRSA), *Martin Fairclough* (PIRSA), *Wenlong Zang* (PIRSA), *Sue Daly* (PIRSA), *Gary Ferris* (PIRSA), *Malcolm Sheard* (CRC LEME, PIRSA), *Mel Linten* (CRC LEME, CSIRO), *John Keeling* (CRC LEME, PIRSA), and *Lisa Worrall* (Geoscience Australia).

EXECUTIVE SUMMARY

Exploring in the Harris Greenstone Belt (HGB) region is complicated by a regolith cover produced by a long and complex history of landscape evolution. The present surface of the HGB indicates little of the complex palaeochannel architectures beneath. Drilling reveals Quaternary sediments concealing a complex pattern of Tertiary palaeochannels commonly incising and overlying weathered bedrock, with channel sediments ranging in thickness from a few meters to 144 m. Complex relationships between the Quaternary sediments, Tertiary channel fills, and older (e.g., Mesozoic) sediments and deeply weathered basement make palaeochannel identification difficult.

The Kingoonya Palaeochannel System (KPS) is one of several incised-valley systems that contain Tertiary marine-influenced fluvial sediments in the Gawler Craton of South Australia. Palaeochannel mapping and sampling with test drilling has indicated that the KPS drained across the HGB region from east to west; significant mineralisation (e.g., Tarcoola and Glenloth) and possible channel mineralisation (e.g. gold, uranium, groundwater) occur. The vast blankets of surficial cover have masked much of the geology of the region, including the history of palaeochannels. Older suites of rocks, in particular those more prone to weathering, such as regolith derived from various basement rocks, are similarly largely hidden.

The data sets integrated in an investigation of the palaeochannels have significance for mineral exploration. The principal objective of the study was the investigation of the palaeochannel architecture and evolution to assist exploration in these palaeodrainage terrains. This was achieved through the combination of results from several geological and geophysical methods. Comprehensive dimensional palaeodrainage landscape models were created based on interpretations from field exposures, a compendium of geological and drilling data, evaluated digital elevation models, remote sensing imagery, magnetics, seismic, gravity and airborne electromagnetics — all of which (where available) have contributed to a systematic investigation of the palaeochannel architecture in GIS. Detailed KPS mapping in the HGB region has provided a Cainozoic lithostratigraphic framework and has outlined the landscape evolution as an aid for mineral exploration. Delineation of the palaeochannels has been successfully demonstrated by test drilling targeting the poorly known, but key spots of the interpreted palaeochannels. The gold and uranium distributions derived from both this and previous works were used to predict the potential and make recommendations for further work. All results, together with the geological and dynamic nature of the palaeochannels, provide a framework for understanding the controls on mineralisation.

Evidence from sedimentology is combined with that of the architectural characteristics to arrive at a general reconstruction of palaeochannel evolution. The palaeochannels were originally incised into the pre-Middle Eocene landscape, mostly weathered basement, and became the sites where Tertiary fluvial, lacustrine and even estuarine sediments accumulated during the Middle to Late Eocene and Middle to Late Miocene. The application of detailed sequence stratigraphy and facies analysis over the palaeodrainage network has established the changes experienced in the palaeochannels as conditions, notably sea level and sediment supply, fluctuated.

Kingoonya Palaeochannel Project

Baohong Hou

1 INTRODUCTION

1.1 Preamble

The highly prospective HGB region in the central Gawler Craton is largely blanketed by its deeply weathered materials and the variable thickness of transported regolith, including palaeochannel fills (Fig. 1.1). It should be emphasised that, to a researcher armed with modern technology and the right geological knowledge or concepts, the cover of regolith can be found to have helpfully preserved any riches the region has to offer. The detailed investigation of palaeochannels in areas of primary mineralisation is important in the exploration for secondary deposits (e.g., gold, uranium). Knowledge of palaeochannel architecture and concentrations of minerals in the palaeochannel profiles are also of interest as guides to the location of both palaeochannel and bedrock lode deposits in the area. Therefore, the processes of palaeochannel formation can, to some extent, highlight or even disguise exploration targets and, when understood, can be applied to advantage in mineral exploration.

As the pervasive aeolian sand and clay cover and widespread regolith crusts in the present-day landscape surface hamper a thorough definition of any palaeochannels, their location and extent is typically poorly known in the study area (Plate 1.1). Their positions are roughly based on regional geological surveys that are supported by limited drillhole data. This is reflected in the variety of palaeochannel locations that have been proposed by various authors and exploration companies (e.g., Daly, 1985; Benbow et al., 1995a; Hou et al., 2001c). However, previously interpreted courses for the KPS do present numerous geological and geophysical inconsistencies relative to recent interpretation based on the GIS supported geological and geophysical data (Hou and Alley, 2003). The sedimentology of the channel fills in the KPS is also less well defined; there are considerable uncertainties due to the unknown character of much of the subsurface channel sediments. Even when guided by past experience, the accuracy of geophysical models (imagery) and the estimation of the parameters of stream dynamics from both field and borehole observations is sometimes problematic. As part of the HGB Program, this report examines both the architecture and evolution of the palaeochannels that once drained the weathered terrain of the HGB region.

1.2 Previous work

There is relatively little information available from systematic research or orientation studies undertaken on the architecture and evolution of the KPS. The limited number of company reports in the HGB region, such as Aberfoyle Pty Ltd and Afmeco Pty Ltd, Nissho Iwai Co. and PNC Exploration Pty Ltd (e.g., Freytag et al., 1983, 1984; Johnson et al., 1982), contain useful information related to Tertiary palaeochannels at several localities with uranium, gold and other minerals in several exploration leases during the period 1978–1980s. Based on field and drillhole observations, a chain of playas across the area was recognised as the present-day surface expression of the KPS (e.g., Daly, 1985; Cowley and Martin, 1991; Benbow et al., 1995a). In summary, it was noted that: i) there exist Tertiary palaeochannel

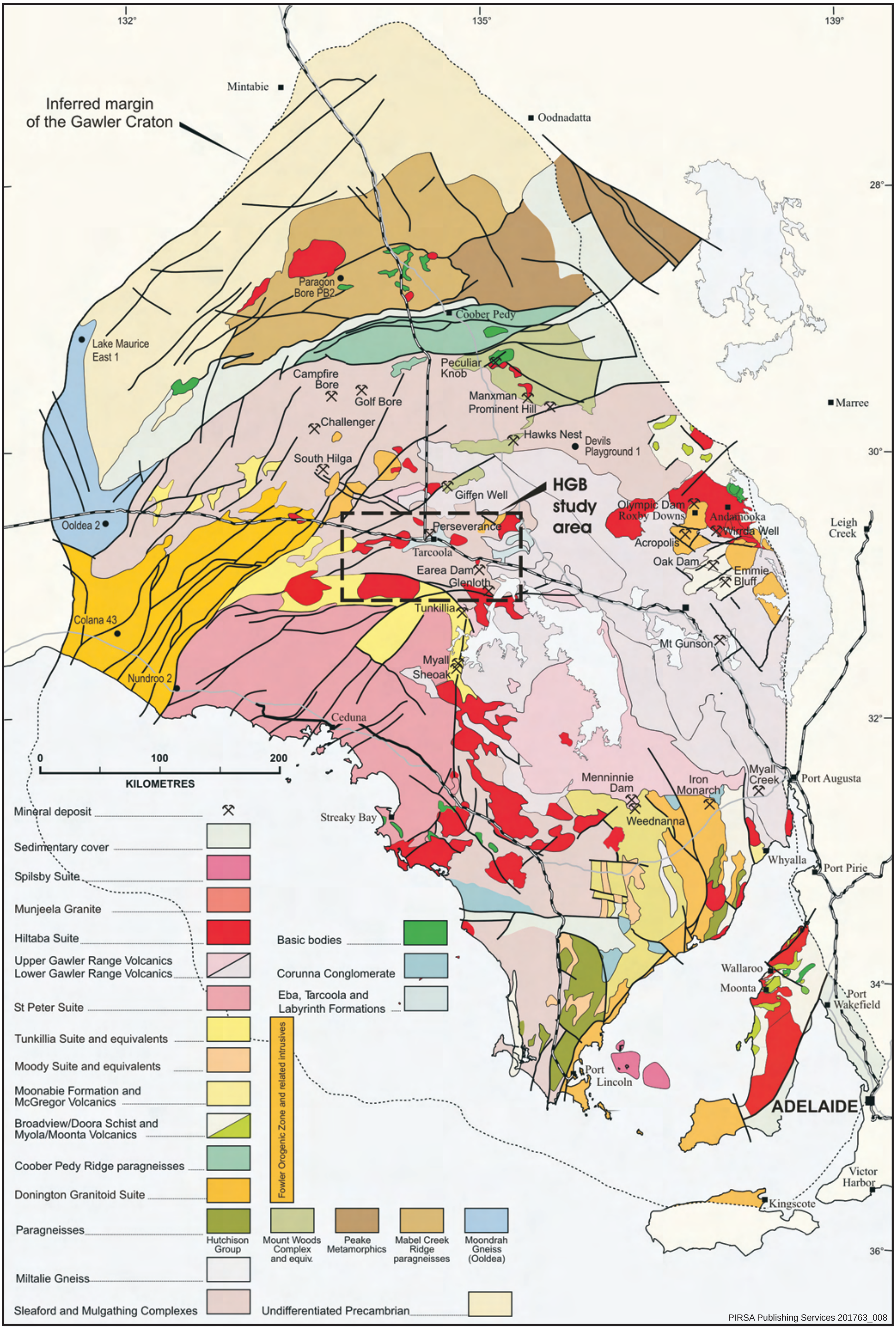

Figure 1.1 Interpreted subsurface geology of the Gawler Craton showing the location of the HGB study area and major mineral deposits (after Ferris et al., 2002).

Plate 1.1 Northerly view of the landscape above the buried Kingoonya Palaeochannel, ~5 km east of Tarcoola (PIRSA photo 049356)

sediments; ii) these channel sediments contain uranium and gold anomalies; iii) regional or local patterns of the palaeochannels are poorly known, iv) higher gold concentrations were intersected near the palaeosurface at the channel base, but no further investigations were undertaken; v) no appropriate palaeochannel mapping was undertaken. Vast databases derived from both Primary Industries and Resources South Australia (PIRSA) and companies will potentially be of enormous value once collated and then combined with other new data sets, such as palaeochannel maps, digital elevation models (DEMs), and remotely sensed and geophysical imagery. Recently, Hou et al. (2000; 2001a, b, c; 2003a) studied the palaeochannels which drained the NW Gawler Craton, including the KPS, using integrated geological and geophysical methods, but detailed work is required on the architecture and evolution of the KPS.

1.3 Objectives and scope of study

Parallel to this report, other parts of the HGB program (e.g., regolith landscape evolution, sedimentary history, tectonic synthesis, mineral potential) are presented in full in the HGB report. The principal objective of this study was to obtain a detailed understanding of the architecture and evolution of the palaeochannels and their relationship to potential mineralisation in the KPS. Also, special aims of the project include to:

- successfully delineate the palaeochannels in GIS by applying multi-techniques
- determine the (palaeo-) landscapes, structures and depositional environment of the KPS
- reconstruct the stratigraphy and sedimentology of the channel fills and its relationship to mineralisation
- compare the KPS with economic analogues
- devise models for locating possible mineralisation related to the palaeochannels.

1.4 Methodology

Evidence from existing geological maps and drillhole data is utilised together with new field studies in an effort to improve our knowledge of the dimensions, trends and continuity of palaeochannels. Topography (DEMs), Landsat, ASTER and NOAA images, magnetic, gravity, seismic and airborne electromagnetics (AEM) methods, where available, are integrated into this phase on the basis of GIS for an attempt to correlate the features observed from geological maps, field studies and drillhole data. The program MVS/EVS (Mining Visualization System upgraded from Environmental Visualization System) was used for 3D palaeochannel modelling. This interpreted result derived from the integrated data sets is tested and improved by the addition of several new drillholes that were logged for spectral geology using the PIMA II (portable infra-red mineral analyser) spectrometer.

Materials utilised during the project include samples gained during fieldwork and others taken from cores and cuttings stored in the PIRSA Core Library in Adelaide. These samples were examined for determination of sedimentary type and facies, environment of deposition, conditions of weathering, and some were subjected to petrological and palynological analysis. Nomenclature is based on the revised stratigraphy of the Tertiary palaeochannels in this region (Hou et al., 2001c; Clarke et al., 2003; Hou et al., 2003a), concepts of sequence stratigraphy (Posamentier et al., 1988; Van Wagoner et al., 1990) and genetic facies models developed for the marine-influenced fluvial deposits (e.g. Allen and Posamentier, 1993; Zaitlin et al., 1994; Hou et al., 2003b). Genetic facies and dynamic interpretations are based on the construction of 18 geological sections using cores and cuttings from >100 drillholes through the channel fills, logged in detail using QikDraw software in GIS (see Figs 4.5–19).

2 GENERAL SETTING

The KPS is located in the goldfield of the central Gawler Craton, once drained approximately from Kingoonya to the western Eucla Basin through Tarcoola (Fig. 2.1). It is one of several incised-valley systems (Tallaringa, Garford, Anthony, Kingoonya and Narlaby) that are the site of some exploration and development for sediment hosted, channel mineralisation (Hou et al., 2001c). To date, anomalies of placer gold, heavy minerals, uranium, coal, palygorskite and significant groundwater have been found at several localities in these palaeodrainage systems (Hou et al., 2001c; 2003c). In particular, secondary gold and uranium anomalies have been discovered in some drillholes within the KPS (Hou and Alley, 2003). The existence of palaeochannel mineral occurrences and their lode deposits/prospects nearby in the KPS is therefore a realistic possibility.

2.1 Stratigraphy

The HGB region comprises a diverse association of units (Table 2.1, App. 1) and the regional geology and history are complex but reasonably well known (Fig. 1.1). The basement rocks are mainly composed of Archaean to Palaeoproterozic Mulgathing Complex and Mesoproterozoic igneous rocks — Hiltaba Suite Granite and Gawler Range Volcanics (GRV; Daly et al., 1979; Daly, 1986; Fanning et al., 1988; Daly and Fanning, 1993). The Mulgathing Complex [Alm], forming an older basement, includes gneiss formed during the Sleafordian Orogeny from sediments (including iron formation) and from felsic to mafic igneous rocks. The Challenger (~130 km northwest of Tarcoola) and Glenloth gold deposits as well as numerous other prospects, are contained within these rocks. Komatiites, volcanic rocks very rich in magnesium and unique to the Archaean, are also present in the HGB region (Fig. 2.2; see reports of parallel projects of the HGB Program). Other Palaeoproterozoic sedimentary and volcanic successions in the HGB region include the Tarcoola [Ltt], Labyrinth [L-b] and Eba [L-e] Formations, Symons Granite [Lls], and the Wilgena Hill Jaspilite [L$_{-i}$] which contains the historically important Tarcoola and Labyrinth gold mines and prospects. Tarcoola Formation and related units form a minor sedimentary component, and the unit [Lls] encompasses miscellaneous metamorphic and intrusive rocks.

Overlying the rocks described above are flat-lying to gently folded Mesoproterozoic continental clastic sediments, comprising the Mentor Formation [Mcm], and thick, extensive, felsic volcanic sheets of the GRV [Ma] (Davies, 2002a, b). Hiltaba Suite granite is associated with the giant copper–gold–uranium deposit at Olympic Dam, the Tarcoola Goldfield and a number of recently discovered gold prospects south of the HGB region (Ferris and Schwarz, 2003). Recent drilling in the HGB region has identified Mesoproterozoic Hiltaba Suite Granite and GRV, which are considered to be broadly contemporaneous with the sediments of the Tarcoola and Labyrinth Formations, though poorly exposed at the surface (Davies, 2002a, b). The youngest phase of igneous activity in the HGB region is represented by the Neoproterozoic Gairdner Dyke Swarm [N-g]; following this until today, the HGB region has only been subjected to relatively minor warping and faulting (Daly and Fanning, 1993).

Cover overlying regolith of the weathered basement ranges widely in age: Palaeozoic (e.g., the Arckaringa Basin, Mulgathing Trough); Mesozoic sediments; and Tertiary palaeochannel deposits (e.g., KPS). The distribution of each is poorly known. Early subsiding areas on the north and northwest parts of the HGB region developed locally during Carboniferous to Permian and accumulated marine and non-marine sediments [CP-b, CP-s]. However, the geological landscape of the region is dominantly one of widespread Mesozoic and Cainozoic surficial sediments blanketing a ‘basement’ consisting of rocks of Archaean to Proterozoic age. An extensive subsiding part of the HGB region developed during the Jurassic to Cretaceous and contains flat-lying continental sediments known as the Algebuckina Sandstone [JK-a], Cadna-owie Formation – Algebuckina Sandstone [JK-1] and Bulldog Shale [Kmb]. Following the Mesozoic sedimentation, a major subsidence, incision and deposition across the HGB region termed the KPS developed during the Tertiary, comprising zonal fluvial-estuarine sediments known as the Pidinga Formation [Tbp], Garford Formation [Tig] and related alteration [Tmp]. The Quaternary is characterised by marked climatic and

Table 2.1 Generalised stratigraphy of the HGB region (after HGB Program database)

Map symbol	Age	Stratigraphy	Description
Qha–Qhe4	Holocene		Undifferentiated alluvial and/or fluvial and downwash sediments (Qha); gypsiferous dunes and/or lunettes – playa sediments (Qhe4).
Ql1–Qel–Qe3	Pleistocene–Holocene		Playa sediments (Ql1); dunefield sands, aeolian, off-white and pale yellow, quartz-rich with carbonate pipes (Qe1); gypsiferous dunes and/or lunettes (Qe3).
Qpa	Pleistocene		Undifferentiated alluvial and/or fluvial sediments, ironstone–gravel spreads, calcrete.
TQ	Quaternary and/or Tertiary		Undifferentiated weathered soil, sands, calcrete, silcrete and gravels.
Tig Tigk	Middle Miocene – Early Pliocene	Garford Formation Kingoonya Member	Alluvial–lacustrine mudstone and carbonate with minor sand (Tig); estuarine–fluvial carbonaceous sand, mudstone and lignite (Tigk); palaeochannel fill.
Tbk	Late Eocene	Khasta Formation	Estuarine very fine – medium-grained sand.
Tbp	Eocene	Pidinga Formation	Carbonaceous sands, silts, lignite, estuarine–fluvial, palaeochannel fill.
Tmp1	Miocene–Pliocene		Ferruginous pebbly grit, conglomerate, fine to medium-grained sandstone, pebbly sandstone, silcreted.
Tep2	Eocene–Pliocene		Sandy clay, sand, gypsiferous and/or carbonaceous clay and sand; probably includes Pidinga and Garford Formations.
Tae2	Paleocene–Eocene		Sandstone, fine grained to pebbly silcreted. Based on Tp-e on KINGOONYA.
Kmb	Cretaceous	Bulldog Shale (Marree Subgroup)	Mudstone, grey, bioturbated, fossiliferous and shaly; minor silt to very fine-grained sandstone intervals.
JK1	Jurassic–Cretaceous	Cadna-owie Formation – Algebuckina Sandstone	Coarse sand and grit, ferruginous sandstone. Cadna-owie Formation and/or Algebuckina Sandstone as on ANDAMOOKA.
JK-a	Jurassic–Cretaceous	Algebuckina Sandstone	Sandstone, fine to coarse grained, with granule and pebble layers and shale intraclasts.
CP-s	Carboniferous–Permian	Stuart Range Formation	Grey to black carbonaceous mudstone, occasional siltstone and rare sandstone, rarely pyretic. Possibly non-marine conformably overlying Boorthanna Formation.
CP-b	Carboniferous–Permian	Boorthanna Formation	Claystone and silty claystone; sandstone and siltstone, pebbly, dolomitic, silty, pebbles, cobbles and rare boulders. Marine in the Arckaringa Basin, non marine in the Mulgathing Trough.
N-g	Neoproterozoic	Gairdner Dyke Swarm (827 Ma)	Dolerite, basalt, gabbro; subsurface only.
M-p	Mesoproterozoic	Pandurra Formation (?1440 Ma)	Alluvial, fluvial to aeolian sandstone; subsurface only.
Ma	Mesoproterozoic	Gawler Range Volcanics (1590 Ma)	Porphyritic rhyolite and rhyodacite dykes and plugs. Intrudes May.
Mae	Mesoproterozoic	Ealbara Rhyolite (GRV)	Rhyolite–rhyodacite ignimbrite; minor dacite, rhyolite, rhyodacite lava, tuffaceous chert, tuff, agglomerate.
Mi	Mesoproterozoic	Chitanilga Volcanic Complex (GRV)	Basalt lava flows, local amygdaloidal; fine-grained rhyodacite, andesite, rhyodacite–rhyolite, complex banding.
Mah	Mesoproterozoic	Chandabooka Dacite (GRV)	Dacite, porphyritic; minor rhyodacite.
Mak	Mesoproterozoic	Konkaby Basalt (GRV)	Andesite–basalt; dacite, vesicular, agglomeratic, tuffaceous.
Mal	Mesoproterozoic	Lake Gairdner Rhyolite(GRV)	Rhyolite–rhyodacite lavas, welded tuff, breccia.
Mai	Mesoproterozoic	Wiltabbie Volcanics(GRV)	Rhyolite; dacite; andesite–basalt; basalt; dolerite; lamprophyric basalt; dykes.
Mah1	Mesoproterozoic	Chandabooka Dacite (GRV)	Tuff, banded, green-grey at base. Based on dotted unit at the base of Prot-an on GAIRDNER.

Map symbol	Age	Stratigraphy	Description
Mh	Mesoproterozoic	Hiltaba Suite, 1590 Ma	Granite–adamellite, anomalous metals in veins. Age 1578±7 Ma (Tarcoola/Kingoonya), 1581±16 Ma (Hiltaba).Intrudes Ltt, Ma.
Mcm	Mesoproterozoic	Mentor Formation	Sandstone; siltstone (lithic, cherty); basalt; rhyolite.
L-u	Palaeoproterozoic	?Muckanippie Anorthosite (?1630 Ma)	Gabbro, dolerite and metabasic plugs and dykes, sheared margins.
Ltt	Palaeoproterozoic	Tarcoola Formation (~1657 Ma)	Metamorphic sediments.
Lttf	Palaeoproterozoic	Fabian Quartzite Member (Tarcoola Formation)	Quartzite, well sorted, laminated to thin bedded, with clay pellets, ripple marks and mudcracks, with micritic dolomite and stromatolites; interbedded with well sorted quartzite.
Lttp	Palaeoproterozoic	Peela Conglomerate Member (Tarcoola Formation)	Conglomerate, arkosic quartzite; green lithic sandstone; with pebbles of Wilgena Hill Jaspilite at the base; alluvial fan deposits near faults.
Ltts	Palaeoproterozoic	Sullivan Shale Member (Tarcoola Formation)	Quartzite; interbedded with laminated carbonaceous and pyritic siltstone and shale. Age 1656±7 Ma.
Ltw	Palaeoproterozoic	Ward Volcanics (1657 Ma, Tarcoola Formation)	Rhyodacitic–basaltic tuffs and volcaniclastics, local amygdaloidal. Age 1656±7 Ma. Interbedded with Sullivan Shale Member and Fabian Quartzite Member.
Lls	Palaeoproterozoic	Symons Granite (~1690 Ma)	Gneissic granite; granodiorite; adamellite. Veins of pegmatite and aplite (1701±30 Ma, Rb–Sr).
L-b	Palaeoproterozoic	Labyrinth Formation (1723 Ma)	Stromatolitic–brecciated–mottled chert, foliated rhyolite, sericitic sandstone, polymict conglomerate.
L-e	Palaeoproterozoic	Eba Formation	Silicified conglomeratic quartzite, siltstone, shale, amygdaloidal basalt? (Mt. Eba).
L-i	Palaeoproterozoic	Wilgena Hill Jaspilite (>1740 Ma)	Jaspilite, BIF.
ALm	Archaean–Palaeoproterozoic	Mulgathing Complex	Granite; tonalite; gneiss; gabbro; basalt; pyroxenite; peridotite; komatiite; metasediments; felsic volcanics.
ALmc	Archaean–Palaeoproterozoic	Christie Gneiss (Mulgathing Complex)	Migmatitic paragneiss, carbonate, calcsilicate, quartzite. Age (U–Pb) 2437±11 Ma.
ALmk	Archaean–Palaeoproterozoic	Kenella Gneiss (Mulgathing Complex)	Migmatitic granite and ?volcanics, local pegmatitic, with paragneiss bands. Mainly at Earea Dam. Age 2420 Ma on monozite.
ALmg	Archaean–Palaeoproterozoic	Glenloth Granite (Mulgathing Complex)	Granodiorite, adamellite, trondhjemite, syenogranite, pink-brown to grey, quartz, microcline and plagioclase. With remnants of gneiss and biotite and hornblende schlieren. Age 2460 Ma, 2499 Ma.
Almh	Archaean	Hopeful Hill Basalt (Mulgathing Complex)	Meta-tholeiitic basalt, medium to fine grained, with plagioclase, horneblende and diopside; local pillow lavas.
ALms	Archaean	South Lake Gabbro (Mulgathing Complex)	Metagabbro, with plagioclase and pyroxene, minor quartz and hornblende from metamorphism.
ALml	Archaean	Lake Harris Komatiite (Mulgathing Complex)	Metakomatiite, bright green, illite–tremolite–chlorite–serpentine, olivine; some sediments and pyroclastics bands.
?Almy	Archaean	Kychering Formation (Mulgathing Complex)	Metasediments: siltstone, sandstone, BIF, carbonate and felsic volcanics. Metamorphically transitional to the Christie Gneiss.
?Almym	Archaean	Mullina Volcanics Member (Mulgathing Complex)	Metavolcanics or volcanic sediments, dacite, andesite rhyodacite and rhyolite. Age ~2522 Ma.
my	Miscellaneous		Mylonitised rocks, undifferentiated.
qz	Miscellaneous		Quartz veins and/or bodies, pegmatite, undifferentiated.

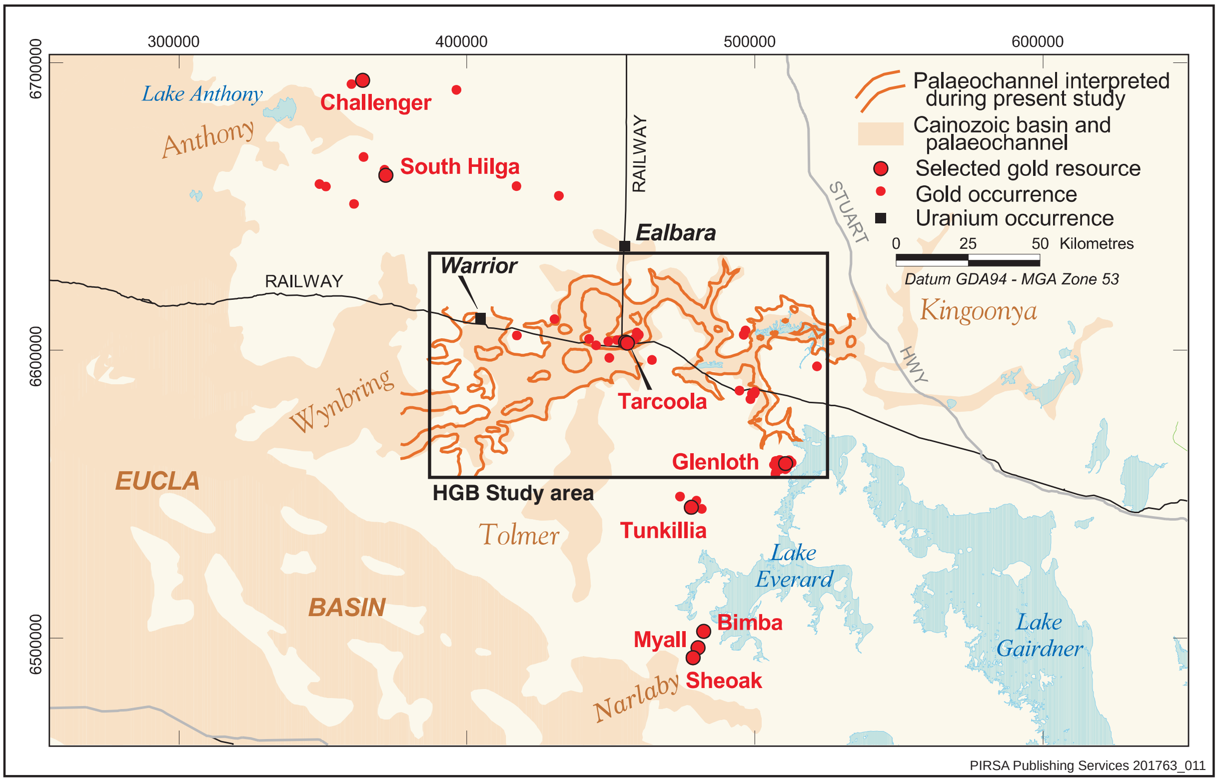

Figure 2.1 Cainozoic geological plan of the HGB region showing the location of the mineral deposits and/or prospects and the 'palaeodrainages' investigated in this study (after Hou and Alley, 2003).

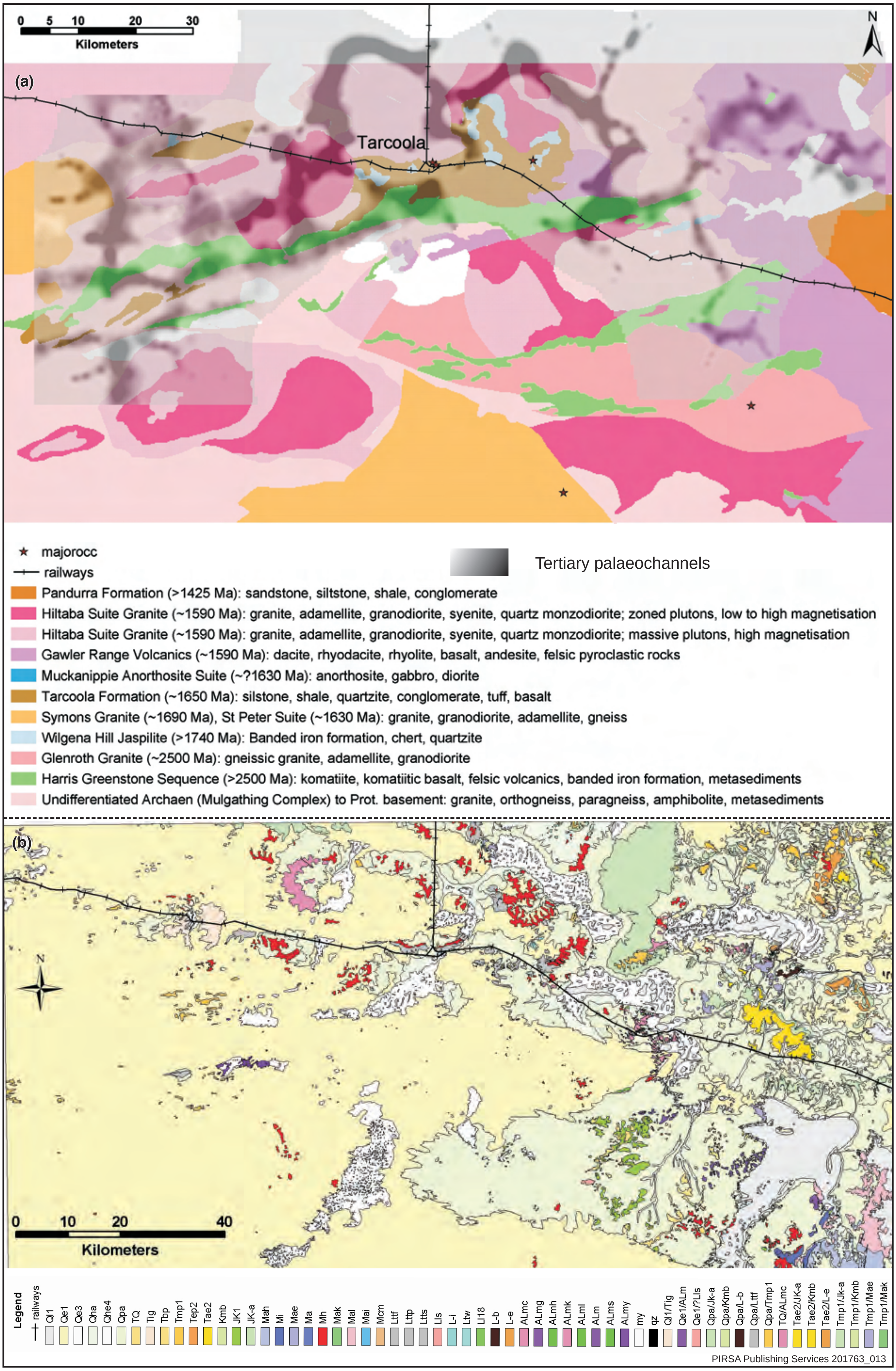

Figure 2.2 (a) Interpreted basement geology of the HGB region, partly covered by the palaeochannels (HGB Program data set). (b) Surficial geology (see Table 2.1 for the legend).

fluvial oscillations, impacting on many landscape features. In the west, the top of Tertiary channels was overlain by Pleistocene fluvial sediments preserved by alluvial plain sand [Qpa]. In the east, evaporative playa [Ql] and cold arid phases (Qe] alternated with periods of moister climate, increased stream discharge and greatly extended lake systems (when extensive alluvia, lacustrine and aeolian sediments [Qhe and Qha] were deposited). Periods of weathering have formed hard carbonate soil profiles (calcrete).

2.2 Basement of central Gawler Craton

The Gawler Craton is an ancient crystalline shield comprising Archaean to Mesoproterozoic metasediments, volcanics and granites, which have been tectonically stable, with the exception of minor epeirogenic movements since ~1450 Ma (e.g., Parker, 1993; Fig. 1.1). The craton records crust formation and tectonothermal events in: the late Archaean to early Palaeoproterozoic (Sleaford Orogeny, 2700–2300 Ma, sedimentation and volcanism followed by early Palaeoproterozoic plutonism and metamorphism); Palaeoproterozoic (Kimban Orogeny, 2000–1700 Ma, initial basin/platform sedimentation followed by widespread plutonism, metamorphism and deformation with local volcanism and continental sedimentation); and Palaeoproterozoic to Mesoproterozoic (Kararan Orogeny, 1650–1450 Ma, development of spatially separated granulite and amphibolite facies rocks in the northern and western portion of the craton; e.g., Fanning et al., 1988; Daly et al., 1998; Ferris et al., 2002). One of numerous domains of the Gawler Craton (Fig. 2.3), the Harris Greenstone Domain (formerly part of the Wilgena Domain) has an overall E–W elongate geological trend with an overall rectilinear complex of faults (Fig. 2.2), and comprises: supercrustal Archaean ultramafic (komatiite) and mafic volcanics; and Archaean aluminous metasediments (Christie Gneiss), felsic extrusives and/or intrusives (Kenella Gneiss) and syn-tectonic acid intrusives (Glenloth Granite; Daly and Fanning, 1993). Petrological investigations have identified a general metamorphic grade of low to mid-amphibolite facies for the greenstone rock types (Davies, 2002a, b).

2.3 Sedimentary cover

The known sedimentary cover of the central Gawler Craton comprises Carboniferous to Permian Boorthanna and Stuart Range Formations, Jurassic to Cretaceous Algebuckina Sandstone and Bulldog Shale, Tertiary palaeochannel fills and Quaternary sediments (Table 2.1). Although supporting evidence is scarce (e.g. Daly, 1985; drilling data from various company reports), it is possible that Middle to Late Palaeozoic incised valleys (e.g., Mulgathing Trough) may have been cut into the basement (e.g., Daly, 1985). The Boorthanna and Stuart Range Formations (mainly occurring in the southern margin of Arckaringa Basin — NE TARCOOLA and north KINGOONYA, e.g., drillholes Konkaby 2, 3 and 4, Esso DP-1; Rogers, 2004) and Mulgathing Trough (west TARCOOLA) unconformably overlie unweathered Precambrian units and are overlain unconformably by Algebuckina Sandstone or younger sedimentary units. The Algebuckina Sandstone (consisting mainly of cross-bedded, kaolinitic, fluviatile, gravely sandstone) and the Bulldog Shale (characterised by bleached white to pale grey, massive and thin-bedded, silty mudstone) are remnants of the Eromanga Basin preserved in the northern and eastern parts of the region (Daly, 1985; Cowley and Martin, 1991). Episodic deposition of marine-influenced fluvial sediments began in the Tertiary to infill the sites of palaeorivers and adjacent depressions carved into much older sedimentary rocks and basement of the interfluves (Benbow et al., 1995a, b; Hou et al., 2001c, 2003a). The roughly mapped palaeodrainage features in the region (Rogers, 2000; Hou et al., 2000, 2001c) are now present in the form of a subtle, branching depression largely obliterated by the Quaternary aeolian sands (Plate 1.2).

2.4 Landform and physiography

Most of the area consists of broad, flat sand plains with drainage into local salt lakes and clay pans interspersed with occasional low rocky hills and granite tors (Plate 1.2). The KPS passes through the area from the east to the west; roughly tracing a series of saline playa lakes which display gypsiferous dunes on the leeside of the lake. Basement hills (e.g. Wallabyng Range, Hopeful Hill) represent high relief along the northern and southern

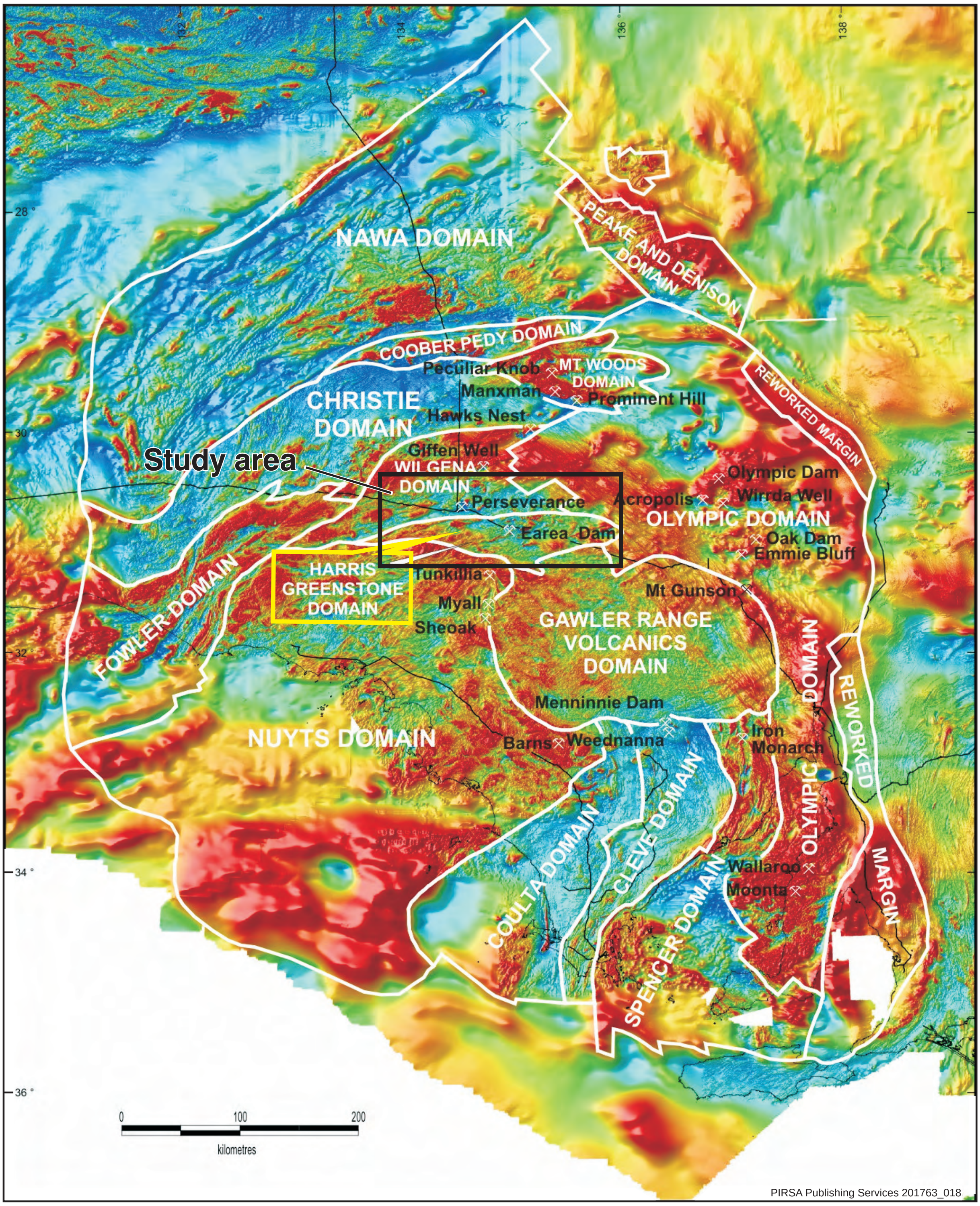

Figure 2.3 Domains of the Gawler Craton on TEM (after Ferris et al., 2002).

margins of the KPS, or within the KPS as basement highs, rising over tens of meters above the surrounding plain. Climatic conditions in the HGB region are characterised by generally warm to hot, arid conditions. Annual rainfall rarely exceeds 200 mm. Long, hot, dry summers are characteristic of the region, which is classed semi-arid. No permanent drainage or waterholes exist in the HGB region. Weathering of the basement in the HGB region is up to 50 m deep based on drillhole data; when fresh granite is encountered it is of the Hiltaba Suite.

2.5 Mineralisation

The location of major and minor deposits and prospects within the HGB region are shown in Figure 1.1, as sourced from MINDEP, the mineral deposits database part of SA_GEODATA, the primary geoscientific database of PIRSA. Most exploration in the HGB region has been for gold. The region includes two small goldfields; Tarcoola and Glenloth with Eared Dam and Lake Labyrinth Goldfields lying near the KPS (Fig. 1.1). Exploration of these goldfields has been continuous for decades; though mining activity has largely ceased with the most recent production restricted to sporadic removal of parcels of ore by small prospectors. Mineralisation at these sites is of Archaean to Middle Proterozoic age. The sites are all linked in terms of the apparent genetic origin of the deposits, which has been attributed to emplacement of granites of the Glenloth or Hiltaba Suite during a period of major continent building and a regional coincidence of fluids with high metal-bearing capacity, shallow heat sources and repeated rock deformation (Davies, 2002a, b).

Drilling of a uranium in-channel anomaly by exploration companies during the period 1978–1980s identified gold anomalies at or near the base of the channel and uranium anomalies within channels (Freytag et al., 1983, 1984; Johnson et al., 1982), and identified the Warrior uranium prospect in the region (Fig. 2.1; Johnson 1982). Despite the long history of geological investigation in the HGB region, there is still considerable ambiguity concerning the geological controls on mineralisation, and it is difficult to directly compare these mineralisations with surface exposures and geophysical signatures. A small patch of outcropping ferruginous and silicified metabasic rock that carried significant nickel values was discovered by Kennecott Exploration (Australia) Pty Ltd at Lake Harris in 1969, and komatiite has been identified in places in the HGB region (e.g., Daly and Vanderstelt, 1992; Hopeful Hill by Mount Isa, 1996). Recognition of greenstone rock types in the HGB region and the well-known correlation between greenstone rocks and gold-deposits in Archaean belts worldwide (Fig. 2.2) has led to a new focus. Because it comprises komatiite (including flows and pyroclastics), basalt and some metasediments over a strike length of 2–300 km and with a minimum thickness of 300 m, the HGB is a virgin exploration target with significant potential for nickel and gold mineralisation (Davies, 2002a, b).

3 ARCHITECTURE OF PALAEOCHANNELS

3.1 Specialised mapping (GIS)

Palaeochannel mapping describes the distribution and 3D nature of channel fills. This can be achieved even though the surface expression of the palaeochannels is completely obscured by the regolith cover in places. Therefore, palaeochannel mapping plays an important role in any comprehensive exploration program, but particularly where palaeodrainage is well developed. In terms of understanding a palaeochannel area, some of the most commonly missing information pertains to poor understanding of channel behaviour and of lateral and vertical lithofacies changes in channel-fill profiles. Eventually, models of channel behaviour and lithofacies changes in the channel-fill should be tied to appropriate scale palaeochannel maps, to allow 3D mapping if possible. GIS and relative systems will have an important role to play in this.

The information from this work is included in the HGB Program data CD, to be released by CRC LEME – PIRSA, and will be of value in exploration of the central Gawler Craton. This GIS database will provide a multitude of compiled data sets all in the one package.

3.2 Topography

Generally, DEMs are very effective in the recognition of potential palaeochannel areas, as the lower topographic zones can reflect areas where some of the softer channel fills have been eroded away. Therefore, DEMs can be used as surrogates for mapping the palaeochannels and related features when the modern and Tertiary geomorphologies are related spatially and genetically (Hou et al., 2003a); although the DEMs do not directly show the distribution of Tertiary channels and landforms, they more typically and indirectly show associations where modern and the ancient relief attributes are linked. The present day topographic lows, roughly corresponding to the Tertiary palaeochannels and related depressions, are characterised by a string of claypans and salinas, while the topographic highs that locally correspond to the basement high interfluves, are characterised by a series of irregular ranges or alternatively, dunes (Fig. 3.1a). This scenario is supported by interpretations of remote sensing and geophysical images, and is confirmed by drillhole data (Fig. 3.1b). With increasing resolution of images, the details interpreted from the images, such as recognition of low-order tributaries, are likely to increase (Hou et al., 2003a).

3.3 Remotely sensed imagery

3.3.1 LANDSAT TM

Although the use of Landsat TM for geological mapping is well known (e.g., Drury, 1993; Drury and Hunt, 1989), how it is used to help identify palaeochannels is generally less widely understood (Hou et al., 2001c, 2003a). The radiance measured by the Landsat sensor is a measure of the integration of soil, rock and vegetation characteristics. The processed Landsat TM image, therefore, shows a high degree of correspondence to a surficial regolith-landform and allows spectrally homogeneous units to be equated with terrain units. As the effective depth penetration of this method is near zero, Landsat TM is effectively an aerial photograph of the landform using spectral ranges including and beyond the visible wavelengths. Therefore, it is useful in defining spectrally anomalous zones or regions when appropriately draped over DEM to enhance terrain visualisations. Geological features are enhanced using the ratios of Landsat TM bands that are useful for separating and identifying different materials on the images, and the image is displayed as a three-band composite image with clay in red, iron oxides in green and silica in blue (Fig. 3.2). The effectiveness of the data can be attributed to the spectral resolution of the Landsat TM data, particularly the ability to detect features related to the adsorption of irone oxides (band 4) and the absorption of clay and carbonate minerals in band 7. Palaeochannels are visible on Landsat TM images as branching features made lighter than the surroundings by the presence of carbonate, gypsiferous clays and strings of playa lakes, which highlight the main remnants of the palaeochannels.

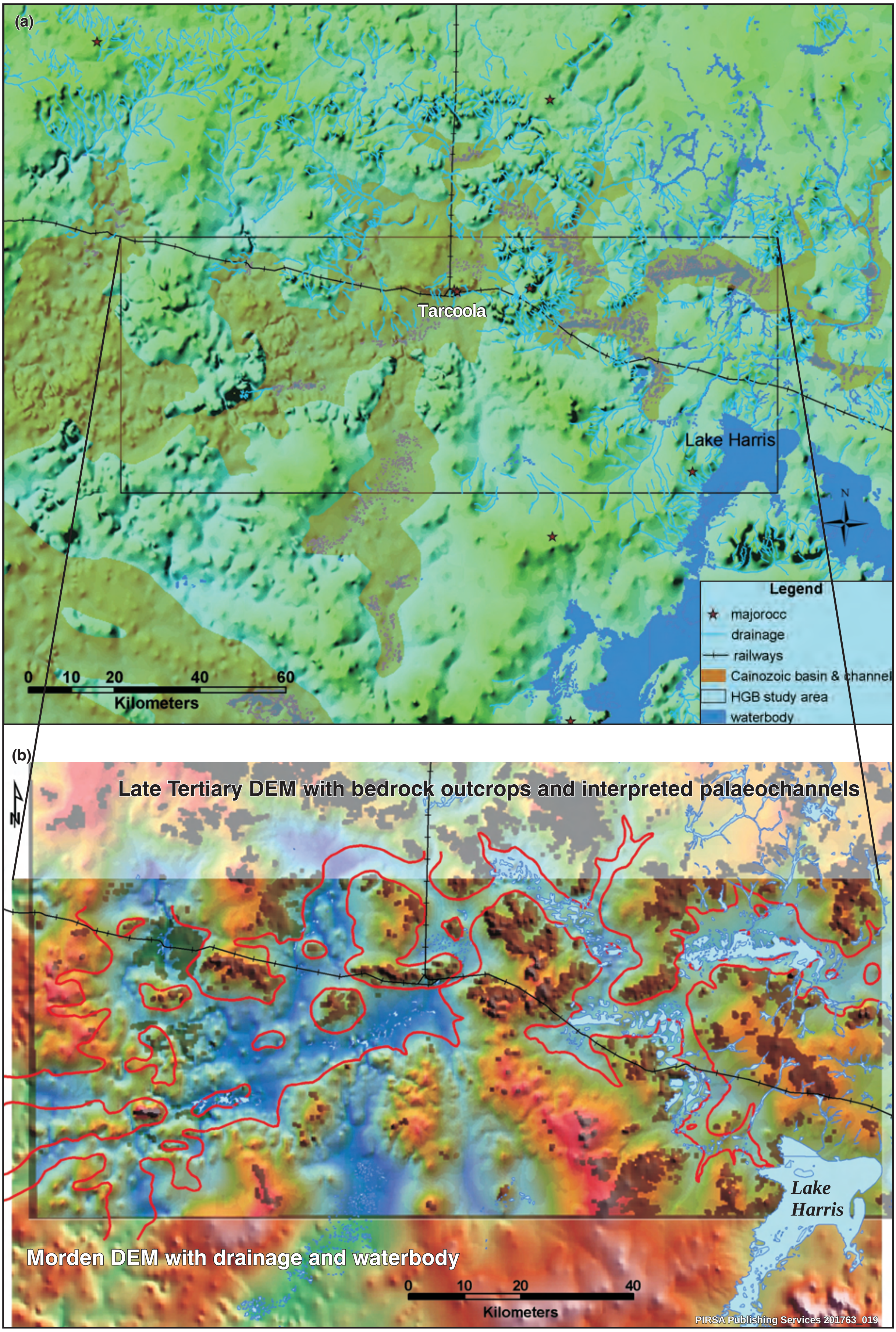

Figure 3.1 DEM images: (a) regional relief (250 pixels); (b) HGB region (150 pixels) with interpreted palaeochannels and late Tertiary landscape.

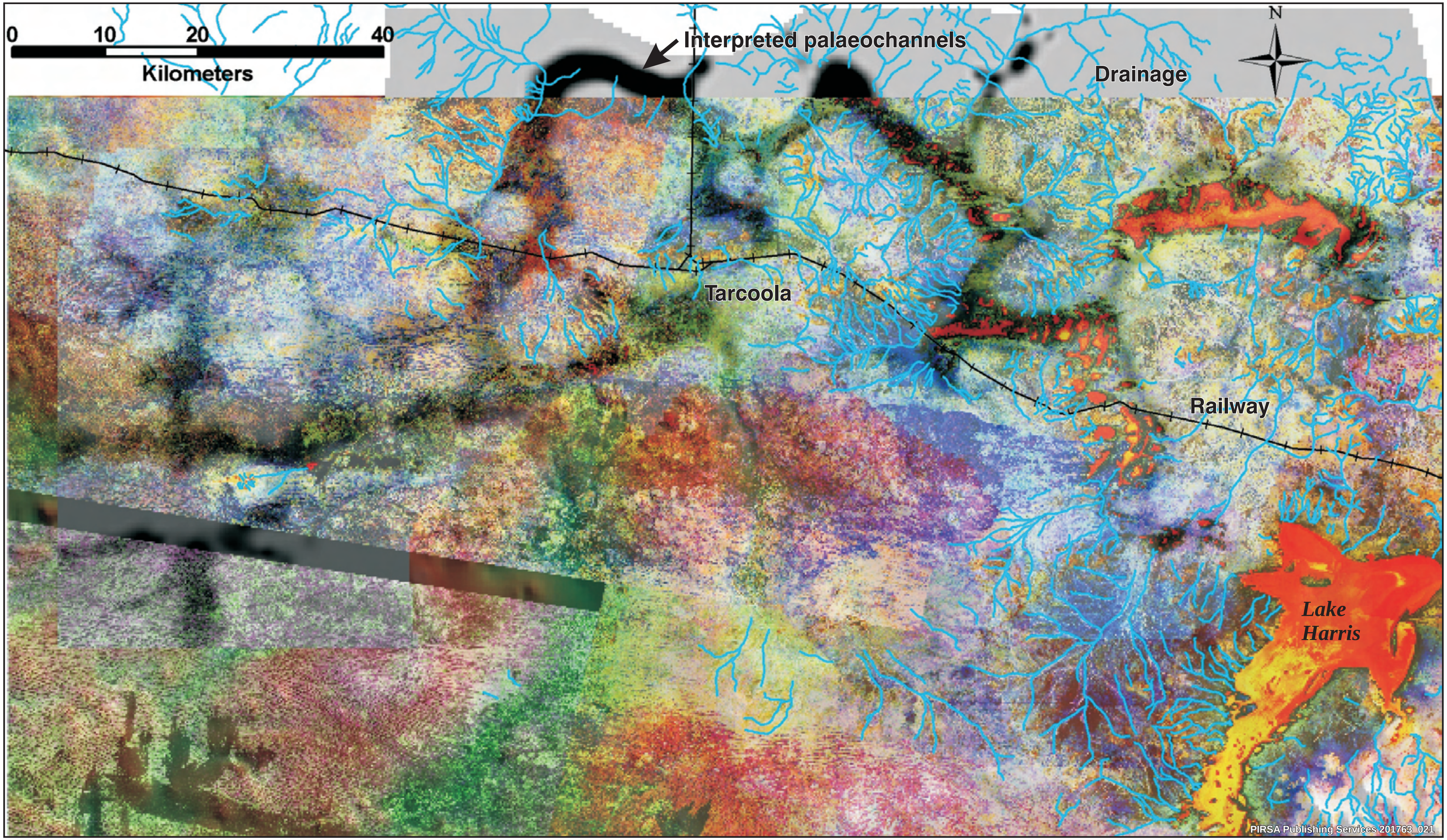

Figure 3.2 Landsat TM image of the HGB region superimposed on DEM and palaeochannels interpreted from integrated data sets.

3.3.2 ASTER DATA

ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) is an advanced multispectral imager covering a wide spectral region from the visible near infrared (VNIR) to the thermal infrared (TIR) of the electromagnetic spectrum. To evaluate the potential of these data as an aid to palaeochannel delineation, scenes were selected over the HGB (Fig. 3.3). Compared to the Landsat imagery (7 bands), ASTER data contains more spectral bands (14 bands) and can distinguish most surficial features related to the palaeochannels, such as clay, dolomitic carbonate, calcrete, gypsiferous soils and playa lakes from surrounding different lithologies, through enhancement by the spectral selectivity of the imagery. With more bands and higher resolution than Landsat TM imagery, the spectral imagery derived from ASTER data can provide reasonably acceptable information for delineating the major components of the palaeodrainage and tributary systems. An important aspect of ASTER data has been the availability of the thermal bands. The emissivity signatures of materials contained in the palaeochannels such as sand, carbonate and salty water are buried in the temperature signal but materials can be empirically discriminated through use of ratios and D-stretch (V Stamoulis, PIRSA, pers. comm., 2003). Due to the lengthy time required for the data processing, however, this process has not been yet completed.

3.3.3 NOAA–AVHRR

NOAA–AVHRR data is a useful remote-sensing method in that it detects temperature variations in palaeochannel sediments caused by higher moisture content. NOAA–AVHRR technique has been applied previously to the identification of palaeodrainage in a number of other regions in Western and South Australia (e.g., Tapley and Wilson, 1985; Tapley, 1988; Statham-Lee, 1995; Hou et al., 2000, 2001c). The radiant temperature recorded by NOAA–AVHRR is the product of the kinetic temperature and emissivity of a material, which is a measure of its ability to absorb and reradiate thermal energy (Kahle, 1980). The amount of surface radiant temperature detected is related to night-time cooling mechanisms, amount of insolation and the thermal properties of the material (Short and Stuart, 1982), which allow for the maximum thermal contrast between surface sediments and underlying materials (Statham-Lee, 1995). Some processing is necessary to improve the clarity and detail of the individual palaeochannels, with dark tones in the image representing cool areas and brighter tones indicating warmer regions (Fig. 3.4a). The positions of palaeodrainage were delineated from the dark tone anomalies when draped over DEM and Landsat images (3.4b), and by referring to geological and drillhole data. Although the 1.1 km resolution of the NOAA–AVHRR satellite means only trunk valleys and major tributaries are visible within the image, it is still possible to map some smaller tributaries as upstream extensions of the modern drainage or depression.

3.4 Geophysical signatures

3.4.1 TOTAL MAGNETIC INTENSITY

Generally, the palaeochannel will display a magnetic signature resulting from either concentration or a lack of magnetic particles in the palaeochannel relative to that in the surrounding bedrock terrains (e.g., Mackey, et al., 2000; Hou et al., 2001c). Basaltic flows concentrated in the palaeochannels also can lead to contrasts (e.g., Mackey, et al., 2000). In most cases, however, direct lithological interpretation from total magnetic intensity (TMI) is not possible without additional information. Figure 3.5 shows the regional TMI with palaeochannels interpreted from integration of the HGB data set. Many geological entities such as faults and intrusions can be easily identified (Fig. 2.2) whilst the probably more subtle effects of regolith and/or sedimentary cover need to be distinguished by using specialised enhancements (Milligan and Gunn, 1997). The magnetic images of the HGB suggest Precambrian metasediment and volcanic zones surrounded by granitic rocks, but the palaeochannel magnetic anomalies are poorly understood, probably due to the deeper sources showing stronger and broader anomalies.

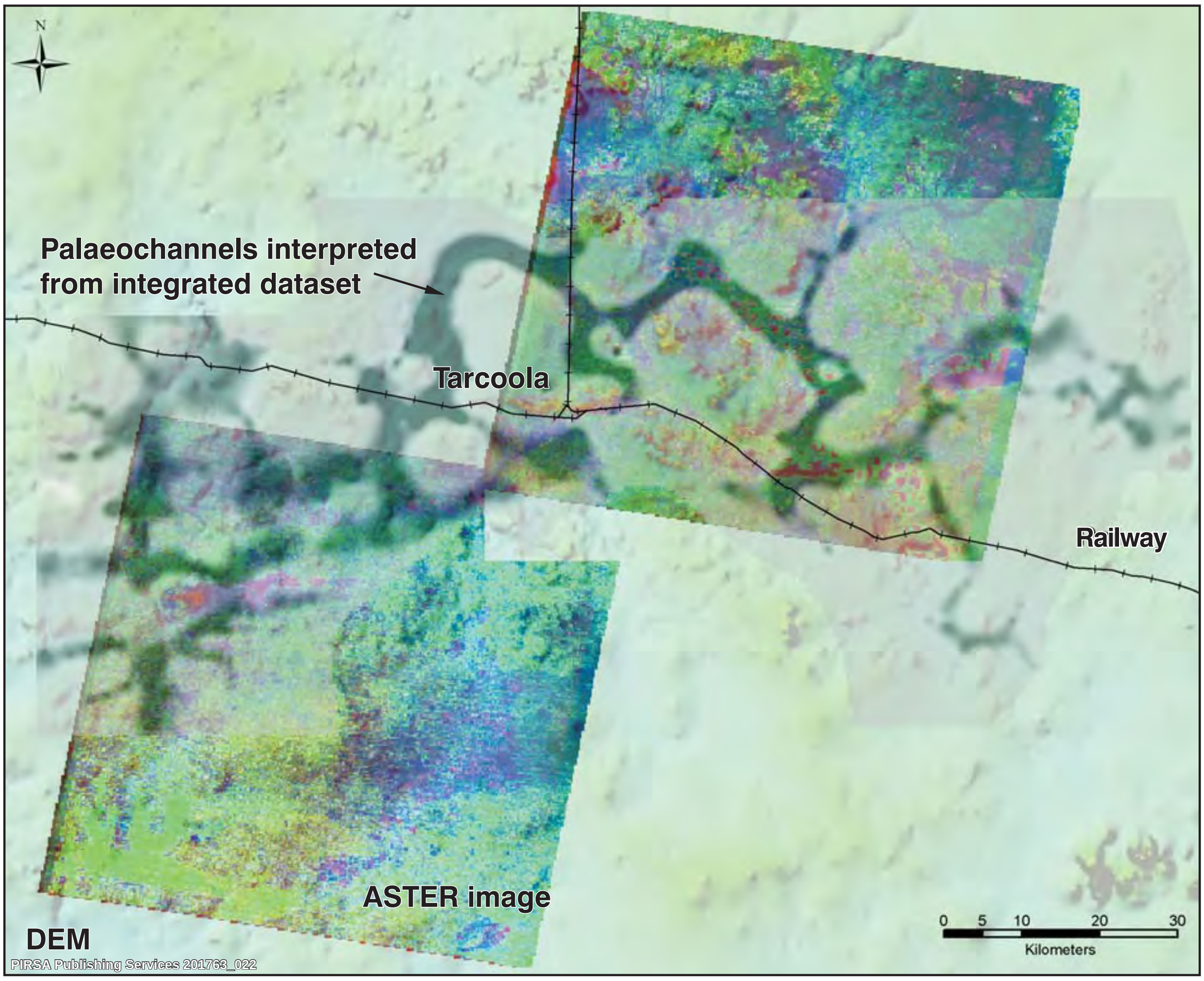

Figure 3.3 ASTER images superimposed on DEM and palaeochannels interpreted from integrated data sets.

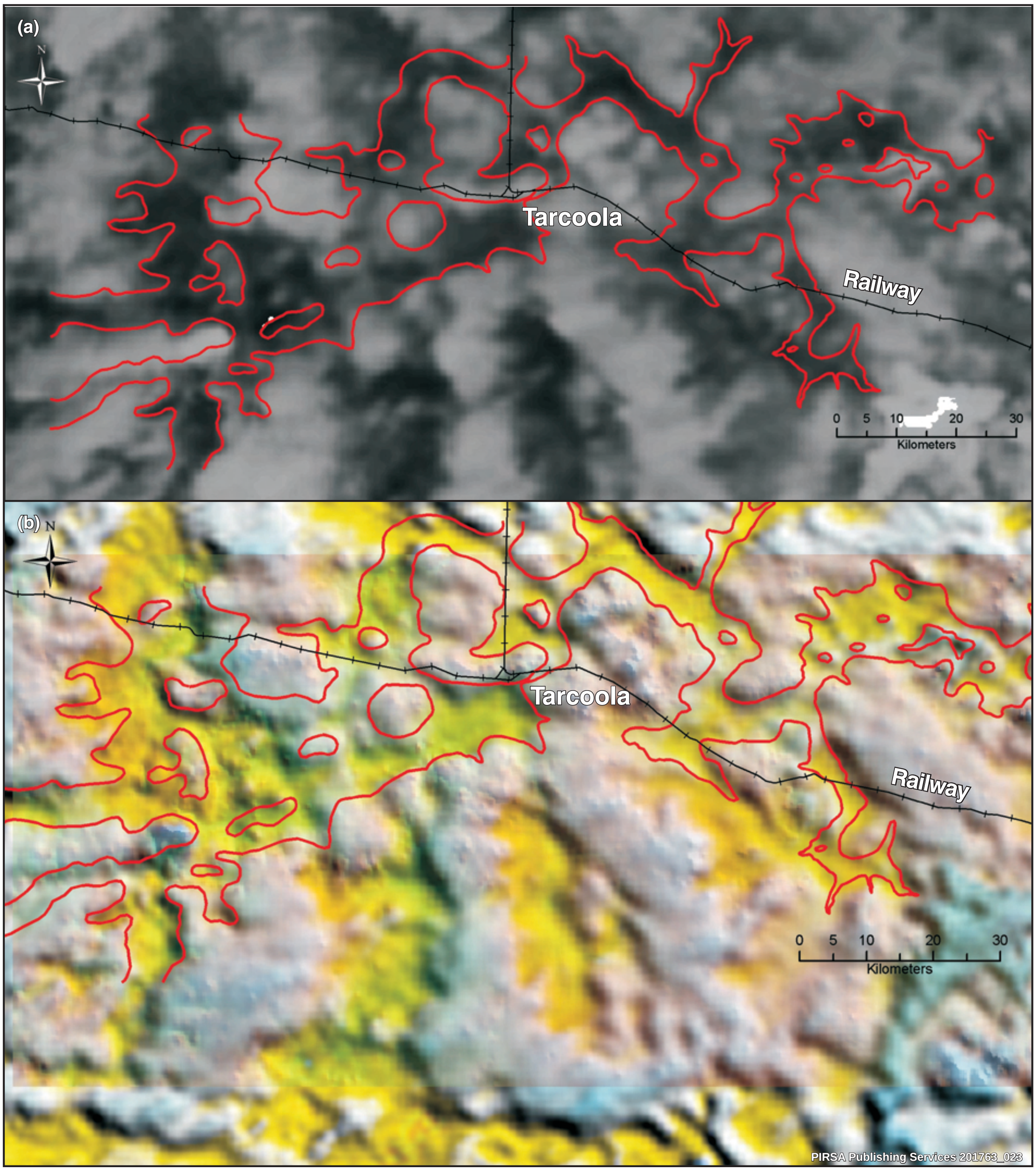

Figure 3.4 NOAA–AVHRR image of the HGB region: (a) showing the main features of the palaeodrainage systems; (b) superimposed on DEM and palaeochannels.

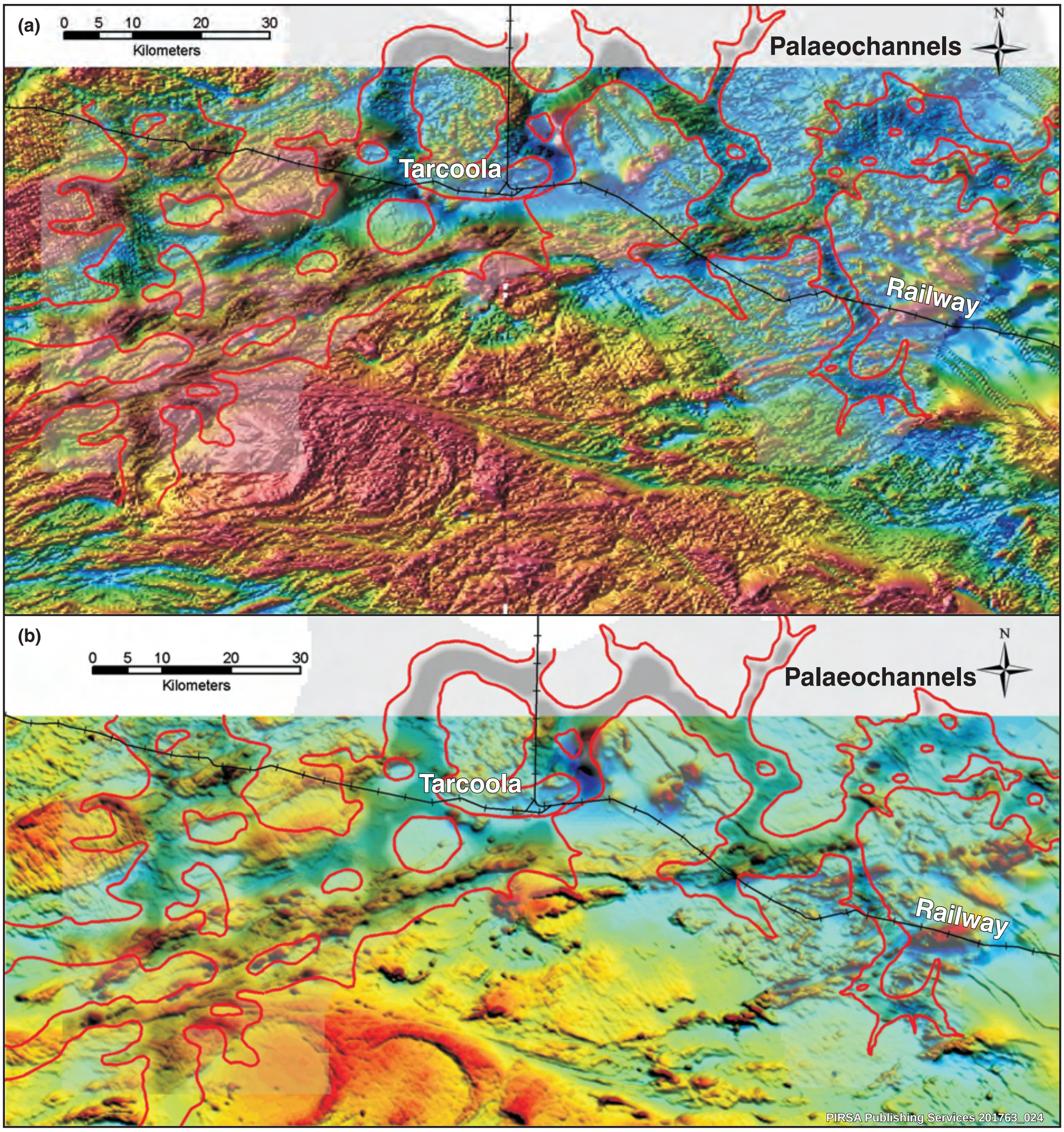

Figure 3.5 TMI images of the HGB region; red indicates high and blue indicates low magnetic susceptibility: (a) with palaeochannels interpreted from integrated datasets, (b) with regolith.

3.4.2 GRAVITY

The fundamental principle governing the use of gravity as an exploration tool for palaeochannels is that a density significant contrast exists of such proportions that it can be detected, so as to enable the differentiation of the channel fills from the underlying and surrounding materials. The area of interest consists of granitic basement overlain by up to 120 m of palaeochannel sediments. For geophysical purposes the channel fill (sand and clay) is assumed to have a density of 1.8g/cc and the granitic basement 2.7 g/cc (Berkman, 1995).

The gravity data of the HGB show that the pattern of regional Bouguer gravity lows and highs in the area has little to do with the trend of palaeochannels (Fig. 3.6). However, eight selected Bouguer gravity lines (2 and 4 km line spacing, 1 km station spacing) can be processed to define the main portions of the palaeochannels (Fig. 3.7a-h). The gravity data in these diagrams have not had the regional field removed and have not been modelled, but even so the shapes of pronounced gravity lows over the palaeochannels locally conform to the irregularities of the channel forms, indicating that lower gravity signatures tend to correlate with channel thickness. Using information from NOAA imagery and drillholes along or nearby the traverses, an estimate of the regional gravitational trend was obtained. A comparison of the gravity trends with other information (e.g., DEM, NOAA, drillholes) in the area shows that the results reflect basement topographic changes, which are largely coincident with palaeochannel patterns in these places.

3.4.3 AEM

As the conductivity of the rocks is dependent on their porosity, moisture content and the conductivity of the groundwater within them, the AEM method will give a very strong response due to highly saline brines in the porous channel sediments whereas the fresh bedrock will contribute very low signal strengths. Recent results from high-resolution airborne geophysical datasets (magnetic, AEM, and DEM) have helped to delineate the more detailed tributary features of the KPS in the area of Lake Harris (Fig. 3.8a), which vary in intensity of conductive signature, width, depth and orientation of parts of the tributary (Fig. 3.8b). A roughly N–S-trending channel on the images shows conductive (channel) features appearing to be at depths equal to those of the tributary in the area and with similar intensity of response. As it has become evident that there is generally little or no conductive contrast between the deeply weathered basement and the Tertiary and Quaternary sediments, the palaeochannels cannot be precisely differentiated with AEM from the older regolith (Fig. 3.8b). The recent test drilling suggests that modern and underlying Tertiary sediments in the channel zones exhibit similar high conductivities (see below).

3.4.4 SEISMIC

Seismic reflection and refraction imaging are widely used for investigating the subsurface structure, particularly in sedimentary terrains, and are therefore useful for delineating palaeochannels. Seismic reflection surveys can be used to define the geometry of interfaces in the regolith and the underlying basement. Seismic refraction surveys are useful to detect variations in the composition of the regolith or the underlying basement because refraction profiling provides a robust image of variations in the seismic wave velocities (Drummond, 2002).

In the results derived from a seismic refraction survey conducted by Afmeco (Freytag et al., 1983; Figs 3.9–10), the thickness of lacustrine or fluvial sediments and the top of the basement are determined, thus showing the velocity at which seismic energy travels in the channel and basement rocks. Each type of fill material has a specific sound propagation velocity, so in general, low velocities are associated with the topsoil layer; medium velocities with the sand and/or gravel layer; and high velocities indicate bedrock. Referring to the drillhole information, velocities near 5 km/s or higher indicate basement rocks in the region, and a sharp drop in velocities between 2 and 5 km/s corresponds to Eocene channels incising the weathered basement. The steady velocity drop to the shallow zones (<1.8 km/s) correlates with the younger channel sediments unconformably overlying the Eocene

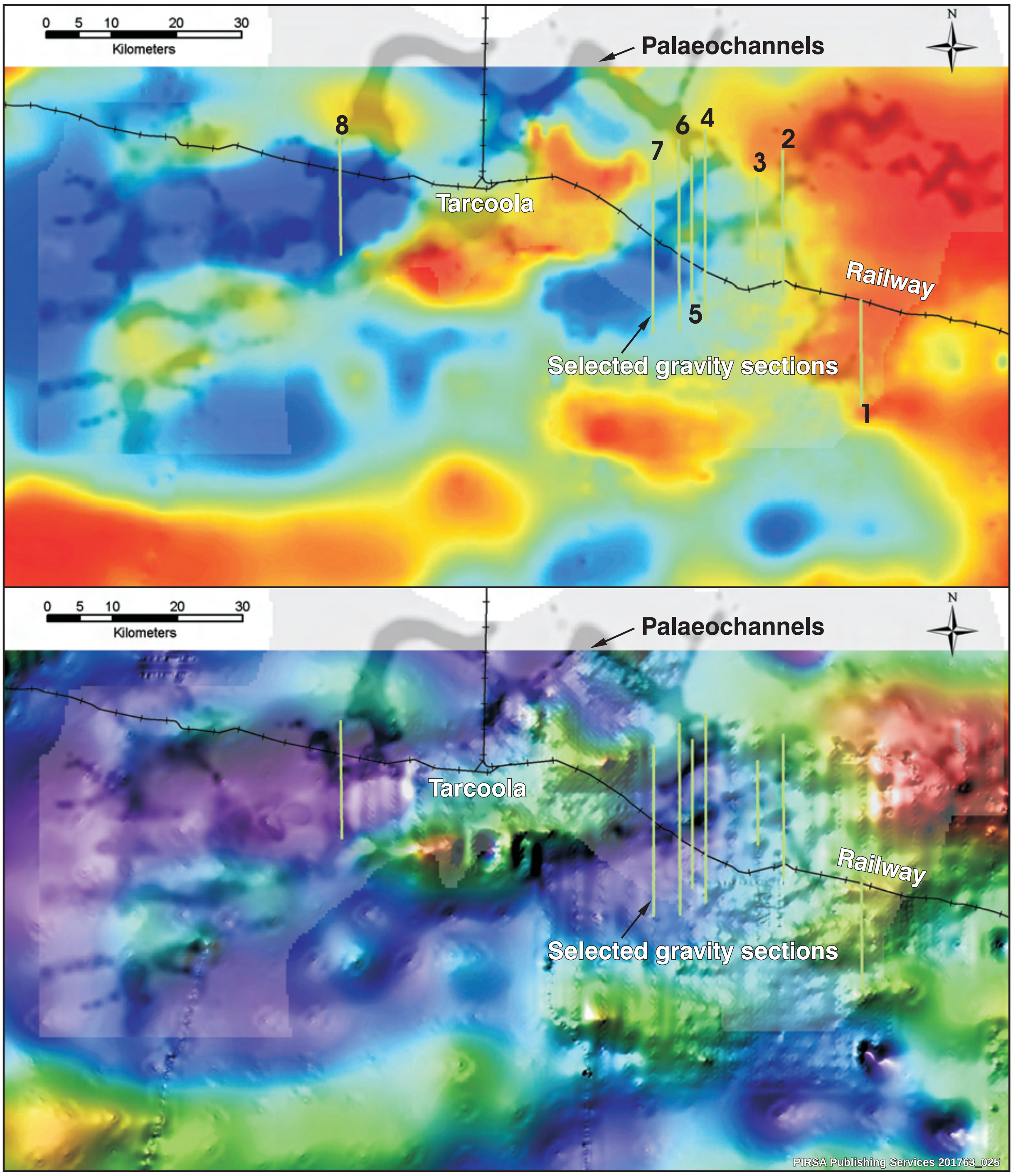

Figure 3.6 Gravity imagery of the HGB region, showing selected gravity sections and comparison of interpreted palaeochannels.

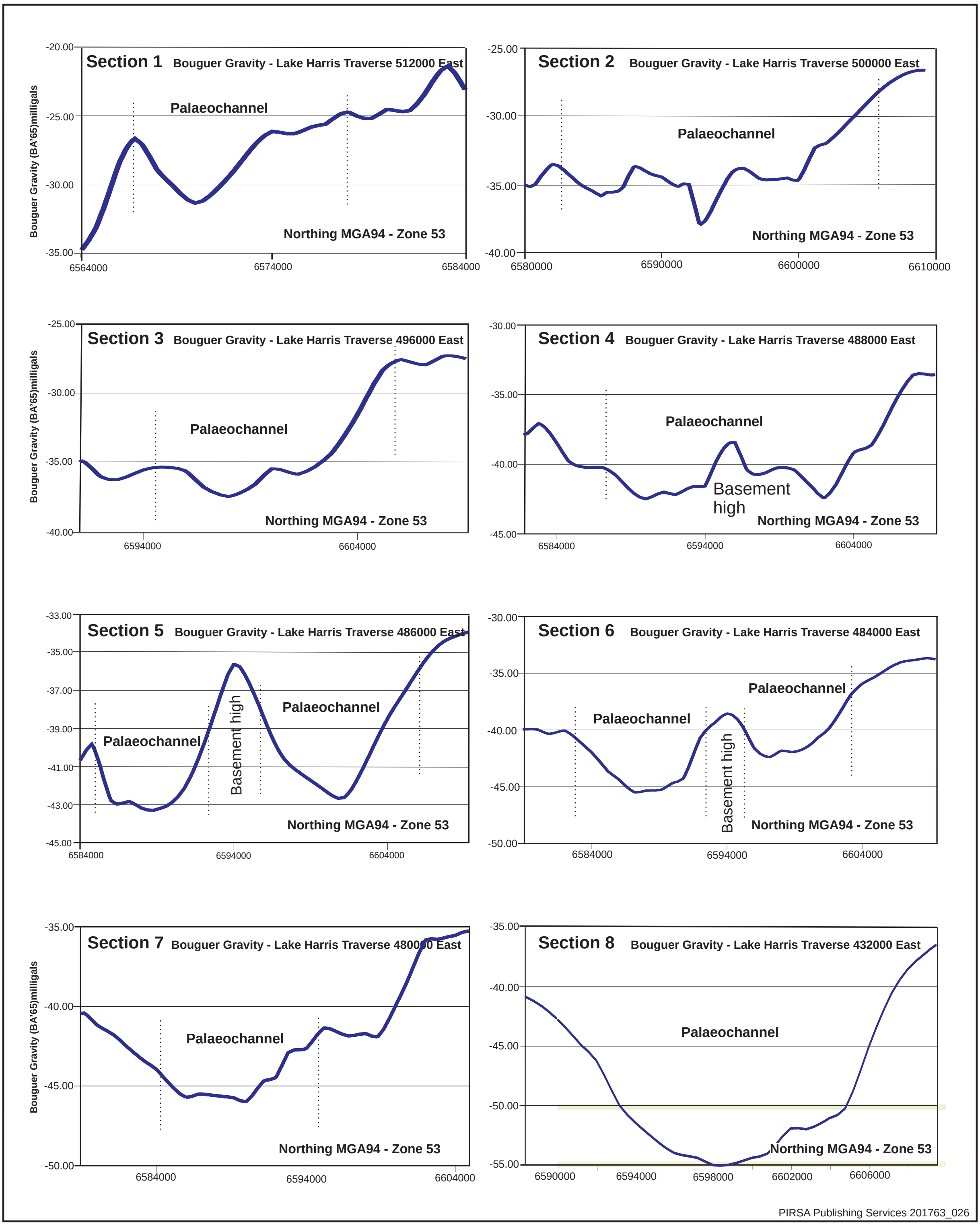

Figure 3.7 Gravity sections across the Kingoonya Palaeochannel (see Fig. 3.6 for locations).

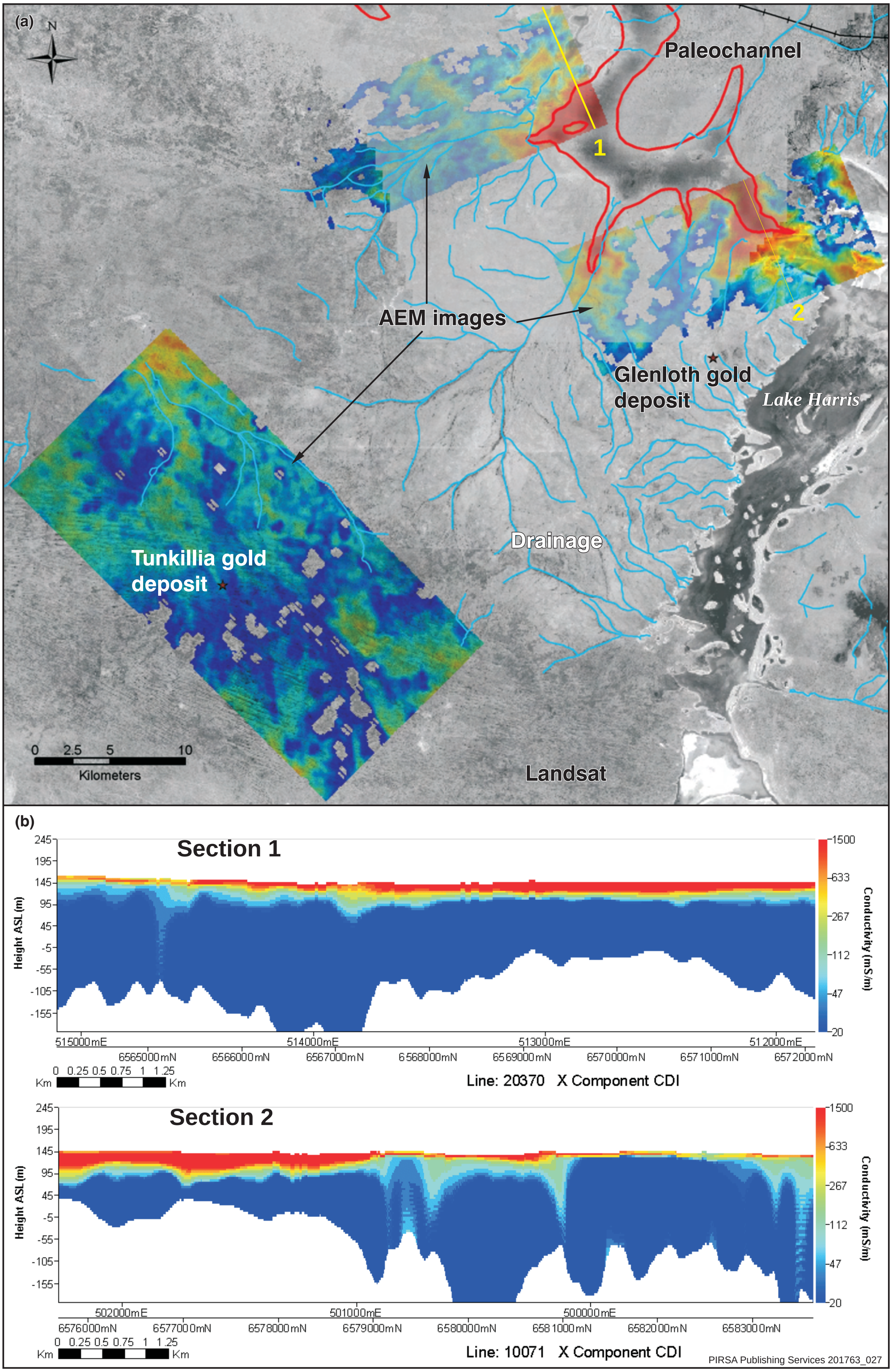

Figure 3.8 AEM images of the Lake Harris area: (a) palaeochannel interpretation of AEM; (b) selected conductivity sections (see Fig. 3.8a for locations).

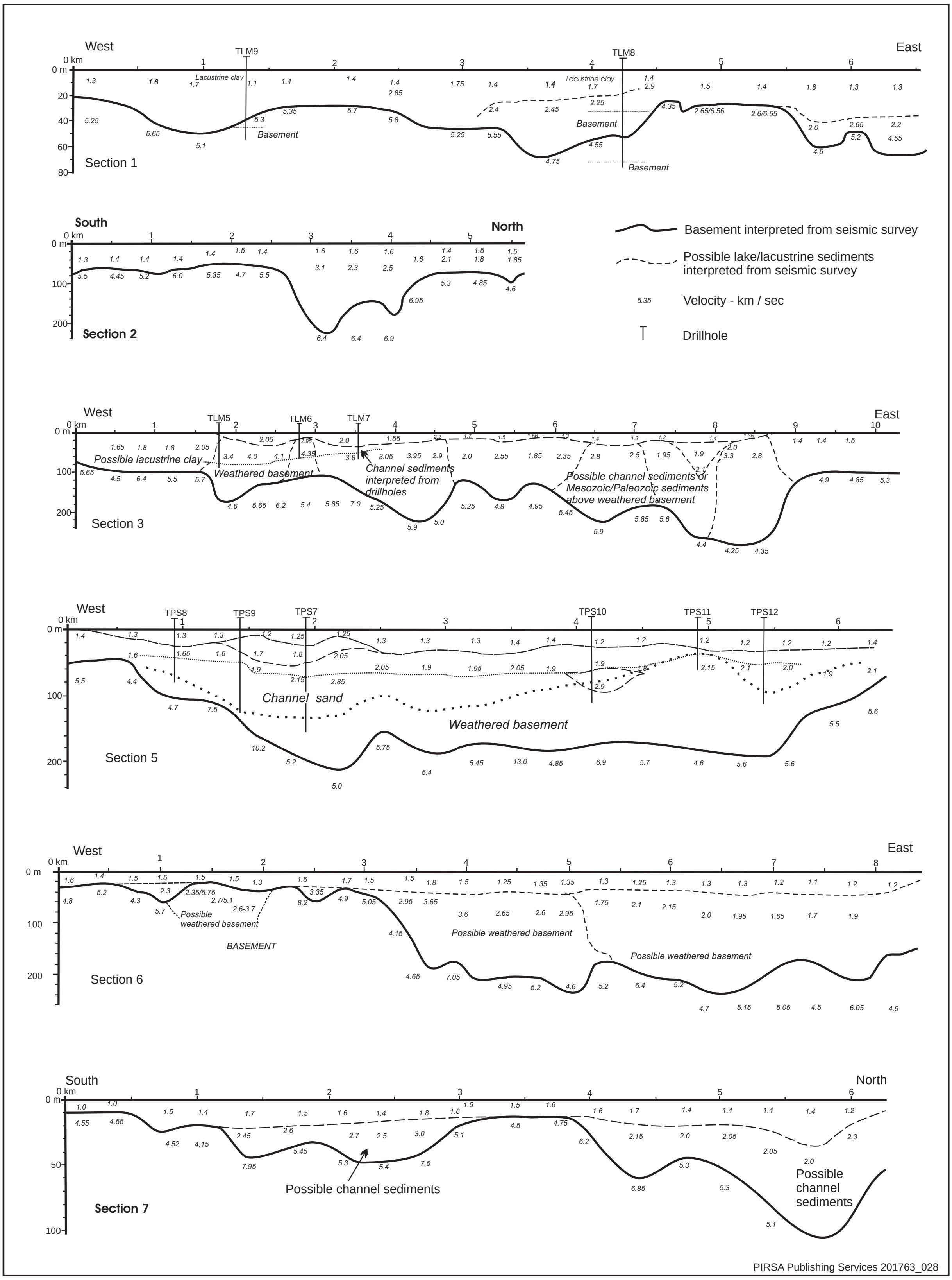

Figure 3.9 Seismic refraction results and comparison of interpreted seismic sections with depth from drilling. (Sections 1–3 and 5–7 modified after Freytag et al., 1983; see Fig. 3.11 for locations.)

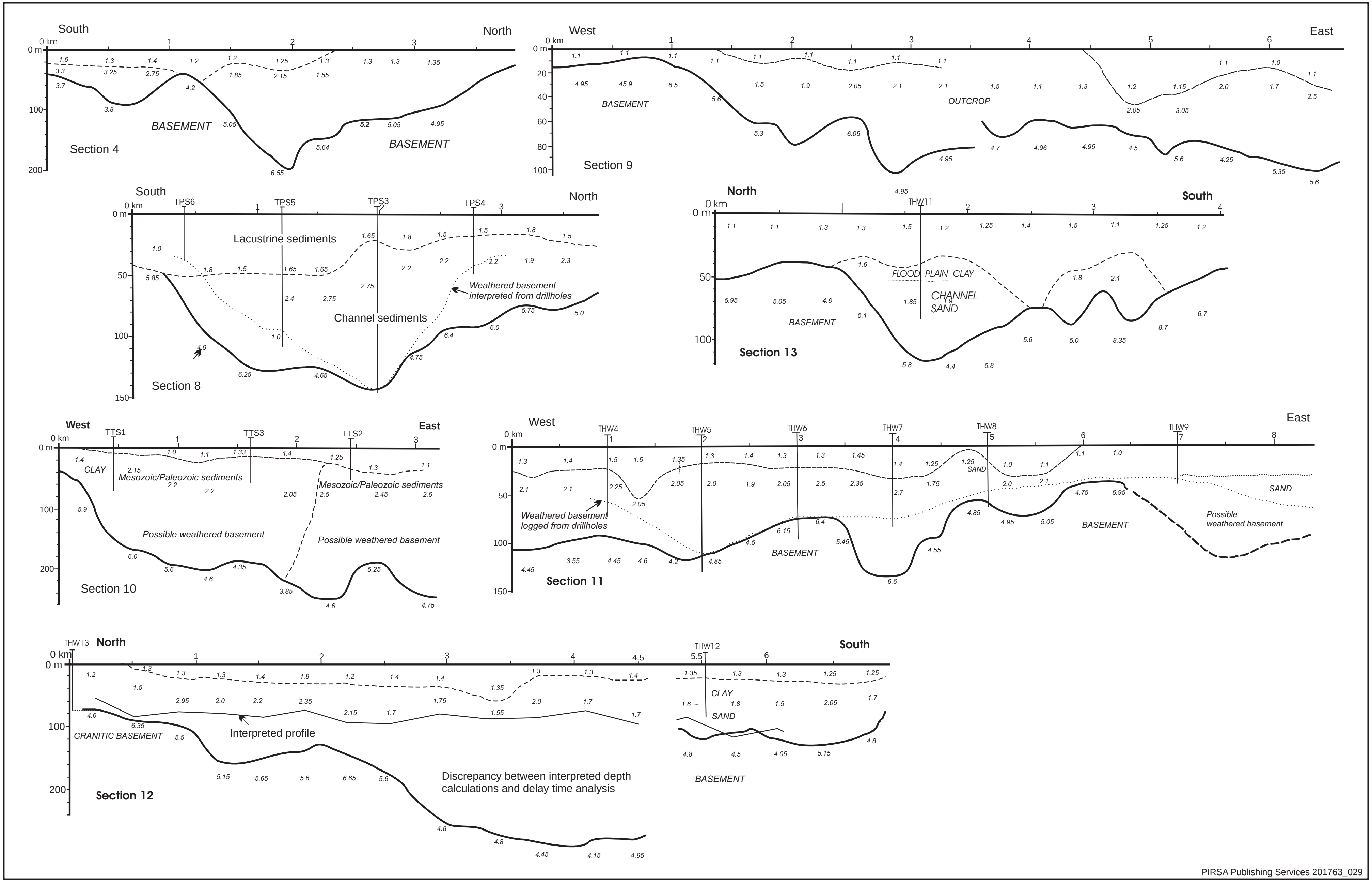

Figure 3.10 Seismic refraction results and comparison of interpreted seismic sections with depth from drilling. (Sections 4 and 8–13 modified after Freytag et al., 1983; see Fig. 3.11 for locations.)

channels and basement in places. The section-profile is composed of three principal types of fill material: dry topsoil and lacustrine sediments at the top, water saturated alluvium and/or fluvium in the middle, and bedrock at the bottom (Figs 3.9–10).

3.5 Test drilling

As part of the Harris Greenstone Drilling Program (Davies, 2002a, b), palaeochannel drilling was carried out to check the palaeochannel architecture interpreted from the multi-geoscientific data in the HGB region. The drilling intersected Tertiary sediments, some logged with PIMA II, confirming the presence of tributaries of the KPS in the Lake Harris area, basement highs within the palaeochannels and komatiitic lava flows beneath the channel in the Tarcoola and Lake Harris areas (Fig. 3.11). The drilling has increased the known areal extent of palaeochannels (drillholes TAR 63–68, 94, 97–115, KIN 37–45) and of komatiite beneath the palaeochannel (drillhole KINPC 2; see App. 2). Drillholes into the palaeochannels over the Lake Harris Komatiite have demonstrated excellent examples of Late Miocene to Early Pliocene lacustrine sediments (KINPC 1), indicating swamp environment separated from the major (Kingoonya) palaeochannel by a basement high (KINPC 3).

Drilling has identified a few sites of presumed basement highs within the palaeochannels (Fig. 3.11). Tar 94 was sited to test for suspected Tertiary channel fill 0.5 km south of Tarcoola in an area of low magnetic response and low topography. Instead of Tertiary palaeochannel fill, a light greyish, massive clay was intersected, classified in the area as Permian to Mesozoic sediments; the result is coincident with non-cooling tone response of NOAA imagery (Fig. 3.4). It is possible that there is an age overlapping of palaeochannels in places, though the poor sampling makes this conclusion rather problematic (e.g., drillhole Tar 94). At Mullina Well, drilling on a section across the channel (Tar 97–115) has confirmed the gravity result (Fig. 3.7-7) in that on a southwestern overbank of Kingoonya Palaeochannel there is a sequence comparable to that encountered at Lake Harris, and on the western section there is a sequence of predominantly lacustrine sediment with thin interbeds of fluvial fills and rare intervals of gravels (see Fig. 4.5–19). Although geological correlation between these two sections remains unresolved, further investigations by age dating offers solutions — the holes intersected a channel sequence of estimated true width ~7 km, consisting of a thin sequence of clay interbedded with minor sands and carbonaceous intervals.

3.6 Palaeochannels and related depressions — 3D modelling

The geological and geophysical signatures interpreted from the above data sets, combined with drillhole data and geological mapping of the area processed by computer modelling, have provided important information for understanding the evolution of the palaeolandscapes (see below). Results can be viewed as 3D plume diagrams, mapped onto surfaces or visualised as slices (in any direction) along and across the palaeochannel and palaeolandscape, with the exploded layers separated by palaeosurfaces of various ages (Figs 3.12–20). The integration of modern elevation data is used to demonstrate the reliability of the method, when compared to the DEM result (Fig. 3.19), where the distribution of the drainages in the strings of present lakes and topographic lows is apparent (compared in Figs. 3.1–2).

The 3D visualisation models of palaeovalley-landform are crucial to an understanding of landscape evolution and of the major controls on the dynamics of palaeorivers (Hou et al., 2004). Critically important studies include the distribution and architecture of palaeochannels and relationships with residual regolith stratigraphy and geology. Three-dimensional palaeochannel models are linked to an understanding of lithofacies relationships of channel fill, and to residual regolith and bedrock geology as revealed by regolith profiles through and nearby the palaeochannels; these studies have revealed details of the subsurface palaeochannel and palaeolandscape, from which the landscape history and palaeochannel dynamics can be deduced (see Section 4). In the HGB region, the KPS is characterised by a broad, irregular valley floor that is bounded by steep sided, valley walls (Fig. 3.13). It is

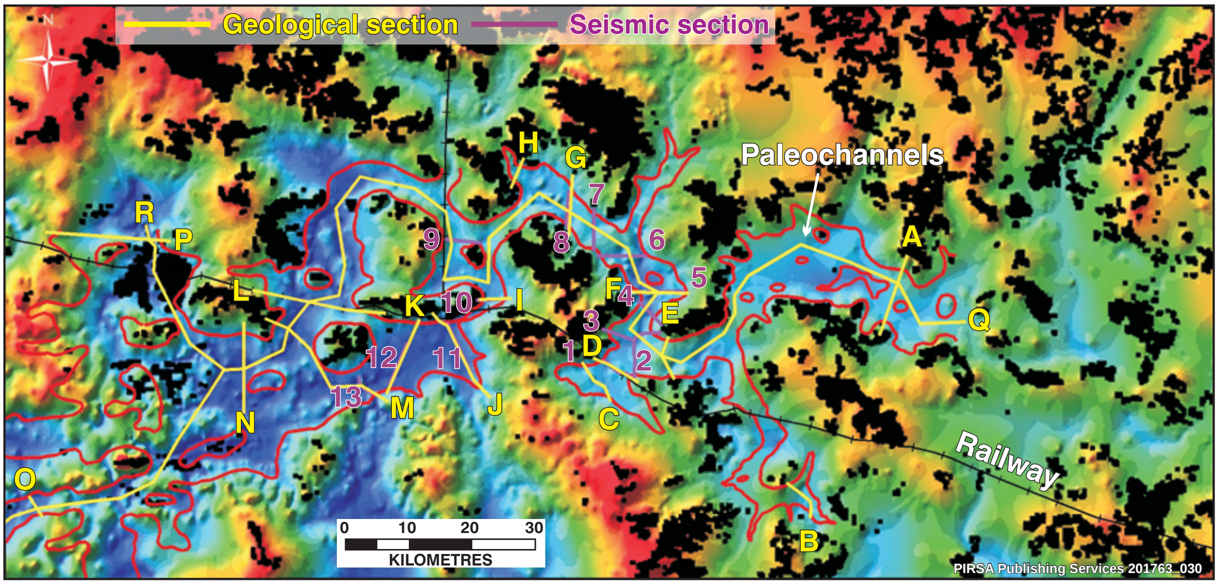

Figure 3.11 Visualisation of terminated Tertiary palaeochannels (prior to Quaternary) with location of seismic traverses, selected geological sections and drillholes which intersected channel fills.

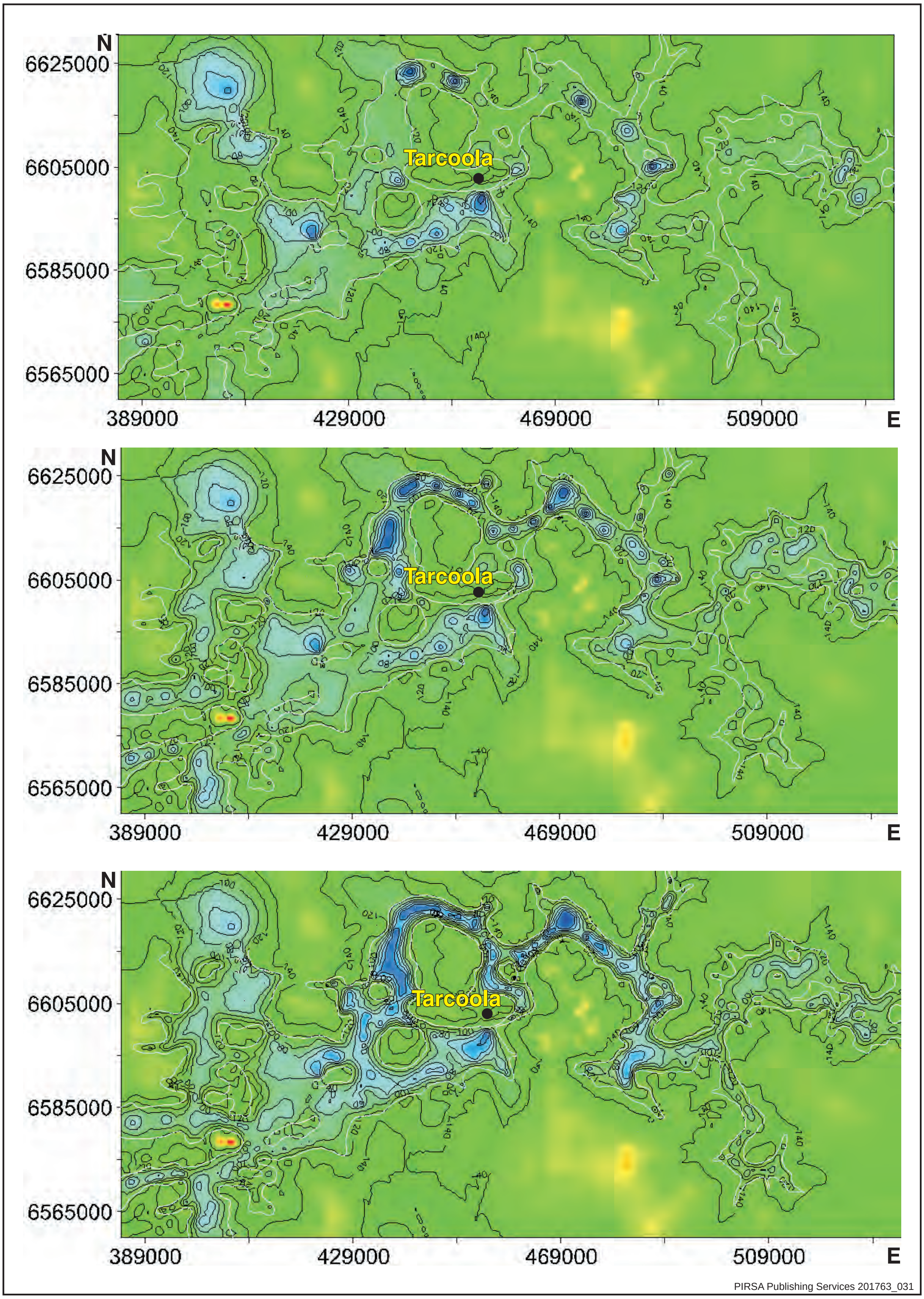

Figure 3.12 Visualisation of 3D modelling results of Cainozoic palaeolandscape evolution using EVS–MVS: topographic contours of Middle Eocene valleys.

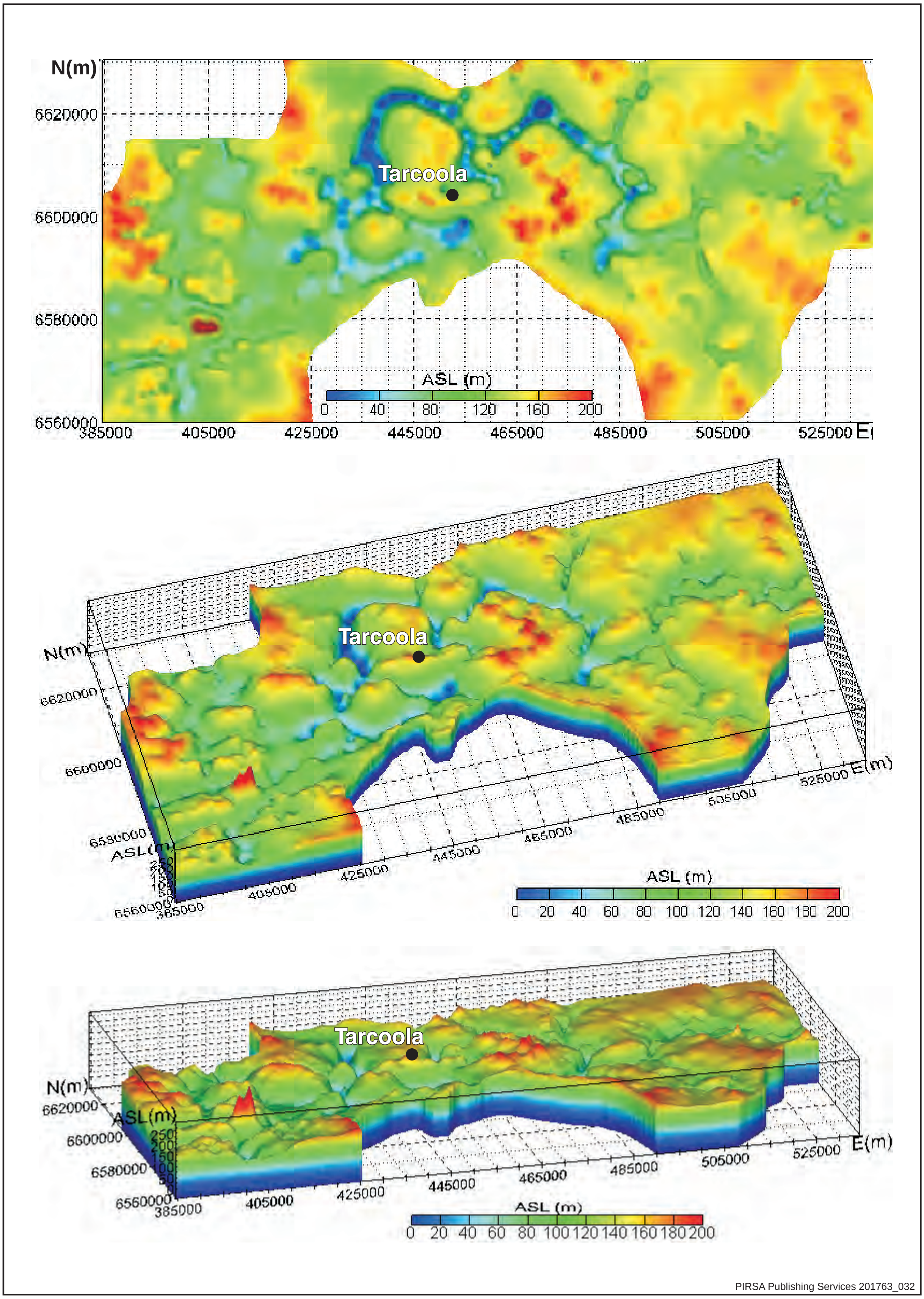

Figure 3.13 Visualisation of 3D modelling results of Cainozoic palaeolandscape evolution using EVS–MVS: incision of the palaeovalleys (Middle Eocene).

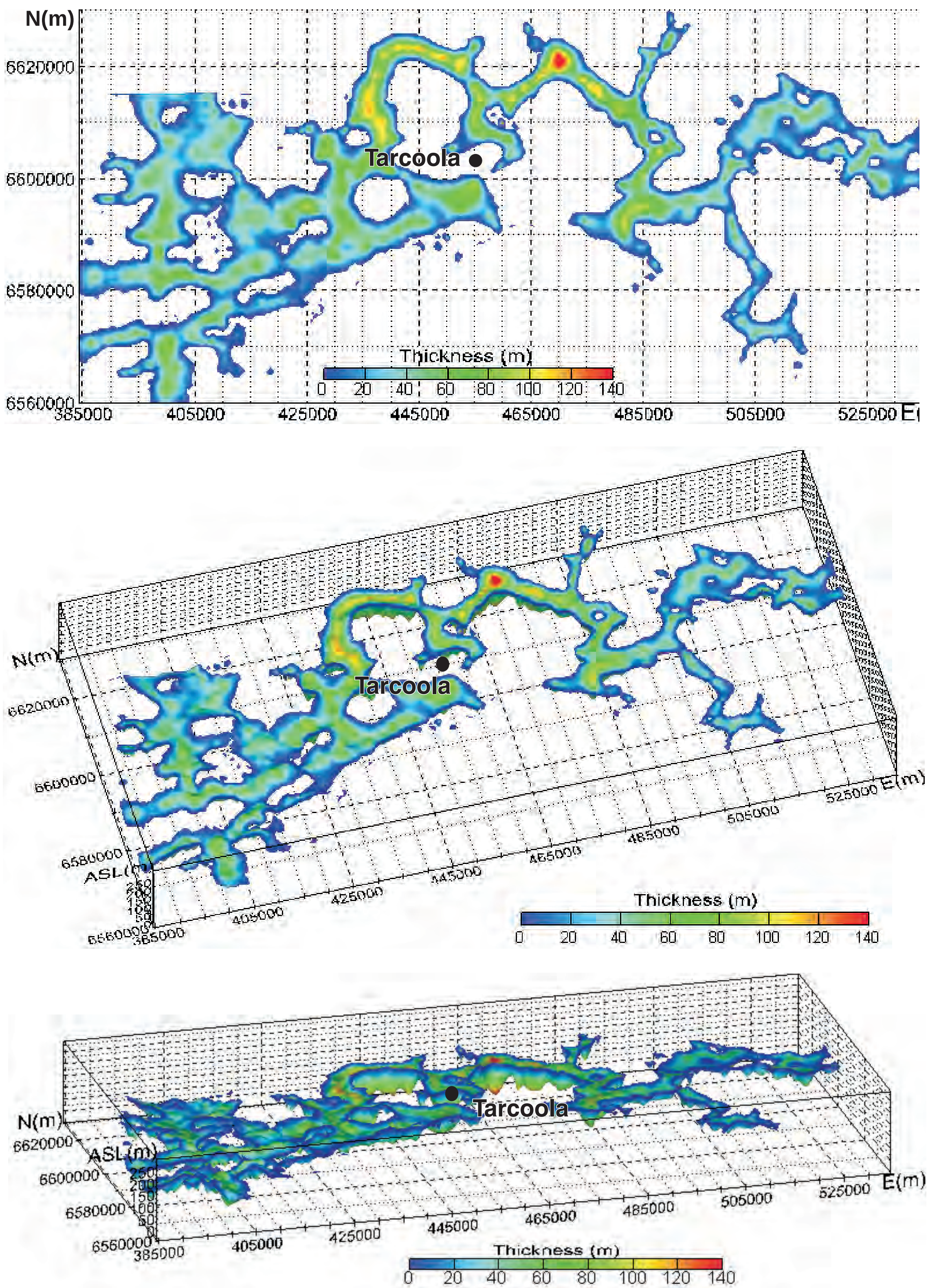

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Figure 3.14 Visualisation of 3D modelling results of Cainozoic palaeolandscape evolution using EVS–MVS: transportation and accumulation of the channel fills.

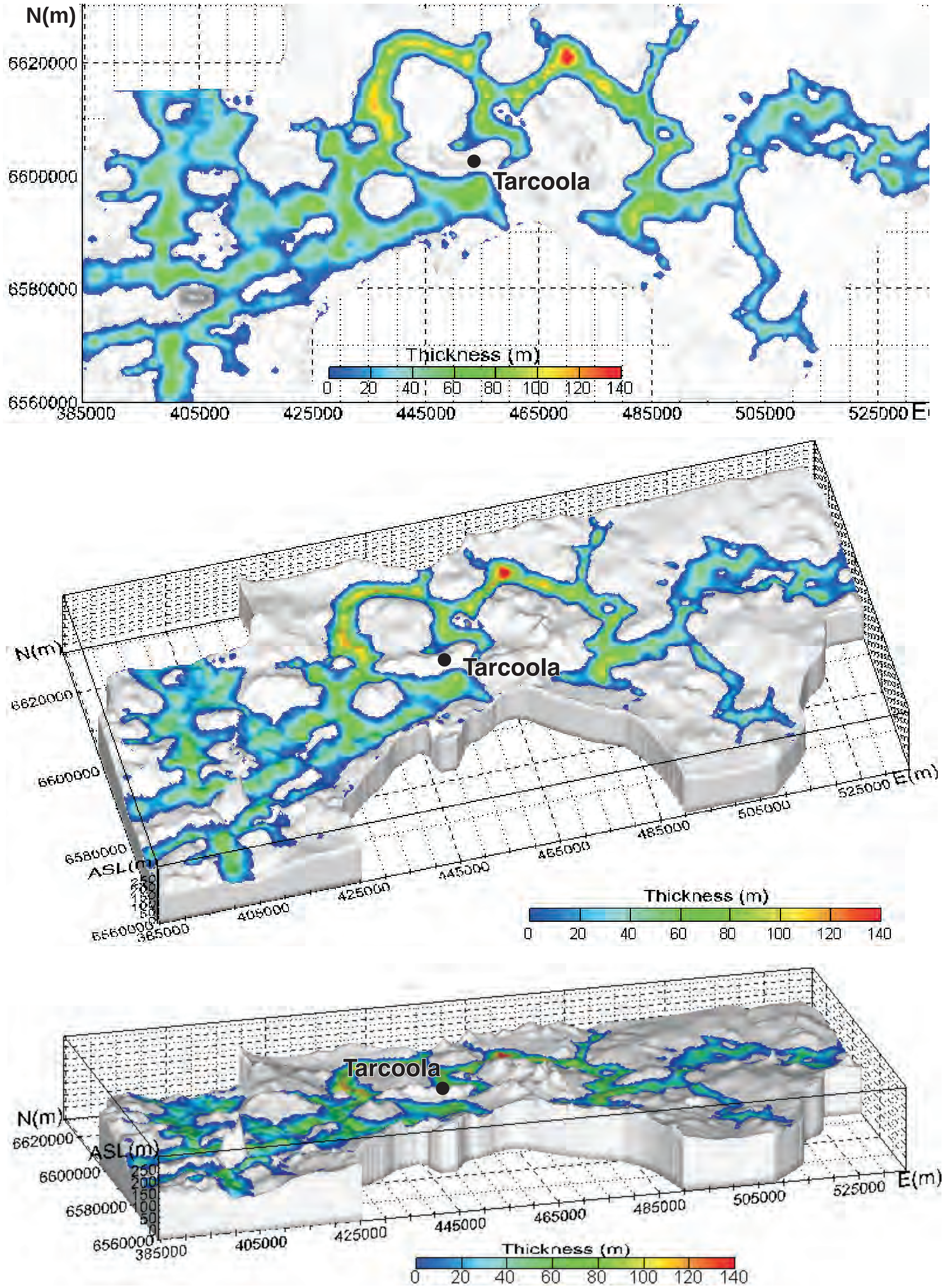

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Figure 3.15 Visualisation of 3D modelling results of Cainozoic palaeolandscape evolution using EVS–MVS: deposition in the palaeochannels.

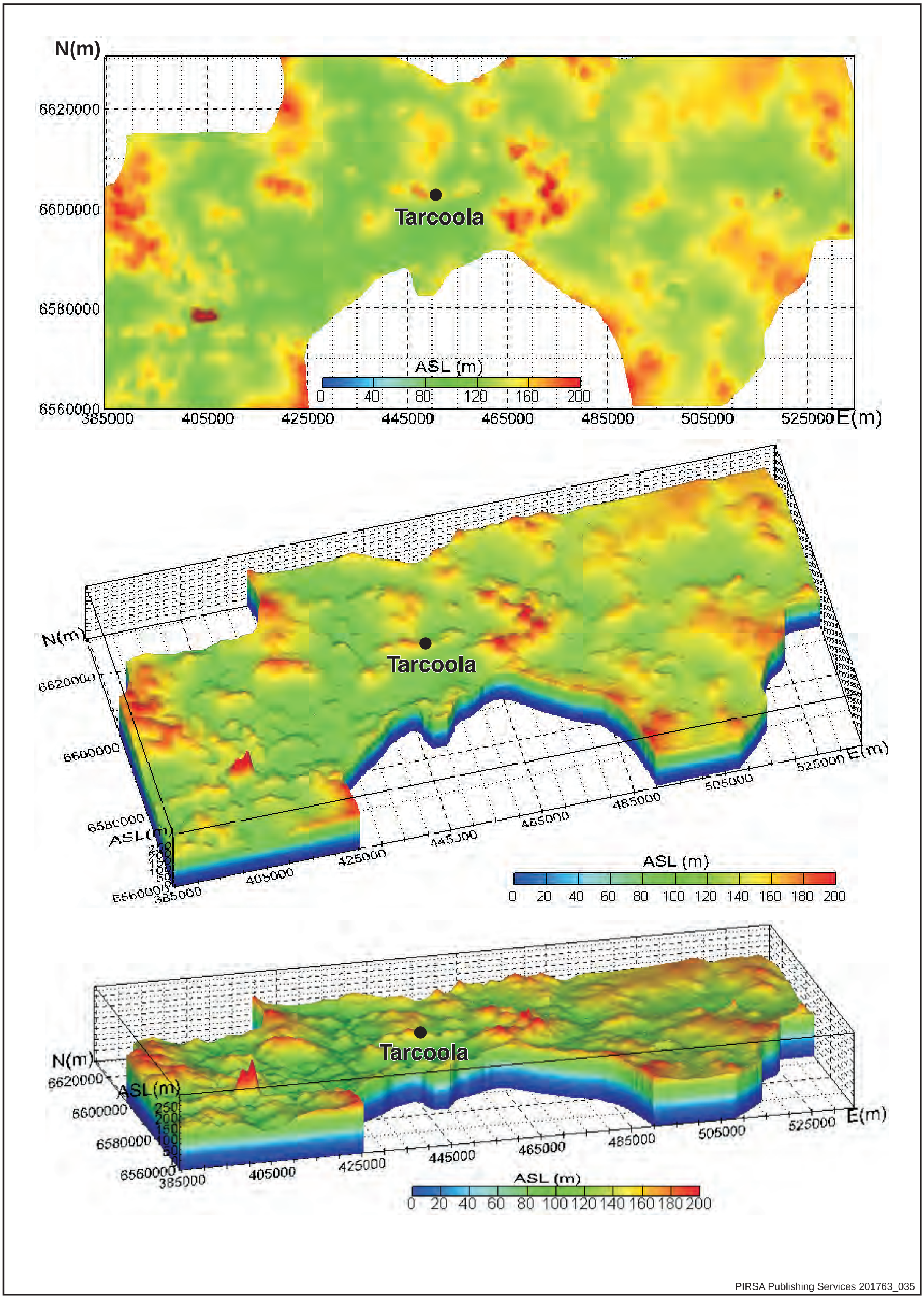

Figure 3.16 Visualisation of 3D modelling results of Cainozoic palaeolandscape evolution using EVS–MVS: termination of palaeochannel evolution (Early Pliocene).

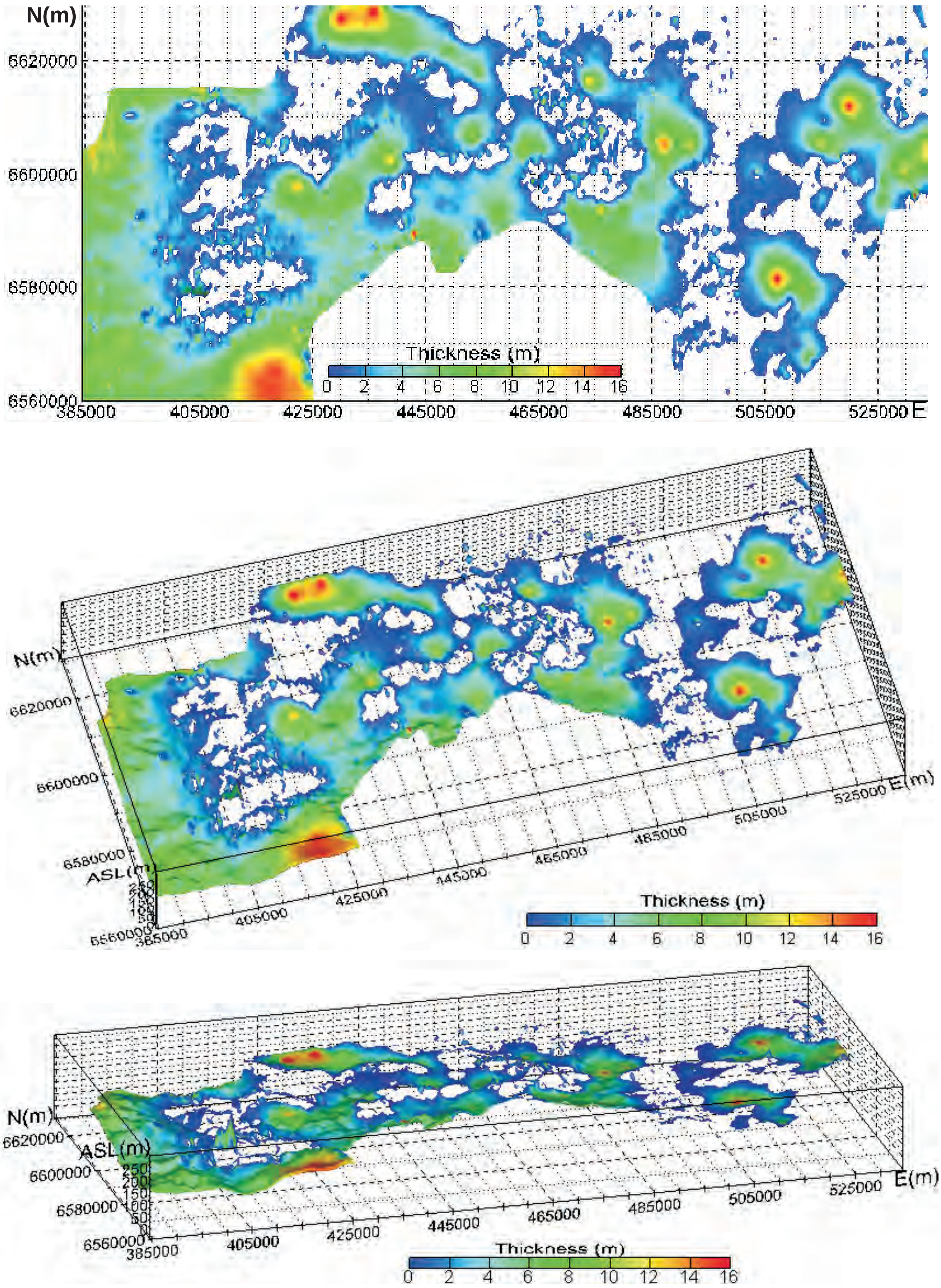

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Figure 3.17 Visualisation of 3D modelling results of Cainozoic palaeolandscape evolution using EVS–MVS: accumulation of Quaternary sediments.

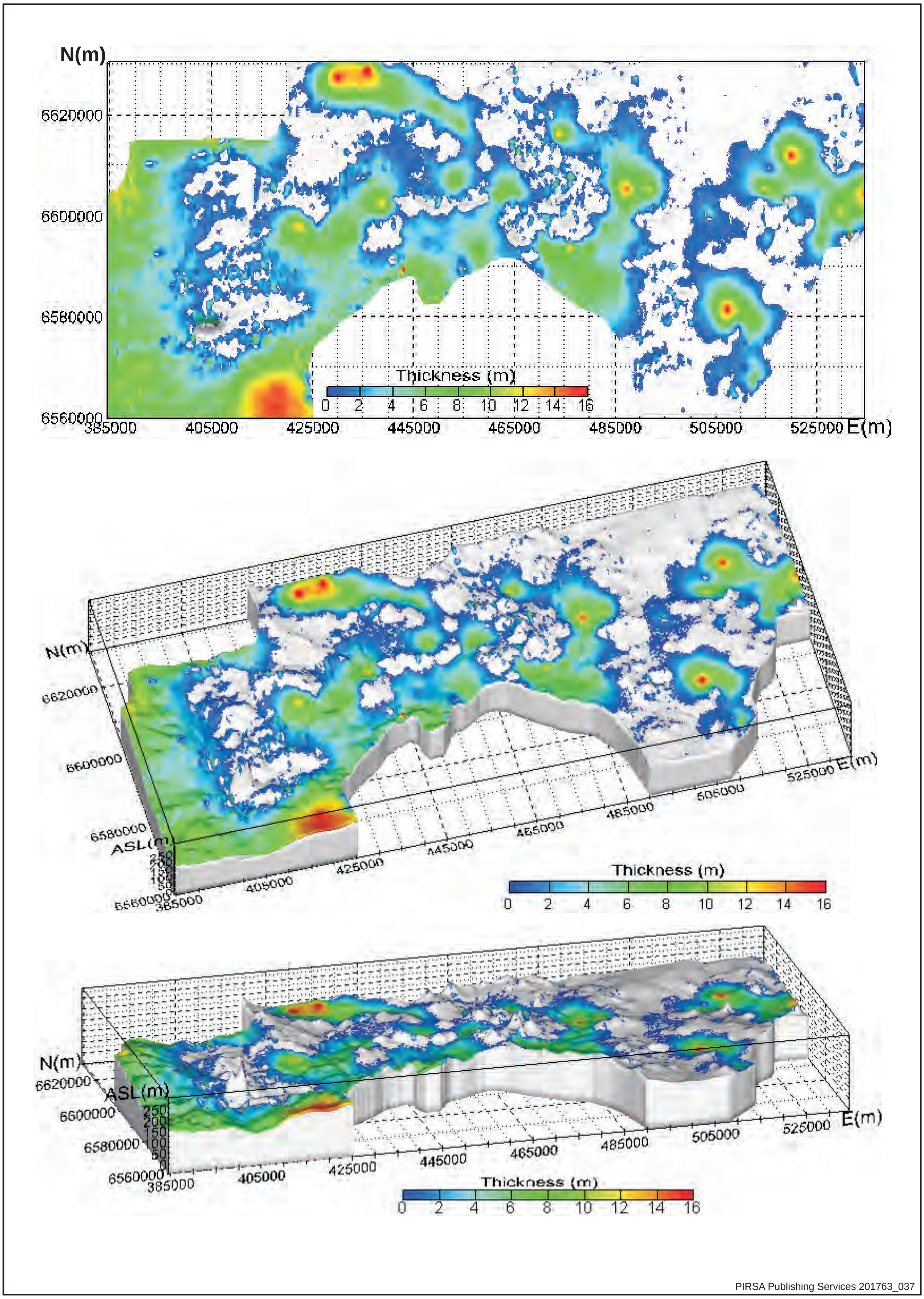

Figure 3.18 Visualisation of 3D modelling results of Cainozoic palaeolandscape evolution using EVS–MVS: deposition of Quaternary cover.

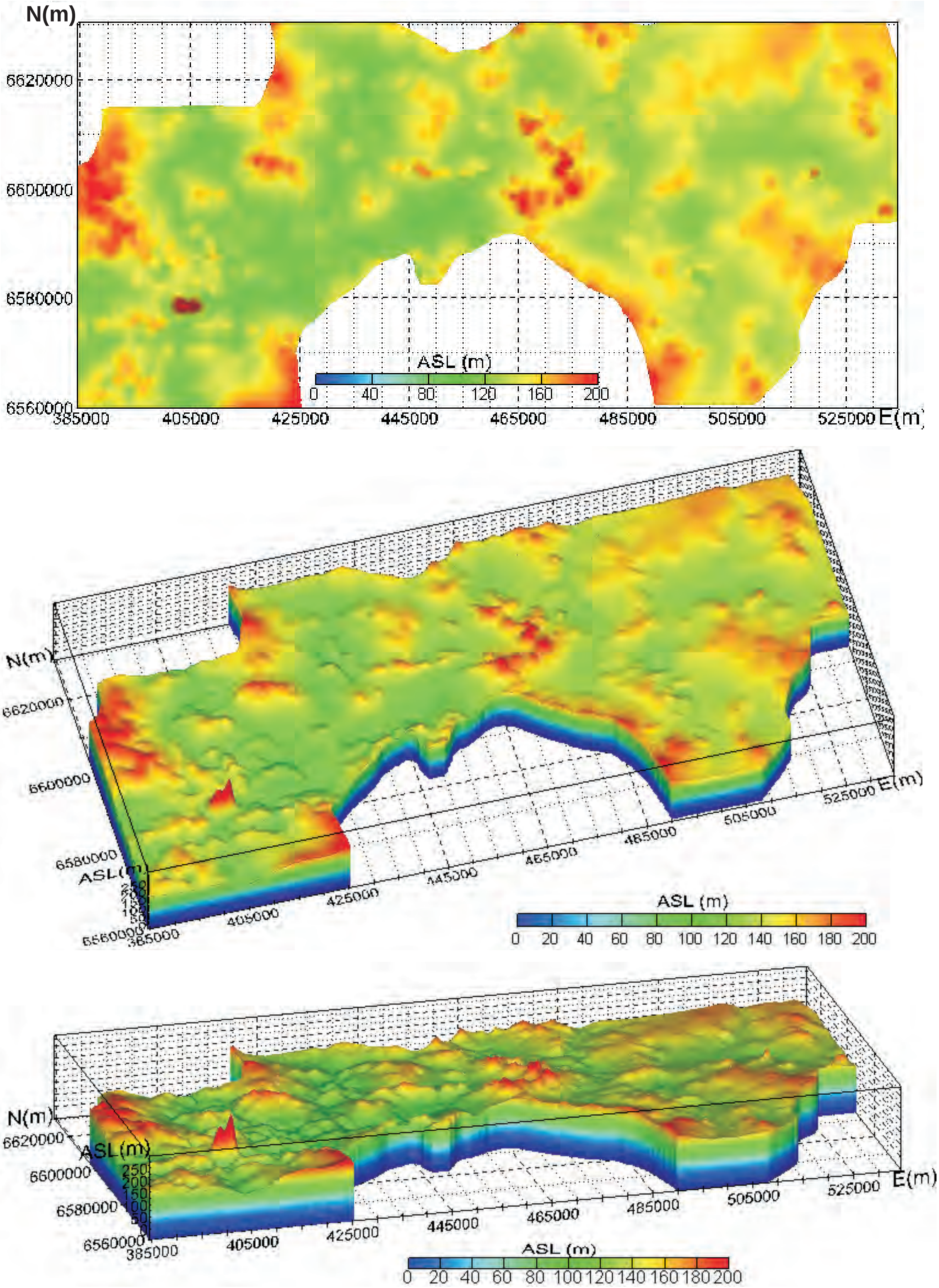

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Figure 3.19 Visualisation of 3D modelling results of Cainozoic palaeolandscape evolution using EVS–MVS: termination of Quaternary sedimentation.

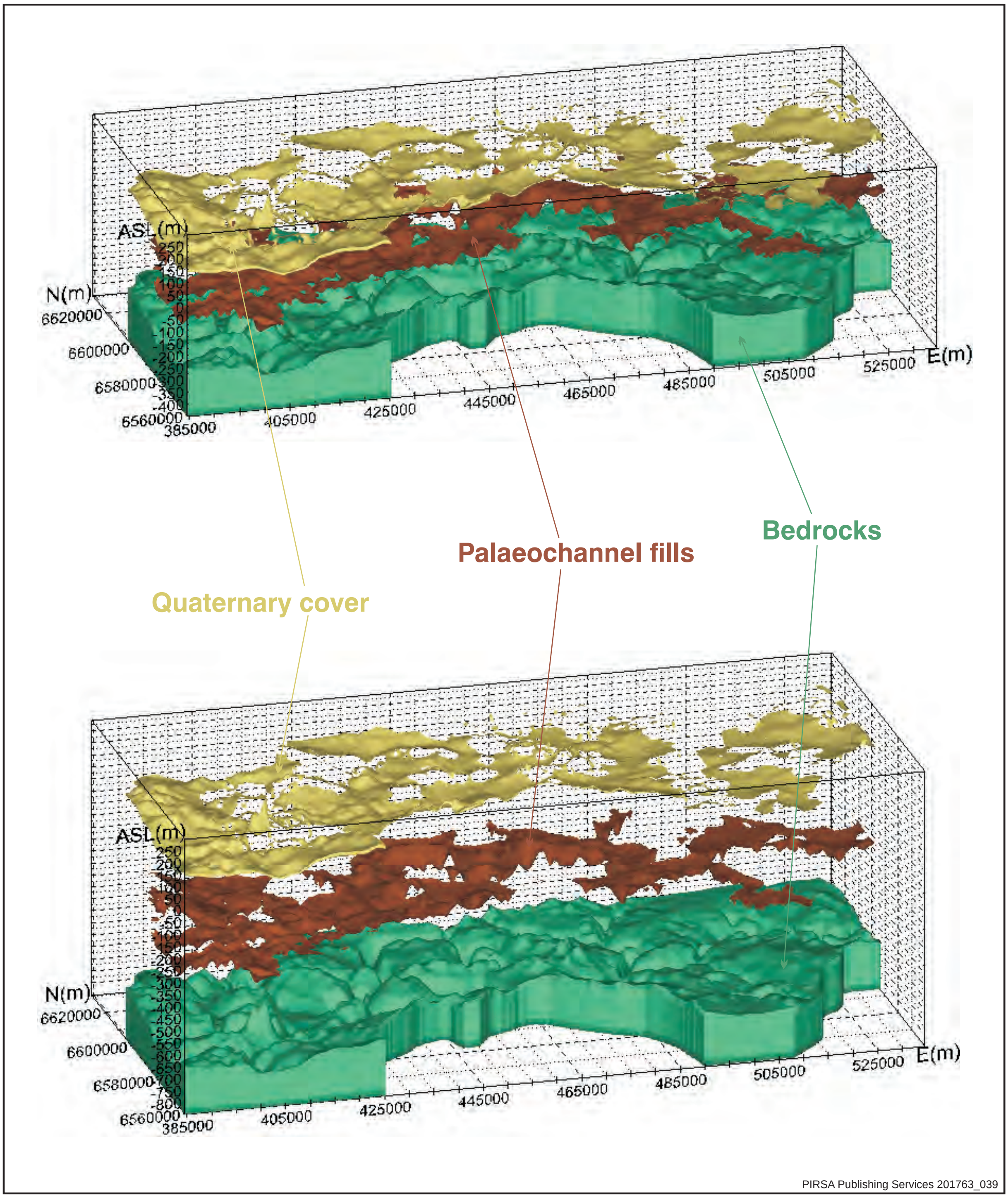

Figure 3.20 Visualisation of 3D modelling results of Cainozoic palaeolandscape evolution using EVS–MVS: relationships between the palaeochannel fill and underlying bedrock and overlying cover.

narrow (~2 km) and shallow (~20 m) in the eastern part of the HGB region, and increases in width (up to 5 km) and depth (up to 110 m) to the west towards the Eucla Basin (Figs 3.12–14, 3.20).

Regionally, the KPS is regarded to flow in an overall westerly and southwesterly direction from a palaeodrainage divide located at the Stuart Range (e.g. Benbow et al., 1995a; Hou et al., 2000; Rogers, 2000; Hou et al., 2003a). The Middle Eocene palaeomorphology of the KPS in the HGB indicates that there exists a basement high (gradient change) located at drillhole TLM 15, suggesting that the KPS developed from the incised valley pass landward into non-incised, fluvial channel system through the 'nick point' (maximum tidal limit; Figs 3.13, 3.20). The Middle Miocene morphology of the KPS indicates that the nick point in the KPS migrated further east, suggesting a larger marine influence than during Eocene time (Figs 3.14–16). This interpretation of two stages of the evolution of the KPS is also supported by stratigraphic and facies features within the channel fills, showing the more extensive distribution of the estuarine-marginal marine facies of the Miocene when compared with that of the Eocene (see Section 4). The western part of both Eocene and Miocene incised valleys in the HGB region are characterised as relatively wide estuarine channels with islands or basement highs, while in the extreme eastern part the estuarine channel was probably blocked by the basement high characterised as the nick point.

4 EVOLUTION OF PALAEOCHANNELS

4.1 Preamble

The term palaeochannel is regularly, and often incorrectly, used in naming and describing the incised and non-incised palaeovalley systems that occur throughout the Australian region. Palaeochannels are ancient channels that have been preserved in the sedimentary record of a palaeoriver system. An incised valley system consisting of incised valley and its valley fill is defined as a fluvially eroded, elongate topographic low typically larger than a single channel form and characterised by abrupt seaward shift of depositional facies across a regionally mappable boundary at its base (Zaitlin et al., 1994). Incised valleys pass landward into non-incised, fluvial channel systems that feed the valleys through the nick point (Hou et al., 2003b). There are often numerous palaeochannels preserved in palaeovalley fill that are related to the initiation and relocation of channels as sediment accumulates. The present overview of the sedimentology of the KPS is based on studies of the HGB region, plus comparison with other palaeovalley systems in the NW Gawler Craton (Hou et al., 2001c; 2003a, b). Because the main objective of this section is to gain a broad understanding of the depositional, environmental and palaeogeographic frameworks, an understanding of the stratigraphic and palaeogeographic evolution of the palaeodrainages is required. For this, the sequence stratigraphic method, supplemented by studies in sedimentary facies of the channel fills, has proved invaluable.

4.2 Stratigraphy and lithology

Analysis of the palaeochannel profiles selected from over 230 drillholes (App. 1) has resulted in a detailed stratigraphic and lithologic record of the palaeochannel sediments deposited in the HGB region (App. 2). The KPS palaeochannel fills consist of basal Eocene Pidinga Formation (Harris, 1966) and overlying Late Eocene Khasta Formation (Hou et al., 2003a; Clarke et al., 2003), and Miocene to Pliocene Garford Formation (Benbow and Pitt, 1978) and its Kingoonya Member (Hou et al., 2003a), mostly carbonaceous clastic strata (Fig. 4.1). The Pidinga Formation is unconformable on Precambrian basement but locally on sedimentary rocks of Palaeozoic or Mesozoic age. The Pidinga, containing Middle to Late Eocene palynoflora assignable to the Lower to Middle *Nothofagidites asperus* Zone (Table 4.1), consists of dominant carbonaceous gravelly, coarse to very fine grained quartzitic sand and clay plus lignite, commonly with massive to locally laminated structures and carbonised wood and leaf fragments. Locally, in drillholes, the basal Pidinga may not be easily distinguished from the underlying weathered rock, due to reworking and/or weathering, but this can be greatly improved by applying spectral parameters using PIMA II (Hou and Alley, 2003). In continuous succession with the underlying Pidinga Formation, the marine-influenced sand of the Khasta Formation tends to be very fine to medium grained, well sorted and rounded.

Relatively fine-grained fluvial–estuarine – marginal marine sediments of the Garford Formation, comprising coarse to very fine sand, clay and lignite and lacustrine sandy, illitic, and dolomitic clay, unconformably overlie the Pidinga Formation (Fig. 4.1) and contain Middle Miocene to Early Pliocene palynoflora assignable to the *Canthiumidites bullus* and *Monotocidites galeatus* Zones (Table 4.1). The boundary between them is difficult to recognise from drillhole samples, because the lithology of the lower parts of the Garford Formation (Kingoonya Member), to most extent, is very similar to that of the Pidinga Formation, characterised by dark clay and sand facies, carbonaceous material and carbonised wood and leaf fragments. Within the Garford, a marked and abrupt colour change from (dark) brown to greenish grey and greyish white is generally associated with the lithological change from fluvial to lacustrine sediments. A considerable hiatus exists between the two formations as no record of Oligocene sedimentation has been reported from the Eucla Basin and other adjacent palaeochannels (Pitt el al., 1978; Jones, 1990; Clarke, 1994; Benbow et al., 1995a; Alley et al., 1999; Clarke and Hou, 2000; Hou et al., 2001c; Clarke et al., 2003; Hou et al., 2003a). Quaternary lacustrine sandy–silty clay and gypsum, plus aeolian and alluvial sand, commonly overlie the Tertiary palaeochannel sediments and are partially dissected by modern drainages.

Table 4.1 Summary of palynological analysis

Drillhole	**Samples**	**Depth** (m)	**Spore–pollen zone**	**Age**	**Palaeoenvironment**	**R_S_No**
Konkaby 1	Cuttings	32–34	Barren, no separation			485700
	Cuttings	38–40	*Canthiumidites bellus – Monotocidites galeatus* Zone	Late Miocene, few pollen grains	Marginal marine, almost barren	485701
	Cuttings	42–44	Barren, no separation	Late Miocene	Marginal marine	485702
	Cuttings	44–46	Barren			
	Cuttings	48–50	Barren, no separation	Late Miocene		485703
	Cuttings	52–54	*C. bellus – M. galeatus* Zone	Middle – Late Miocene, minor	Marginal marine, few dinoflagellates	485704
	Cuttings	64–66	Lower *Nothofagidites asperus* Zone	Middle Eocene	Non-marine, fluvio	
	Cuttings	74–76	Lower *N. asperus* Zone	Middle Eocene	Non-marine, fluvio-lacustrine	
	Cuttings	86–88	Lower *N. asperus* Zone	Middle Eocene	Non-marine, fluvio	
	Cuttings	128–130	Lower *N. asperus* Zone	Middle Eocene	Non-marine, fluvio	
Konkaby 5	Cuttings	16–18	Barren, no separation			485705
	Cuttings	51–53	? Lower *N. asperus* Zone	Middle – ? Late Eocene	Marginal marine	
	Cuttings	57–59	Lower *N. asperus* Zone	Middle Eocene	Marginal marine; estuarine	
	Cuttings	63–65	Lower *N. asperus* Zone	Middle Eocene	Estuarine–lacustrine	
	Cuttings	77–79	Lower *N. asperus* Zone	Middle Eocene	Weak marine influence	
	Cuttings	85–87	Lower *N. asperus* Zone	Middle Eocene	Weak marine influence	
	Cuttings	97–99	Lower *N. asperus* Zone	Middle Eocene	Estuarine – lagoonal	
	Cuttings	111–113	Lower *N. asperus* Zone	Middle Eocene	Estuarine – lagoonal	
Malbooma 1	Core	58–59 ft	Barren			
	Core	68–69 ft	Barren			
	Core	80–81 ft	Lower *N. asperus* Zone	Middle Eocene	Estuarine	
	Core	92–93 ft	Lower *N. asperus* Zone	Middle Eocene	Fluvio-lacustrine	
	Core	112–113 ft	Lower *N. asperus* Zone	Middle Eocene	Weak marine	
TPS 7	Cuttings	22–23	*M. galeatus* Zone	Late Miocene – Early Pliocene	Terrestrial, weak marine	
	Cuttings	44–45	*M. galeatus* Zone	Miocene – Pliocene	Terrestrial	

Drillhole	Samples	Depth (m)	Spore–pollen zone	Age	Palaeoenvironment	R_S_No
	Cuttings	58–59	*M. galeatus* Zone	Miocene – Pliocene	Terrestrial	
	Cuttings	77–78	*M. galeatus* Zone	Miocene – Pliocene	Terrestrial	
	Cuttings	79–80	*M. galeatus* Zone	Miocene – Pliocene	Terrestrial	
	Cuttings	87–88	Top Lower *N. asperus* Zone	Late Middle Eocene	Marginal marine, weak marine	
	Cuttings	89–90	Top Lower *N. asperus* Zone	Late Middle Eocene	Marginal marine, non-marine?	
	Cuttings	101–102	Top Lower *N. asperus* Zone	Late Middle Eocene	Marginal marine, estuarine	
	Cuttings	109–110	Top Lower *N. asperus* Zone	Late Middle Eocene	Marginal marine, estuarine–lacustrine	
	Cuttings	125–126	Top Lower *N. asperus* Zone	Late Middle Eocene	Marginal marine, weak marine	
TPS 12	Cuttings	62–63	Top Lower *N. asperus* Zone	Late Middle Eocene	Fluvio-lacustrine	
	Cuttings	68–69	Top Lower *N. asperus* Zone	Late Middle Eocene	Estuarine	
	Cuttings	69–70	Top Lower *N. asperus* Zone	Late Middle Eocene	Estuarine	
TPS 13	Cuttings	61–62	Barren			
	Cuttings	66–67	Top Lower *N. asperus* Zone	Late Middle Eocene	Marginal marine	
TPS 14	Cuttings	17–18	*M. galeatus* Zone	Miocene – Pliocene	Weak marine	
TPS 15	Cuttings	11–12	Barren, no separation			485711
	Cuttings	12–13	Non-diagnostic key taxa	Miocene	Almost barren, only two taxa	485712
TPS 17	Cuttings	16–17	Barren, no separation			485713
	Cuttings	17–18	*M. galeatus* Zone	Late Miocene – Early Pliocene	Non–marine	485714
	Cuttings	20–21	*M. galeatus* Zone	Late Miocene – Early Pliocene	Marginal marine, dinoflagellates	485715
	Cuttings	32–33	Barren, no separation			485716
	Cuttings	37–38	Barren			485717
	Cuttings	40–41	Barren			485719
	Cuttings	41–42	Barren			
	Cuttings	45–46	Barren, no separation			485720

Drillhole	Samples	Depth (m)	Spore–pollen zone	Age	Palaeoenvironment	R_S_No
	Cuttings	47–48	Barren			485721
	Cuttings	48–49	*C. bellus* Zone, marine dinoflagellates	Upper Lower to Middle Miocene	Estuarine, algae + freshwater	485722
	Cuttings	49–50	Barren			485723
	Cuttings	50–51	*C. bellus* Zone	Upper Lower to Middle Miocene	Non-marine	485723
	Cuttings	67–68	*C. bellus* Zone	Upper Lower to Middle Miocene	Minor-marine	485725
	Cuttings	56–57	? *Proteacidites tuberculatus* Zone	Late Oligocene – early Miocene	Estuarine	
	Cuttings	77–78	? *P. tuberculatus* Zone	Late Oligocene – early Miocene	Estuarine	
	Cuttings	80–81	Lower *N. asperus* Zone	Middle Eocene	Weak marine	
KIN 20	Cuttings	24–26	*M. galeatus* Zone	Miocene – Pliocene	Estuarine	
		66–68	Middle *N. asperus* Zone	Middle – early Late Eocene	Fluvio-lacustrine	
		68–70	Middle *N. asperus* Zone	Middle – early Late Eocene	Fluvio-lacustrine	508469
KIN 21	Cuttings	24–26	*M. galeatus* Zone	Miocene – Pliocene	Estuarine	
		26–28	*M. galeatus* Zone	Miocene – Pliocene	Marginal marine	
KIN_22	Cuttings	20–22	*M. galeatus* Zone	Late Miocene – Early Pliocene	Non-marine, lacustrine	
KIN 45	Cuttings	24–26	*M. galeatus* Zone	Miocene – ? Pliocene	Estuarine – marginal marine	
SADME TD 5	Core	67.6 ft	Barren, no separation			485699
TC 52	Core	22.5–22.6	Barren			
TC 54	Core	29.2	*M. galeatus* Zone	Miocene – Pliocene	Terrestrial	
	Core	32.6–34	Upper *N. asperus* Zone	Late Eocene – Early Oligocene	Estuarine – weak marine	
	Core	39.1–39.3	Lower *N. asperus* Zone	Middle Eocene	Lacustrine–estuarine	
	Core	46–46.4	Lower *N. asperus* Zone	Middle Eocene	Lacustrine–estuarine	

Drillhole	Samples	Depth (m)	Spore–pollen zone	Age	Palaeoenvironment	R_S_No
TC 55	Core	36–37	Middle *N. asperus* Zone	Middle – Early Late Eocene	Estuarine–lacustrine	
TC 57	Core	34.3–35	Middle *N. asperus* Zone	Middle – early Late Eocene	Lacustrine–estuarine	
	Core	35.4–35.7	Middle *N. asperus* Zone	Middle – early Late Eocene	Lacustrine–estuarine	
	Core	36.5–36.7	Middle *N. asperus* Zone	Middle – early Late Eocene	Lacustrine–estuarine	
	Core	36.7–36.8	Middle *N. asperus* Zone	Middle – early Late Eocene	Lacustrine–estuarine	
TC 58	Core	32.5–33	Middle *N. asperus* Zone	Middle – early Late Eocene	Estuarine–lacustrine	
KINPC 2	Cuttings	15–16	Barren			
	Cuttings	16–17	*M. galeatus* Zone	Late Miocene – Early Pliocene	Coastal	
	Cuttings	17–18	*M. galeatus* Zone	Late Miocene – Early Pliocene	Coastal	
	Cuttings	18–19	*M. galeatus* Zone	Late Miocene – Early Pliocene	Coastal	
	Cuttings	21–22	*M. galeatus* Zone	Late Miocene – Early Pliocene	Coastal	
	Cuttings	24–25	*M. galeatus* Zone	Late Miocene – Early Pliocene	Coastal	
	Cuttings	26–27	*M. galeatus* Zone	Late Miocene – Early Pliocene	Coastal	
	Cuttings	28–29	Barren			
THW 16	Cuttings	12–13	Barren			
	Cuttings	13–14	Barren			
	Cuttings	35–36	Barren			
	Cuttings	38–39	*Proteacidites tuberculatus* Zone	Late Oligocene – Early Miocene	Lacustrine–estuarine	
	Cuttings	41–42	Middle *N. asperus* Zone	Middle – early Late Eocene	Lacustrine	
THW 21	Cuttings	33–34	Middle *N. asperus* Zone	Middle – early Late Eocene	Swamp–lacustrine–estuarine	
	Cuttings	35	Middle *N. asperus* Zone	Middle – early Late Eocene	Lacustrine–estuarine	
	Cuttings	41–42	Middle *N. asperus* Zone	Middle – early Late Eocene	Swamp–lacustrine–estuarine	

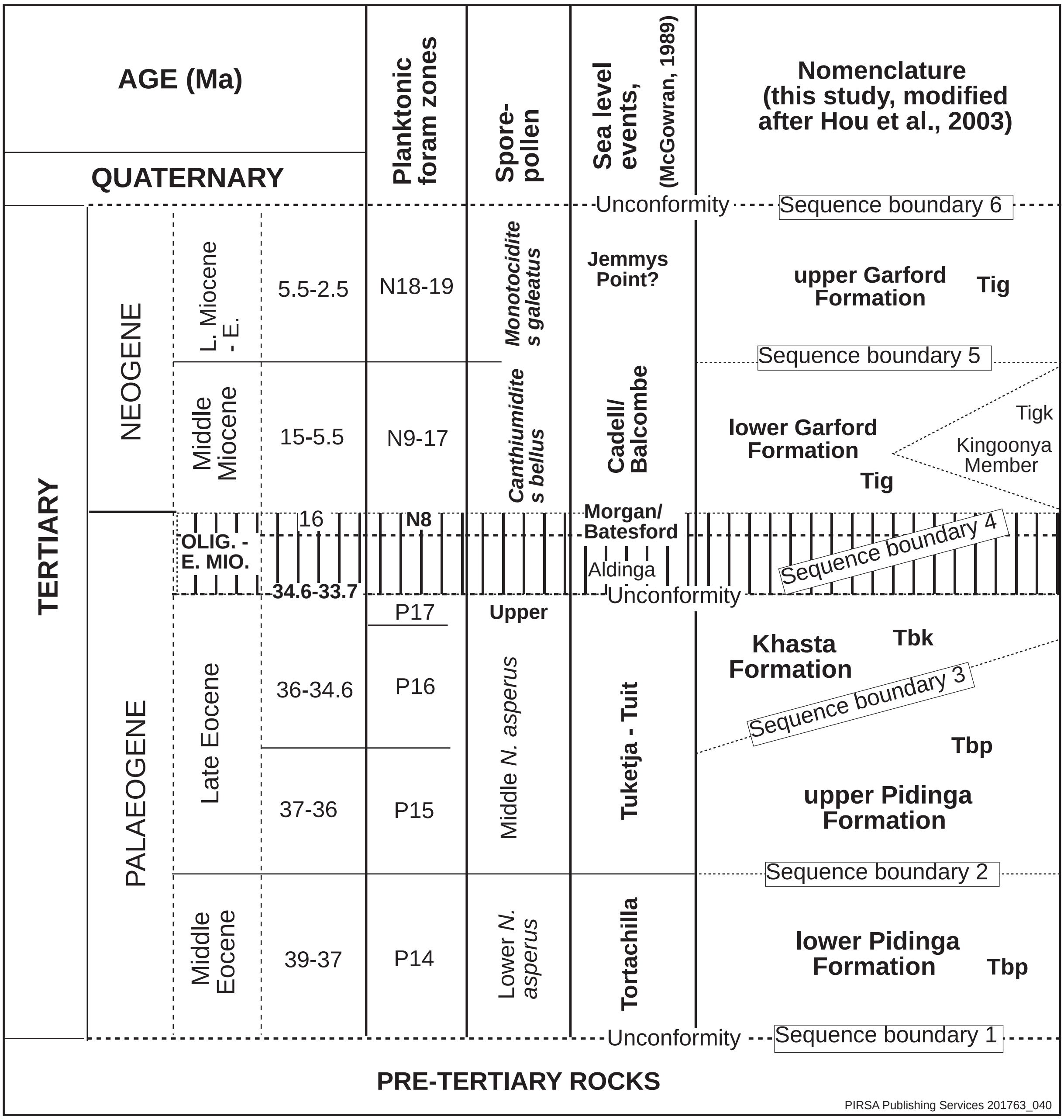

Figure 4.1 Stratigraphic nomenclature of the Kingoonya Palaeochannel.

4.3 Specialised logging with PIMA II

The PIMA II spectrometer was used to measure the reflectance spectra of samples specially taken from test drillholes and gold- or uranium-bearing drillholes in the short infra-red wavelength (SWIR; 1300–2500 nm), and the results have been compared to those from conventional hand specimen and log examination, with excellent correlation (Figs 4.2–4). PIMA allows identification of the mineralogy as many minerals have characteristic spectra in the SWIR spectral region due to the absorption by the mineral of certain wavelengths of light. Importantly, the spectral parameters of the drill samples also allow the distinction to be made between basal channel sediments and the otherwise very similar deeply weathered and reworked basement in selected downhole profiles. The downhole spectra recorded by the PIMA II allow the determination of fine spectral details, such as crystallinity variations and element substitution (Pontual, et al., 1994), and have been used in conjunction with geological examinations to help build a more consistent and comprehensive understanding of the drilling profile (Figs 4.2–4). For instance, residual kaolinites are highly crystalline (e.g., K4b) while transported kaolinites tend to be very poorly to poorly crystalline (e.g., K1, 2 and 3; Pontual et al., 1997). The sharp downward increase of the KX Index at the basal erosive surface indicates a transported-residual boundary, whereas the sharp downward increase of the KX Index from the top of the Pidinga Formation suggests a sequence boundary (Hou and Alley, 2003). Lacustrine sediments are characterised by particularly high smectite content because lakes tend to act as sinks for cations. The smectite content is generally low in the upper (leached) parts of the residual lateritic zone and is highly variable downward (Pontual et al., 1997).

4.4 3D stratigraphic and lithofacies associations

Eighteen geological cross-sections, together with seismic refraction results (where available), were analysed in detail to reconstruct the palaeochannel profiles and to evaluate channel-fill sediments throughout most of the HGB region (Fig. 3.11). Using GIS geological sections were created in 3D by using QikDraw software to examine the stratigraphic and lithofacies changes and relationships throughout the KPS (Figs 4.5–19). Recognition of facies types (Table 4.2) is based on the sedimentological information from the profiles, and sections through the channel fills illustrate the lithofacies associations and changes. As in most cases of marine-influenced fluvial lithologies elsewhere around the world, the palaeochannel fill lithologies in the HGB region are highly variable and facies relationships are complex.

Cross-sections in Figures 4.6–19 indicate a blanket Quaternary cover overlies the Garford Formation channel — lacustrine sediments, consisting dominantly of clayey facies in the upper part and sandy facies in the lower sections of the Miocene channels. In contrast to the palaeochannels of the NW Gawler Craton (e.g., Tallaringa and Garford), the Garford clays and sands here are often intercalated with marine-influenced pyritic and carbonaceous facies, indicating estuarine-channel environments. The Miocene channel sediments unconformably overlie the Eocene channels and appear to overlap laterally on the bedrock of the interfluves. The sections thus suggest the presence of a regional sequence boundary between the Miocene and Eocene channels, and indicate a larger marine transgression during the Middle Miocene to Early Pliocene than that during the Eocene. Sections C, H and I, for instance, intersected up to 20 m of marine-influenced clay and sand with thin beds of carbonaceous pyritic sandy clay (Tigk) of the Garford Fm without encountering any Eocene sediments, before intersecting weathered basement rocks (Figs 4.7, 4.11). This demonstrates that the scale of the Miocene marine transgression was larger than that of the Eocene.

Cross-section Q reveals a complex and irregular basement of weathered grey to pinkish quartz–felspathic gneiss and/or granite beneath the channel base (Figs 4.17–18). There appears to be a very gentle westerly gradient component on the basement surface at the selected drillhole sites. Throughout the KPS in the HGB region, Eocene channels are characterised by narrow and deep valleys, often separated by basement highs (cross-sections A, B, F, G, J, K; Figs 4.6-7, 4.9–10, 4.12–13). The apparent wider channels are all

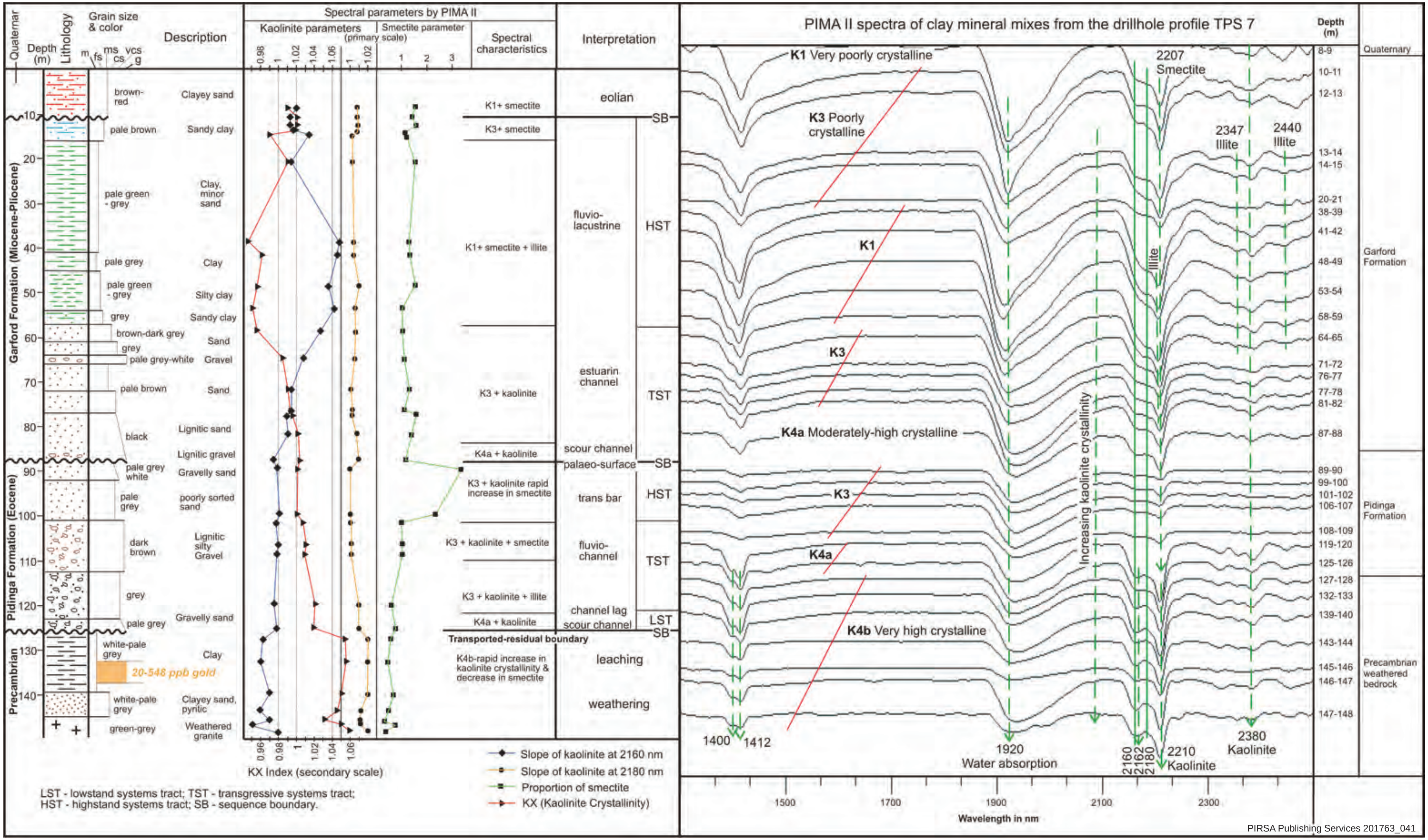

Figure 4.2 Logged sections of TPS 7 with spectral parameters from PIMA II (see Figs 3.11 and 4.5 for the drillhole location).

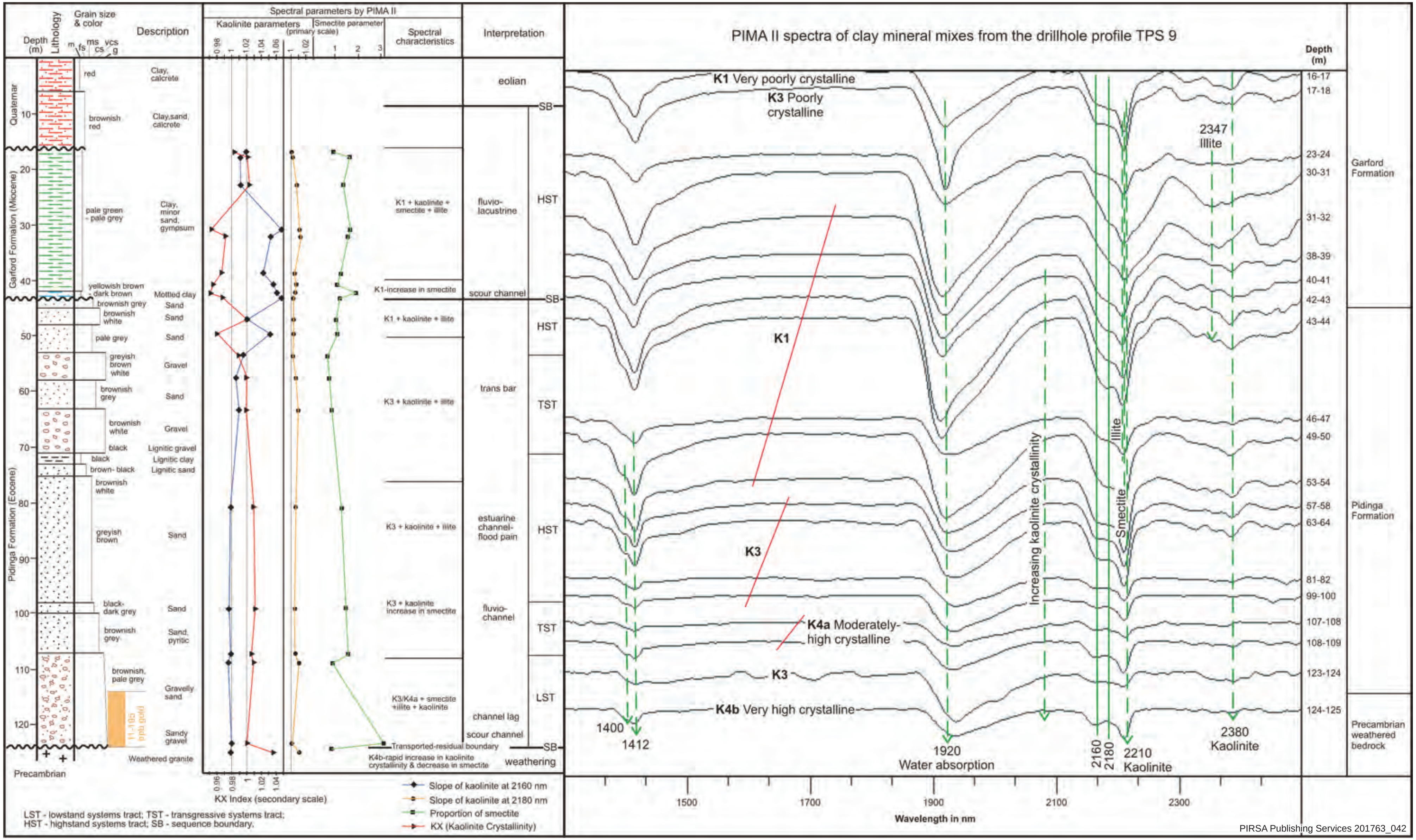

Figure 4.3 Logged sections of TPS 9 with spectral parameters from PIMA II (see Figs 3.11 and 4.5 for the drillhole location).

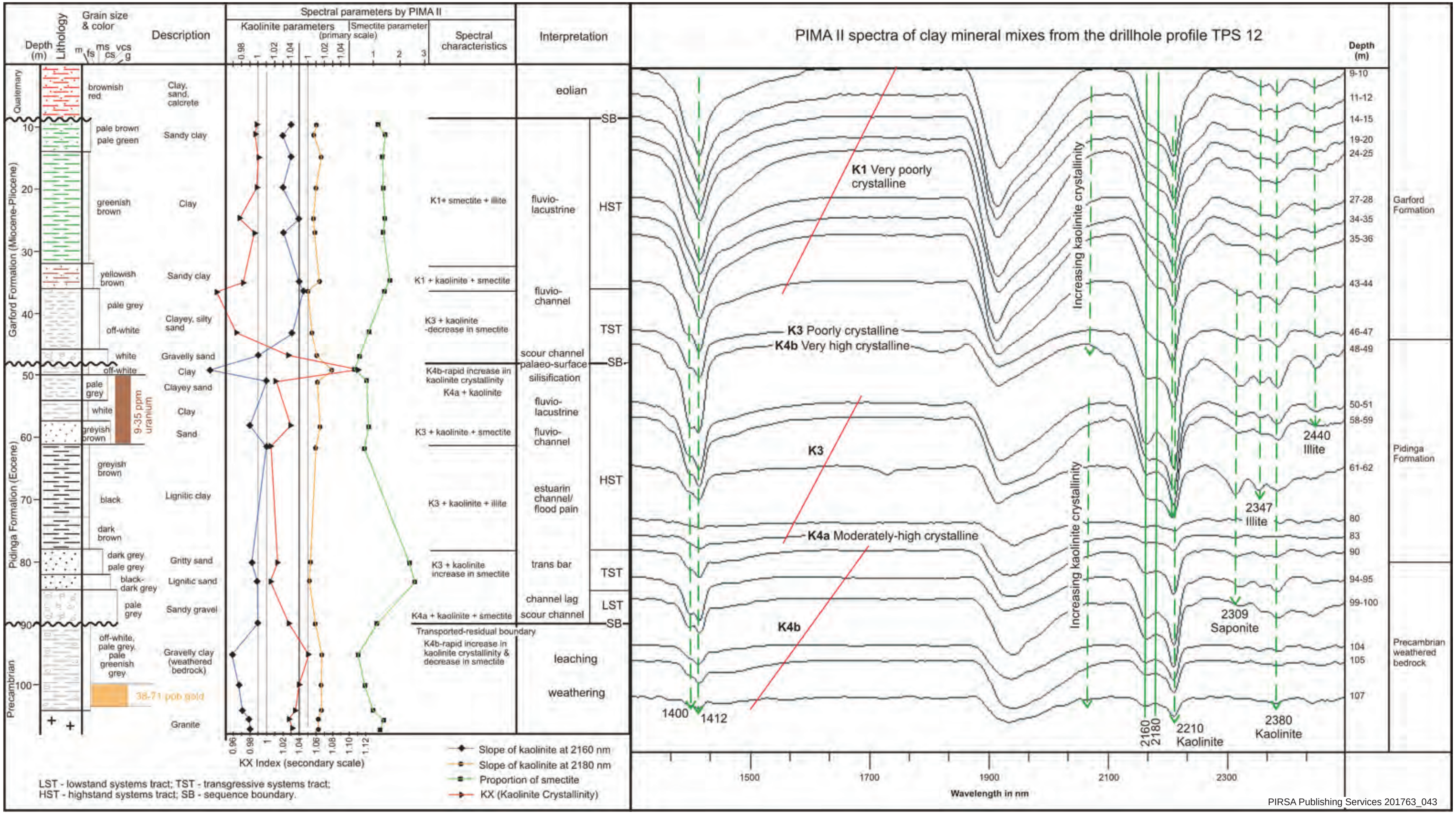

Figure 4.4 Logged sections of TPS 12 with spectral parameters from PIMA II (see Figs 3.11 and 4.5 for the drillhole location).

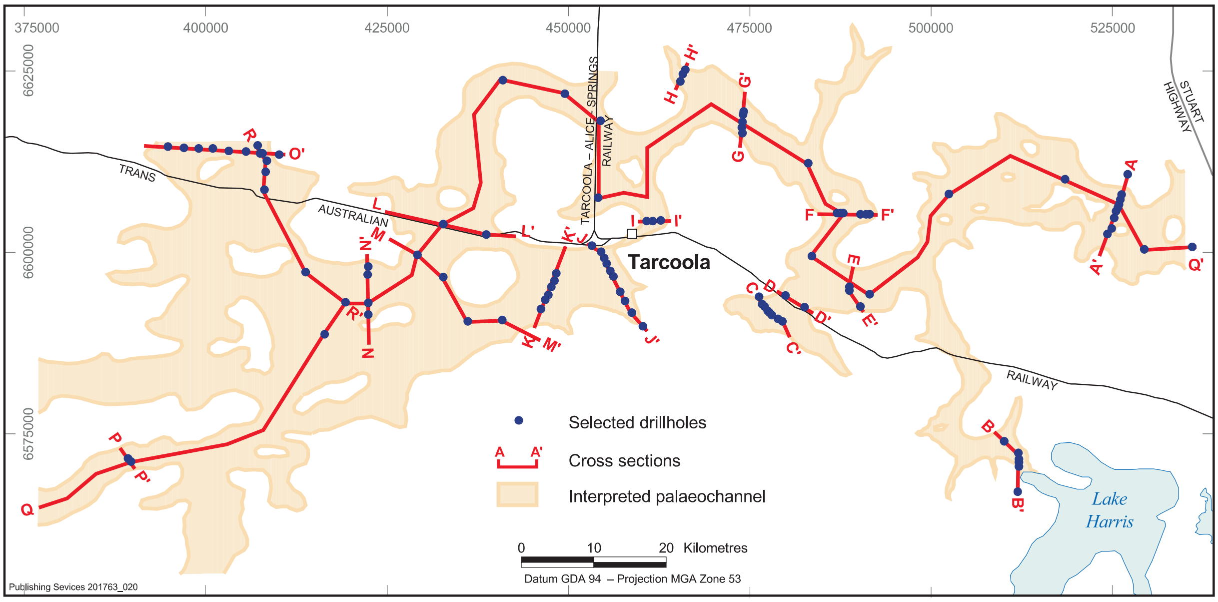

Figure 4.5 Locality map for sequential geological cross-sections (A–R) through the length of the Kingoonya Palaeochannel.

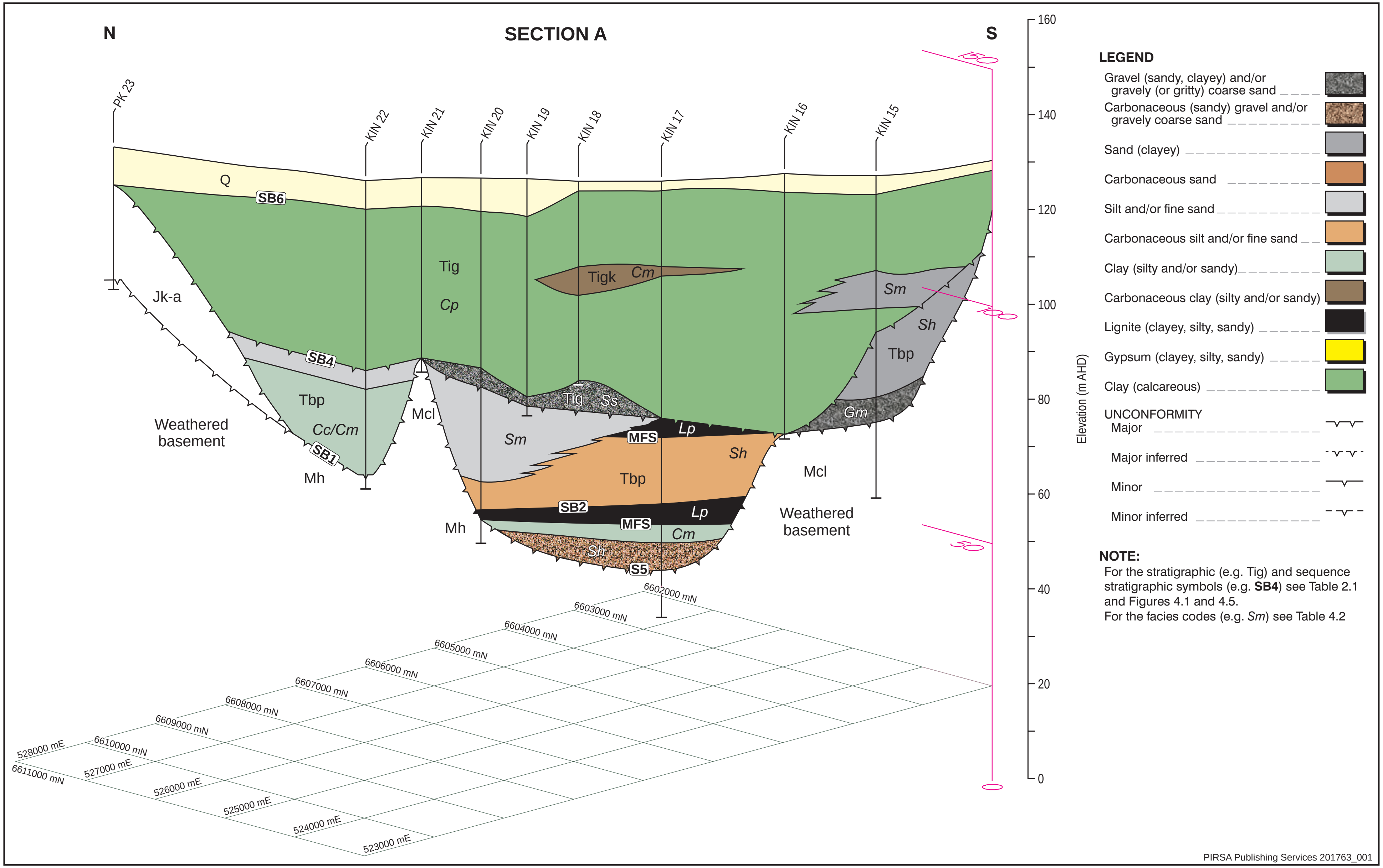

Figure 4.6 Geological cross-section A (PK 23 to KIN 15) and borehole controls, illustrating lithofacies association in the channel sediments. (See Figs 3.11 and 4.5 for section location; see Table 4.2 for the facies codes).

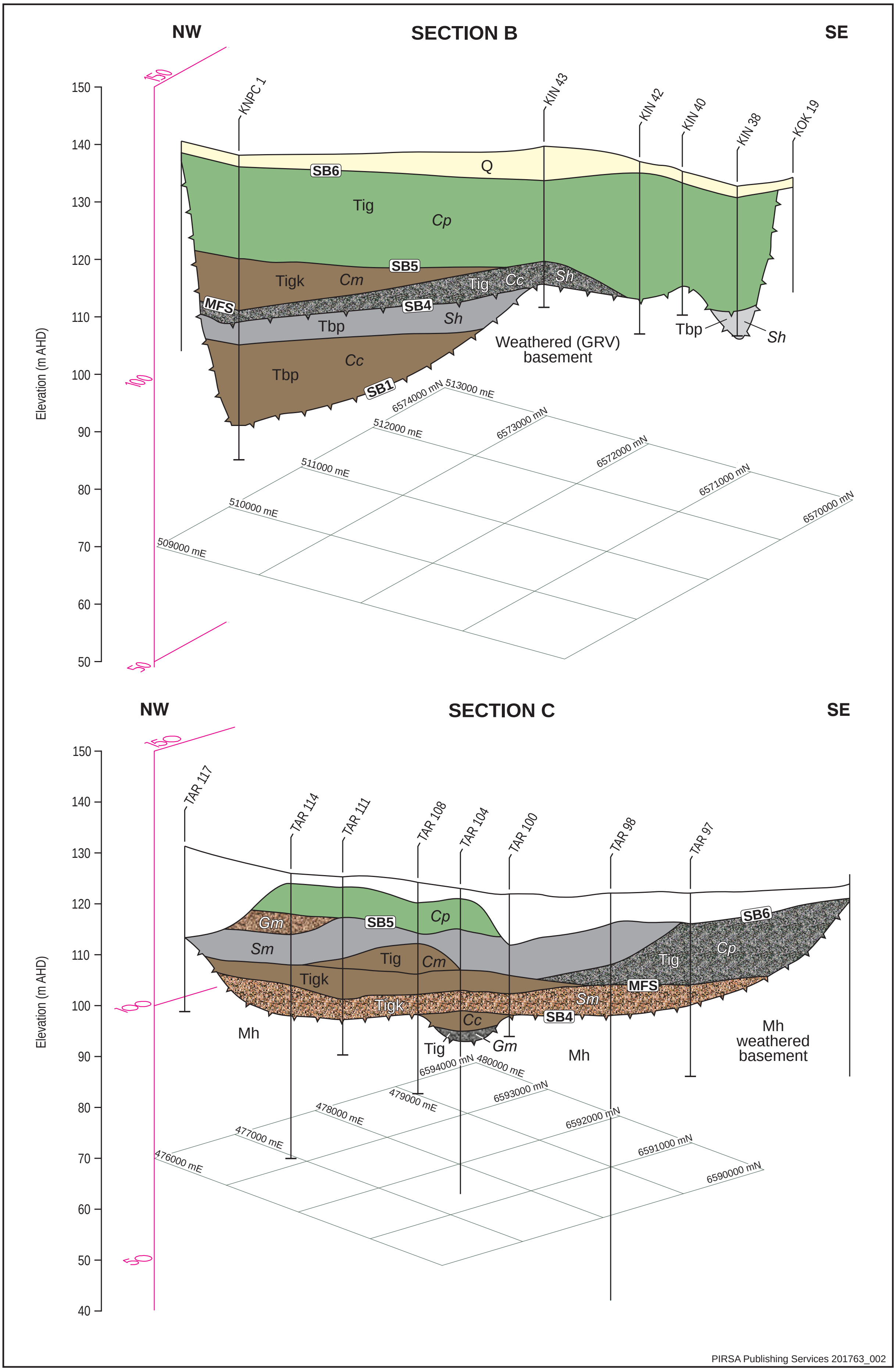

Figure 4.7 Geological cross-sections B (KINPC 1 to KOK 19) and C (TAR 117 to TAR 97) and borehole controls, illustrating lithofacies association in the channel sediments. (See Fig. 4.6 for legend; see Figs 3.11 and 4.5 for section location; see Table 4.2 for the facies codes).

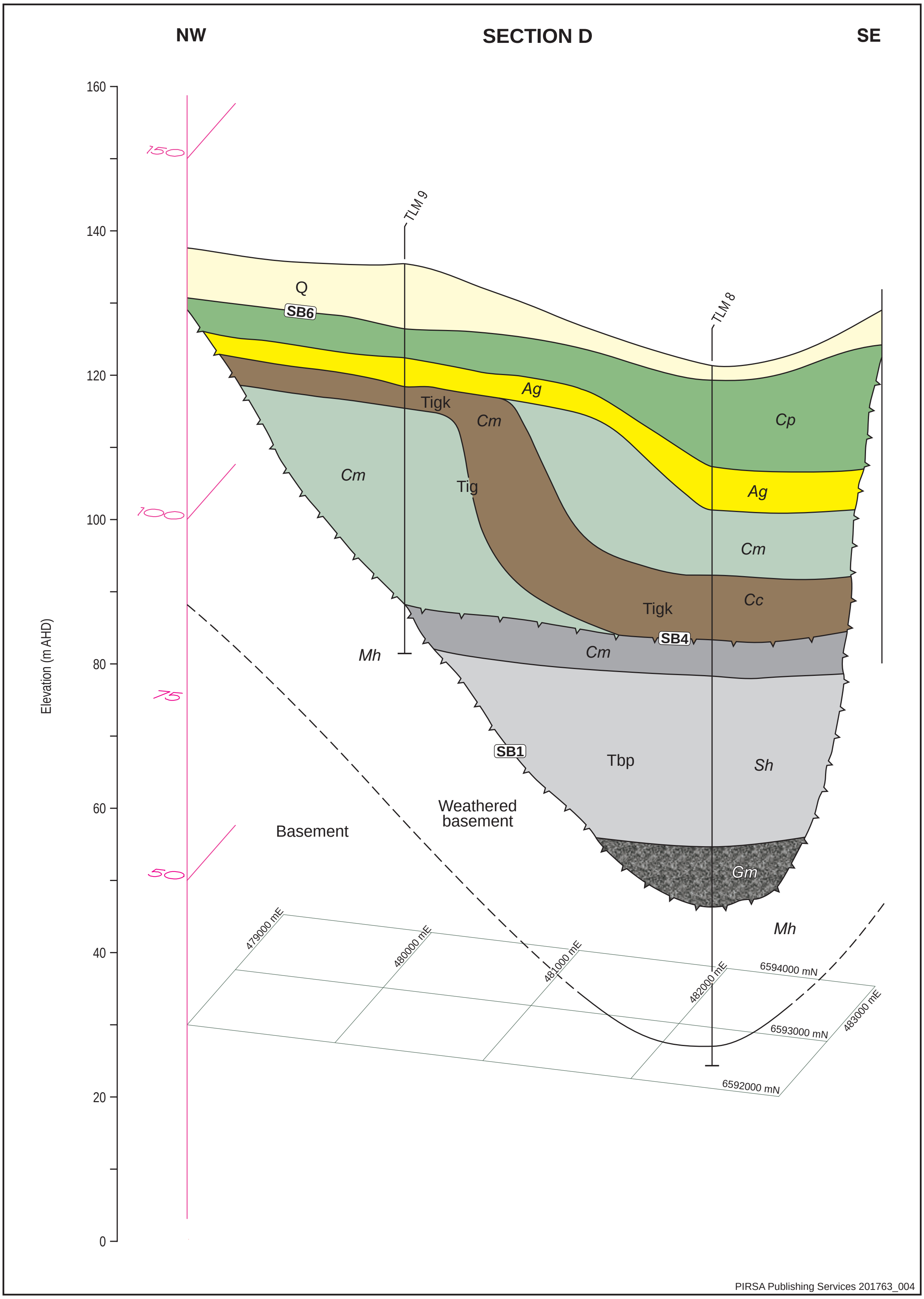

Figure 4.8 Geological cross-section D (TLM 9 to TLM 8) and borehole controls, illustrating lithofacies association in the channel sediments. (See Fig. 4.6 for legend; see Figs 3.11 and 4.5 for section location; see Table 4.2 for the facies codes).

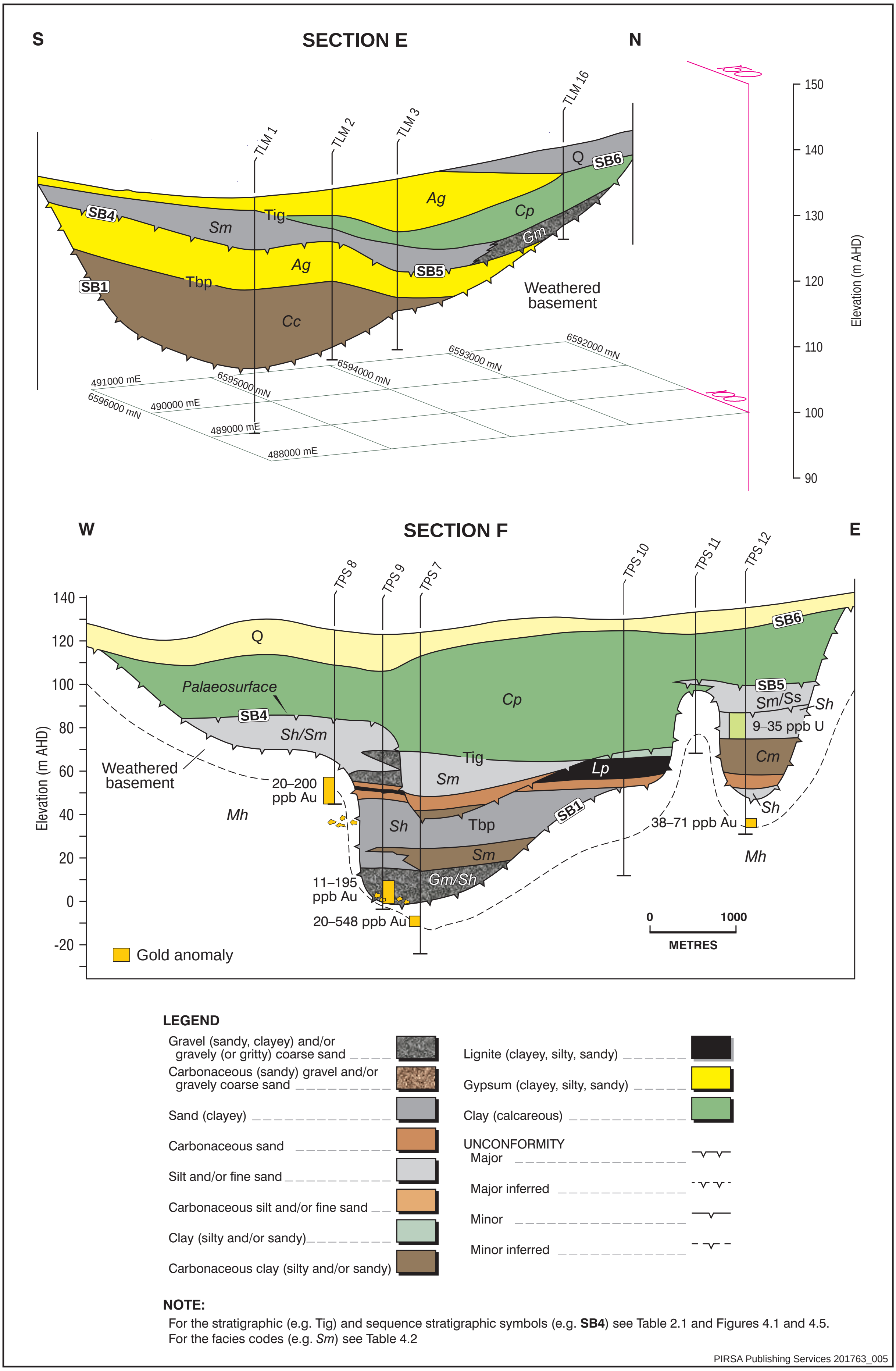

Figure 4.9 Geological cross-sections E (TLM 1 to TLM 16) and F (TPS 8 to TPS 12) and borehole controls, illustrating lithofacies association in the channel sediments. (See Figs 3.11 and 4.5 for section location; see Table 4.2 for the facies codes).

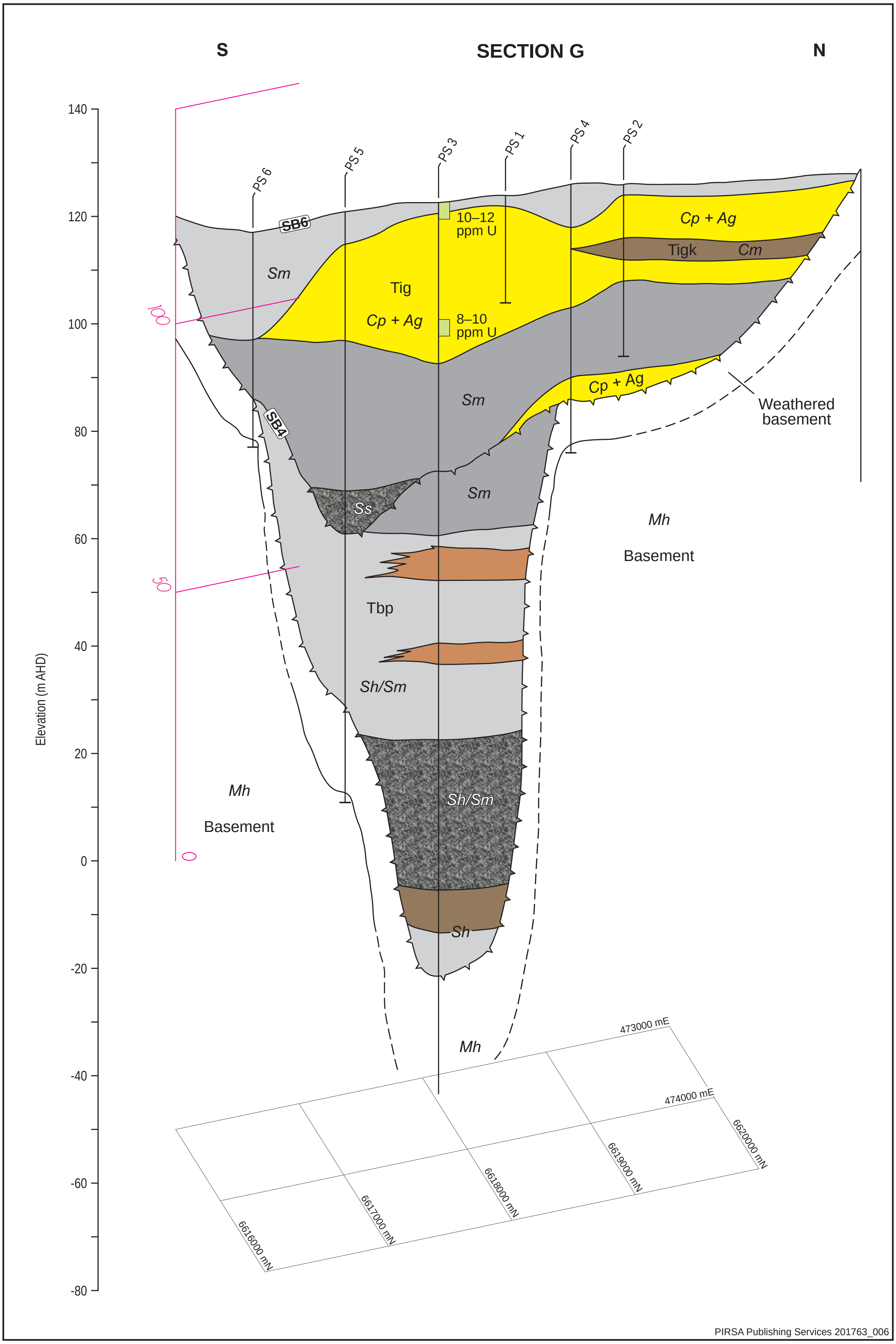

Figure 4.10 Geological cross-section G (PS 6 to PS 2) and borehole controls, illustrating lithofacies association in the channel sediments. (See Fig. 4.6 for legend; see Figs 3.11 and 4.5 for section location; see Table 4.2 for the facies codes).

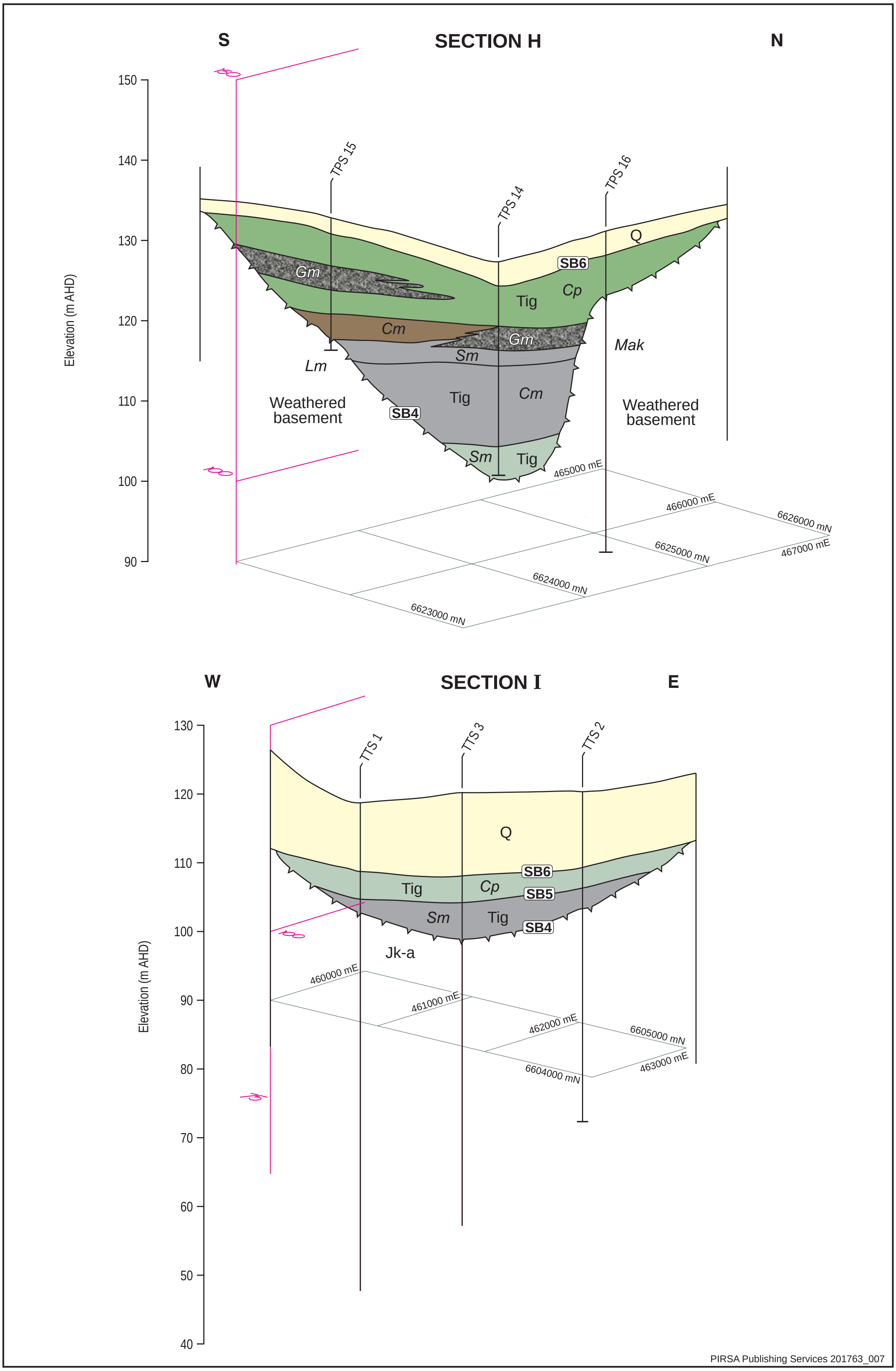

Figure 4.11 Geological cross-sections H (TPS 15 to TPS 16) and I (TTS 1 to TTS 2) and borehole controls, illustrating lithofacies association in the channel sediments. (See Fig. 4.6 for legend; see Figs 3.11 and 4.5 for section location; see Table 4.2 for the facies codes).

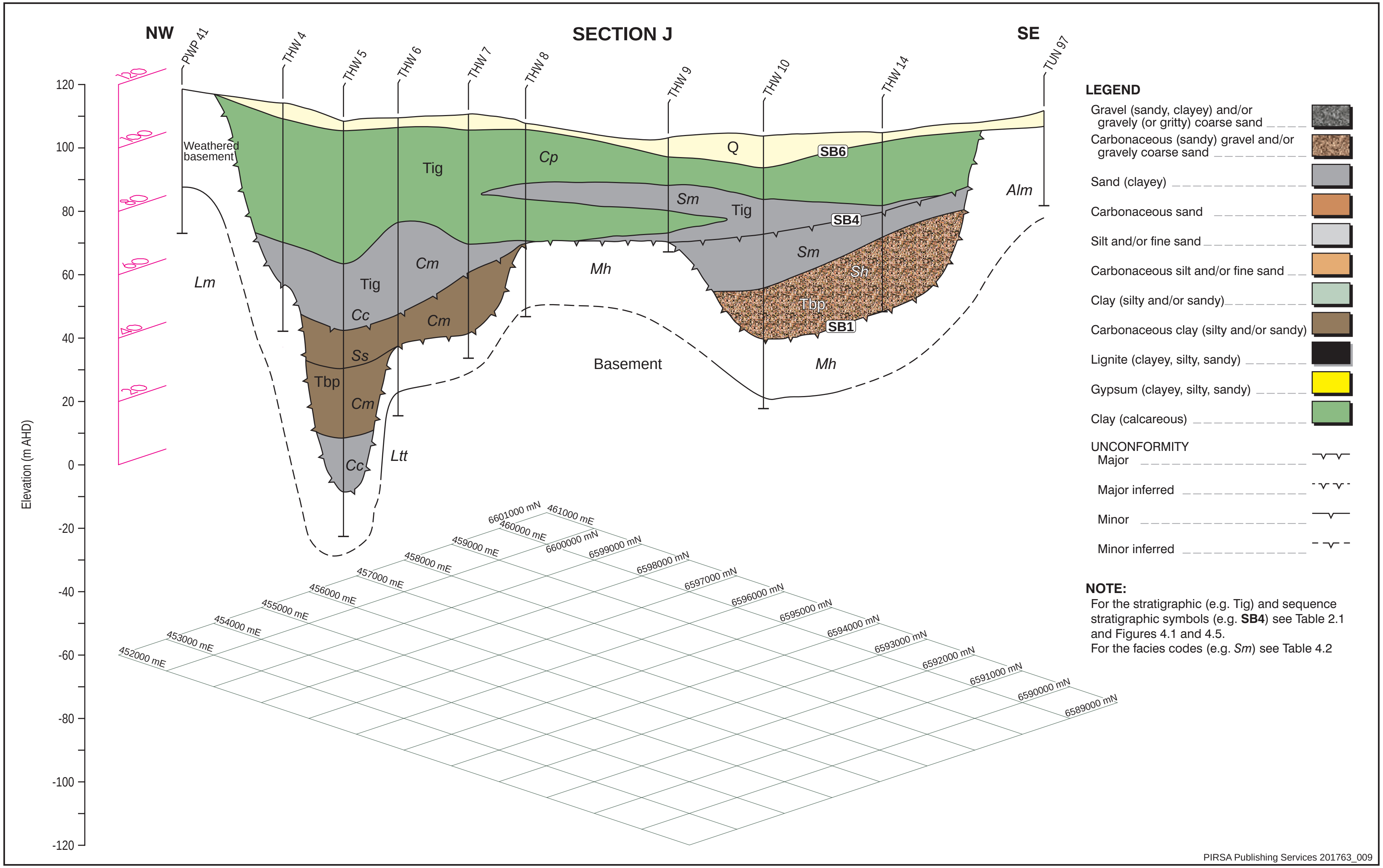

Figure 4.12 Geological cross-section J (PWP 41 to TUN 97) and borehole controls, illustrating lithofacies association in the channel sediments. (See Figs 3.11 and 4.5 for section location; see Table 4.2 for the facies codes).

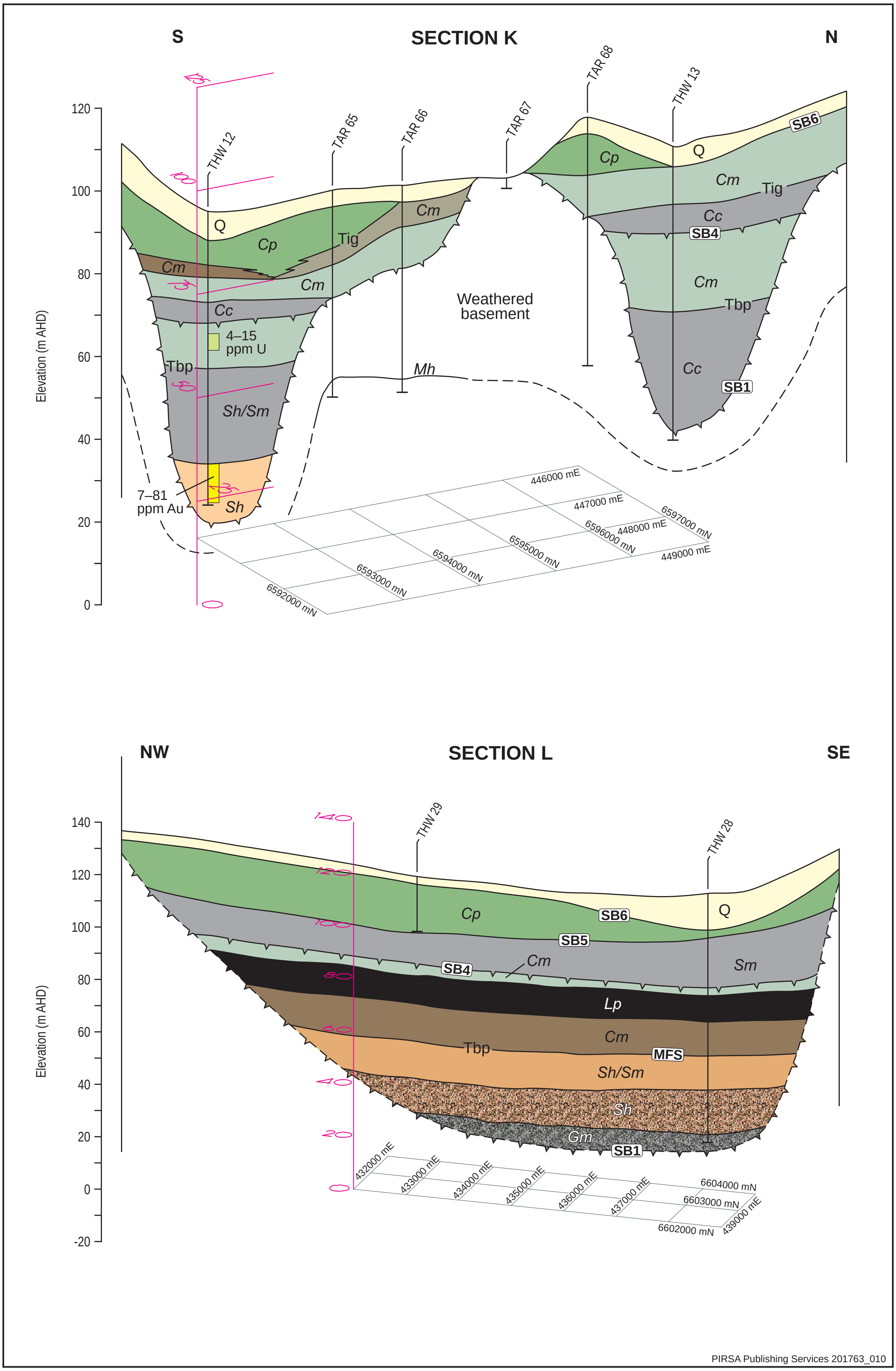

Figure 4.13 Geological cross-sections K (THW 12 to THW 13) and L (THW 29 to THW 28) and borehole controls, illustrating lithofacies association in the channel sediments. (See Fig. 4.6 for legend; see Figs 3.11 and 4.5 for section location; see Table 4.2 for the facies codes).

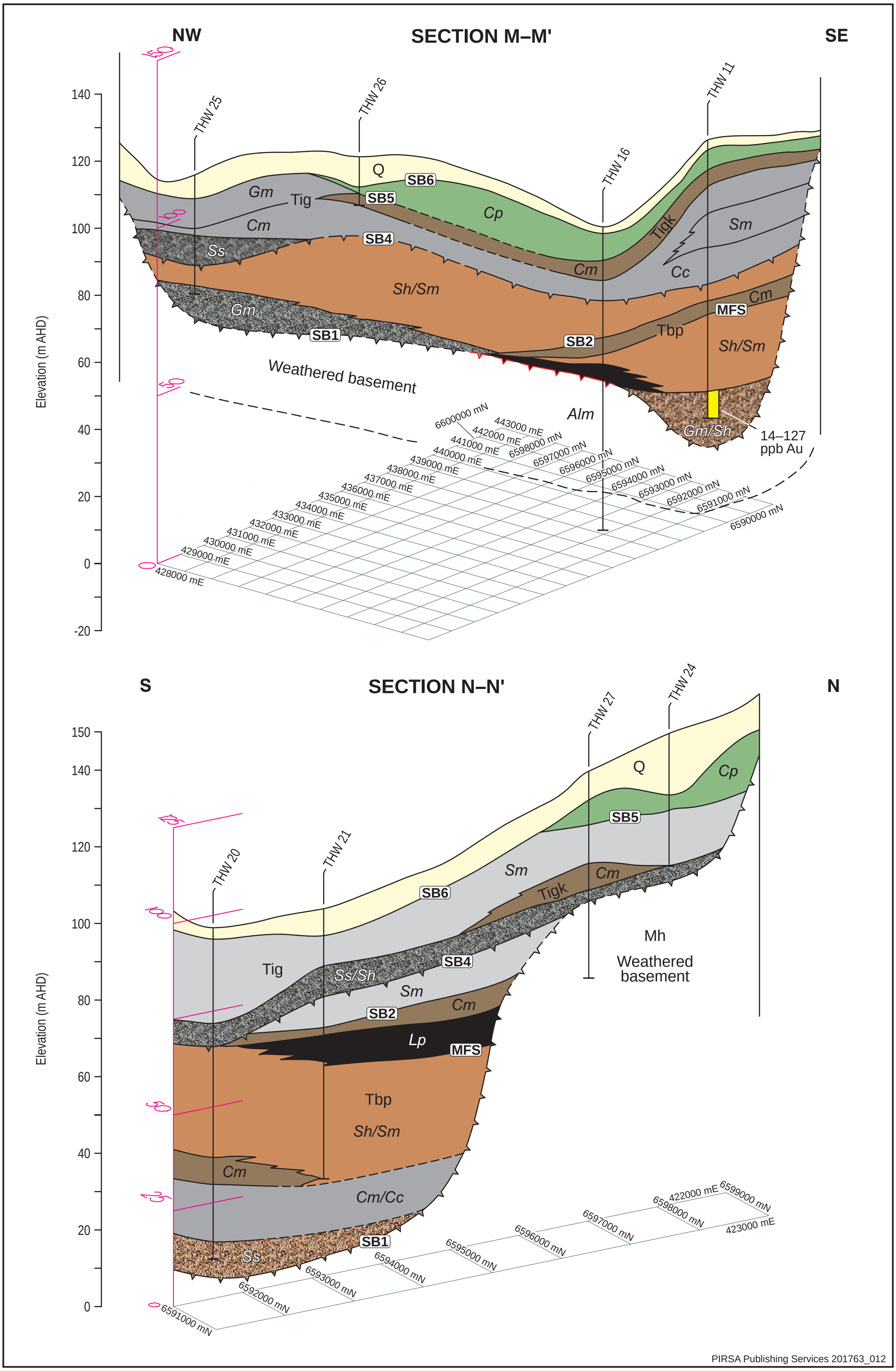

Figure 4.14 Geological cross-sections M (THW 25 to THW 11) and N (THW 20 to THW 24) and borehole controls, illustrating lithofacies association in the channel sediments. (See Fig. 4.6 for legend; see Figs 3.11 and 4.5 for section location; see Table 4.2 for the facies codes).

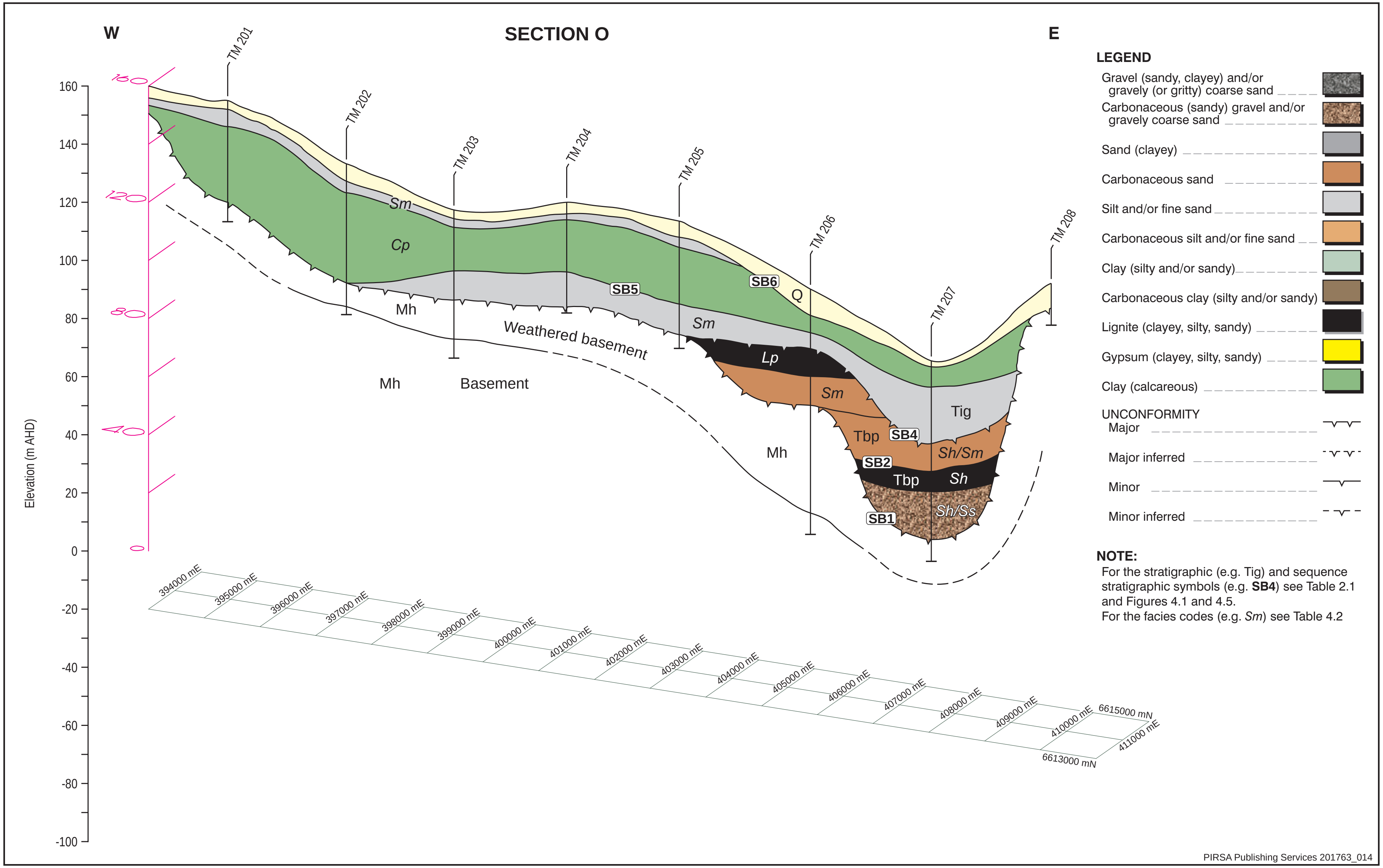

Figure 4.15 Geological cross-section O (TM 201 to TM 208) and borehole controls, illustrating lithofacies association in the channel sediments. (See Figs 3.11 and 4.5 for section location; see Table 4.2 for the facies codes).

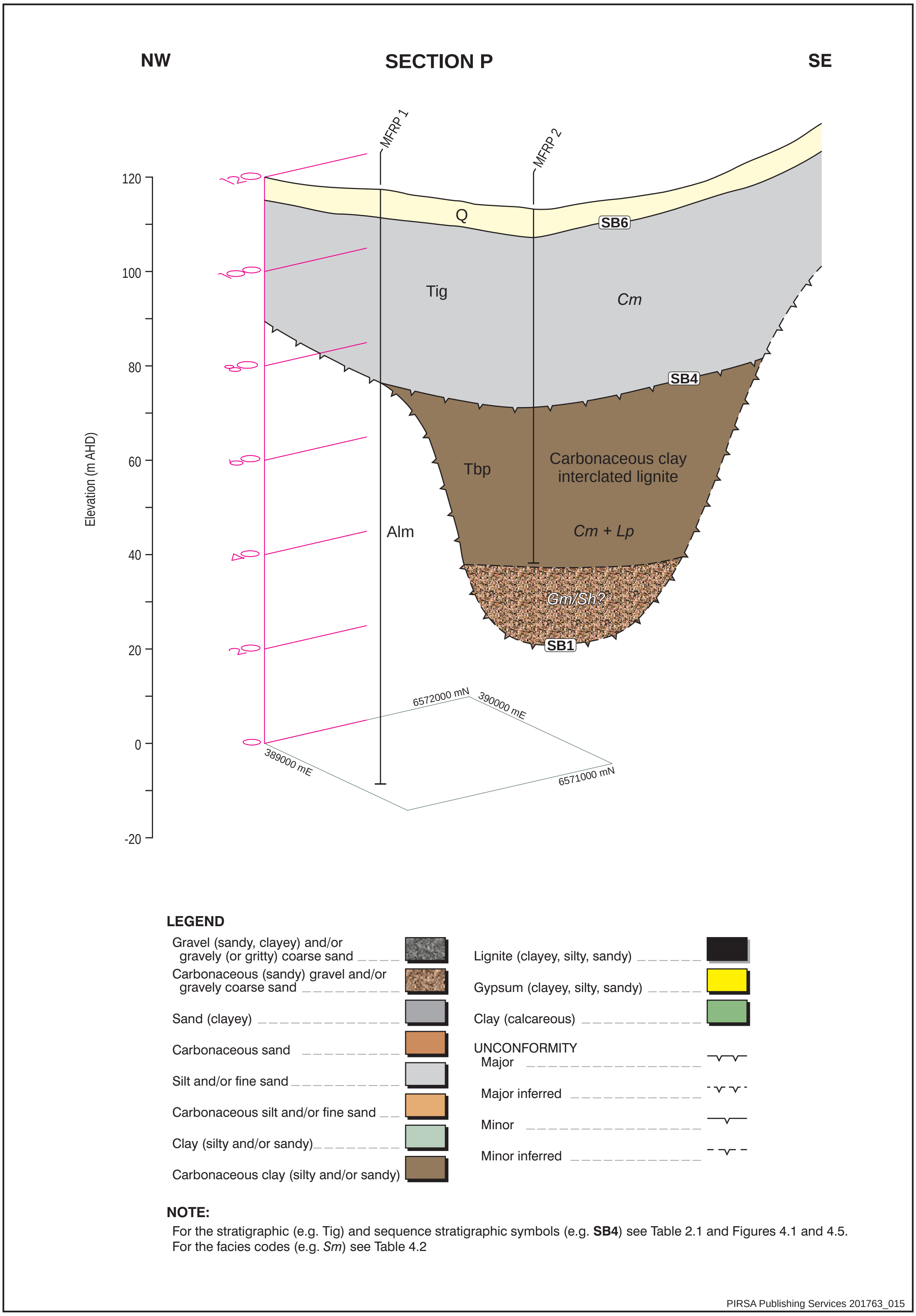

Figure 4.16 Geological cross-section P (MFRP 1 to MFRP 2) and borehole controls, illustrating lithofacies association in the channel sediments. (See Figs 3.11 and 4.5 for section location; see Table 4.2 for the facies codes).

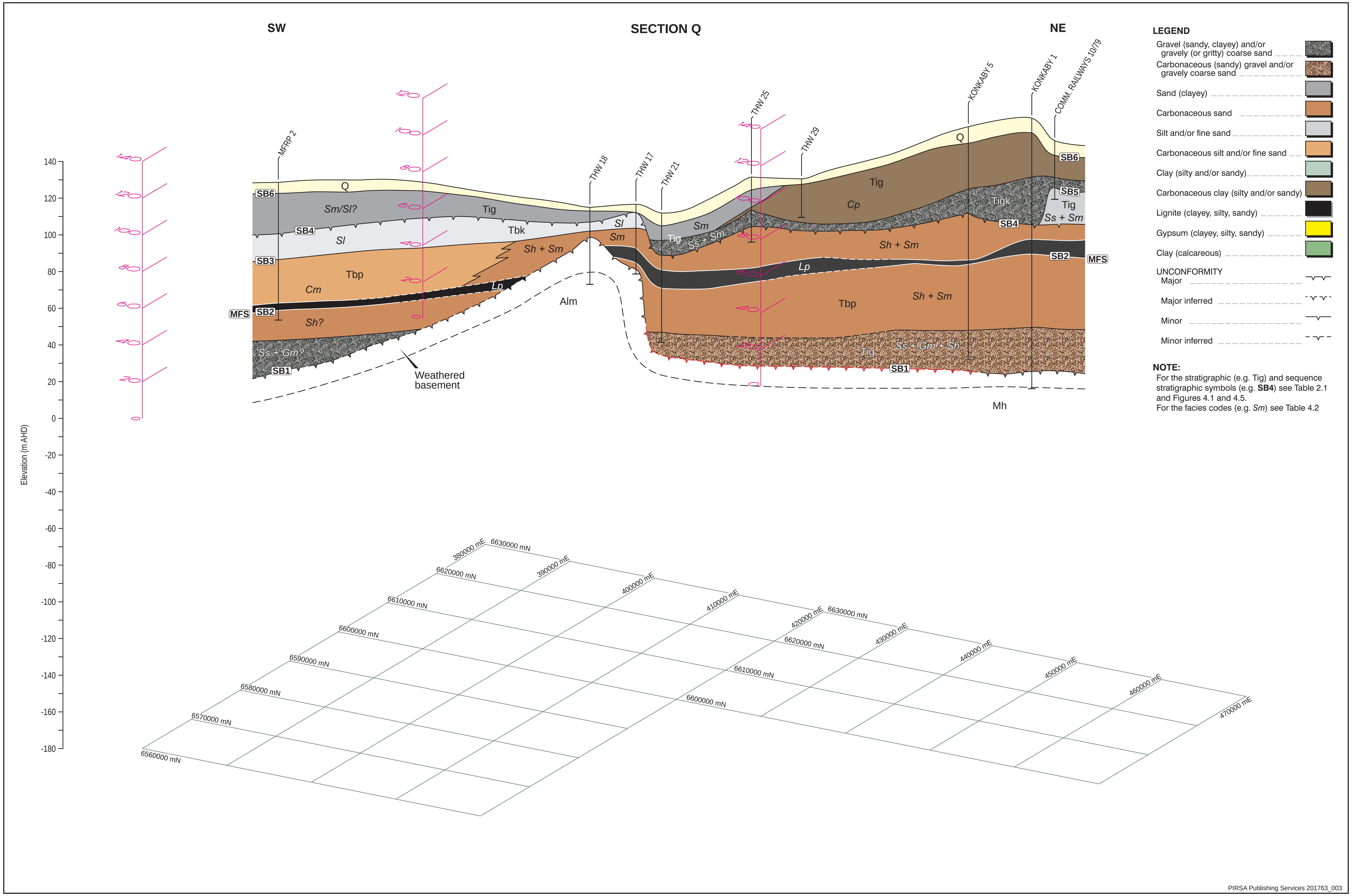

Figure 4.17 Geological cross-section Q (1 of 2; MFRP 2 to Commonwealth Railways 10/79) and borehole controls, illustrating lithofacies association in the channel sediments. (See Figs 3.11 and 4.5 for section location; see Table 4.2 for the facies codes).

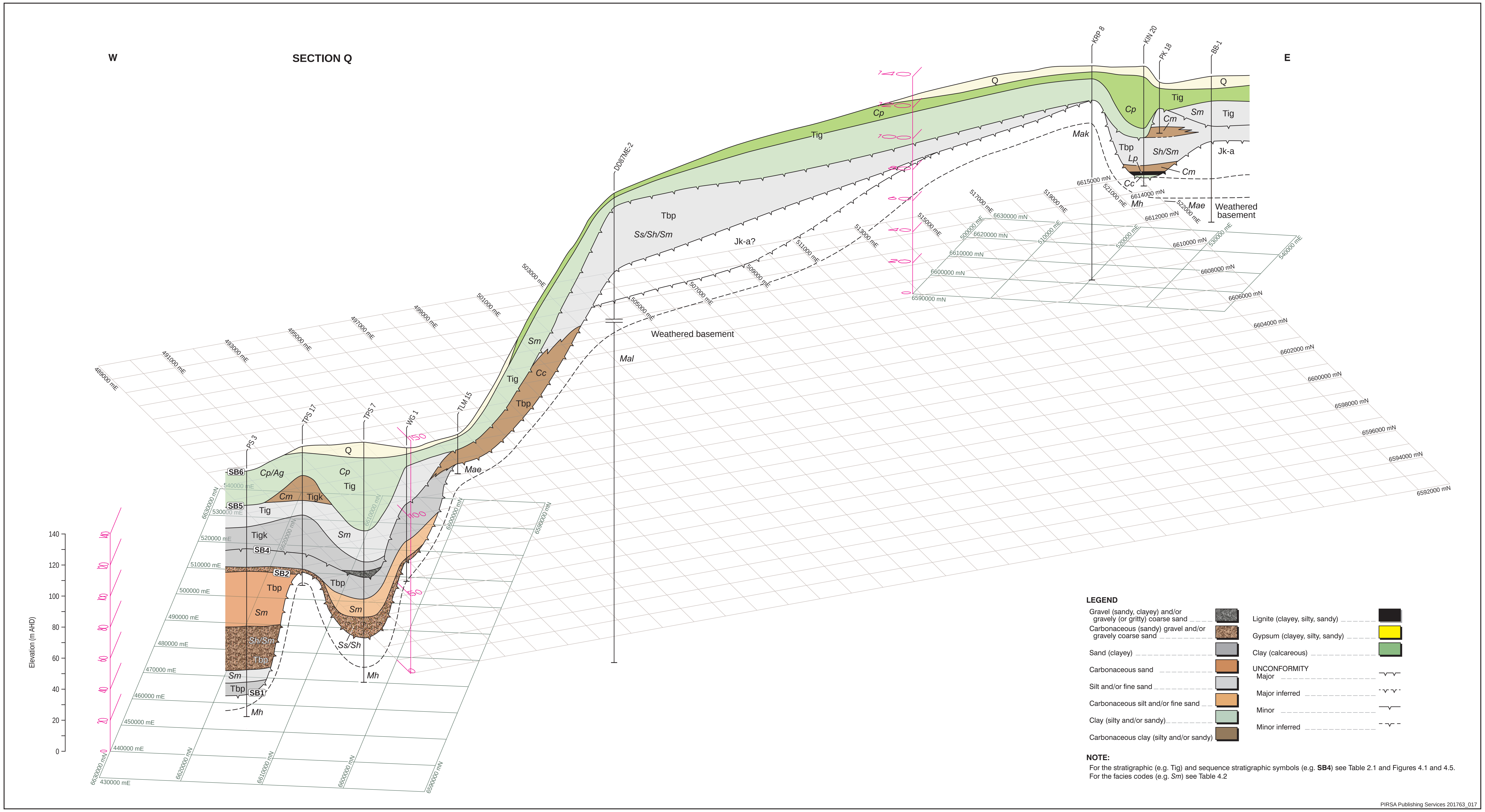

Figure 4.18 Geological cross-section Q (2 of 2; PS 3 to BB 1) and borehole controls, illustrating lithofacies association in the channel sediments. (See Figs 3.11 and 4.5 for section location; see Table 4.2 for the facies codes).

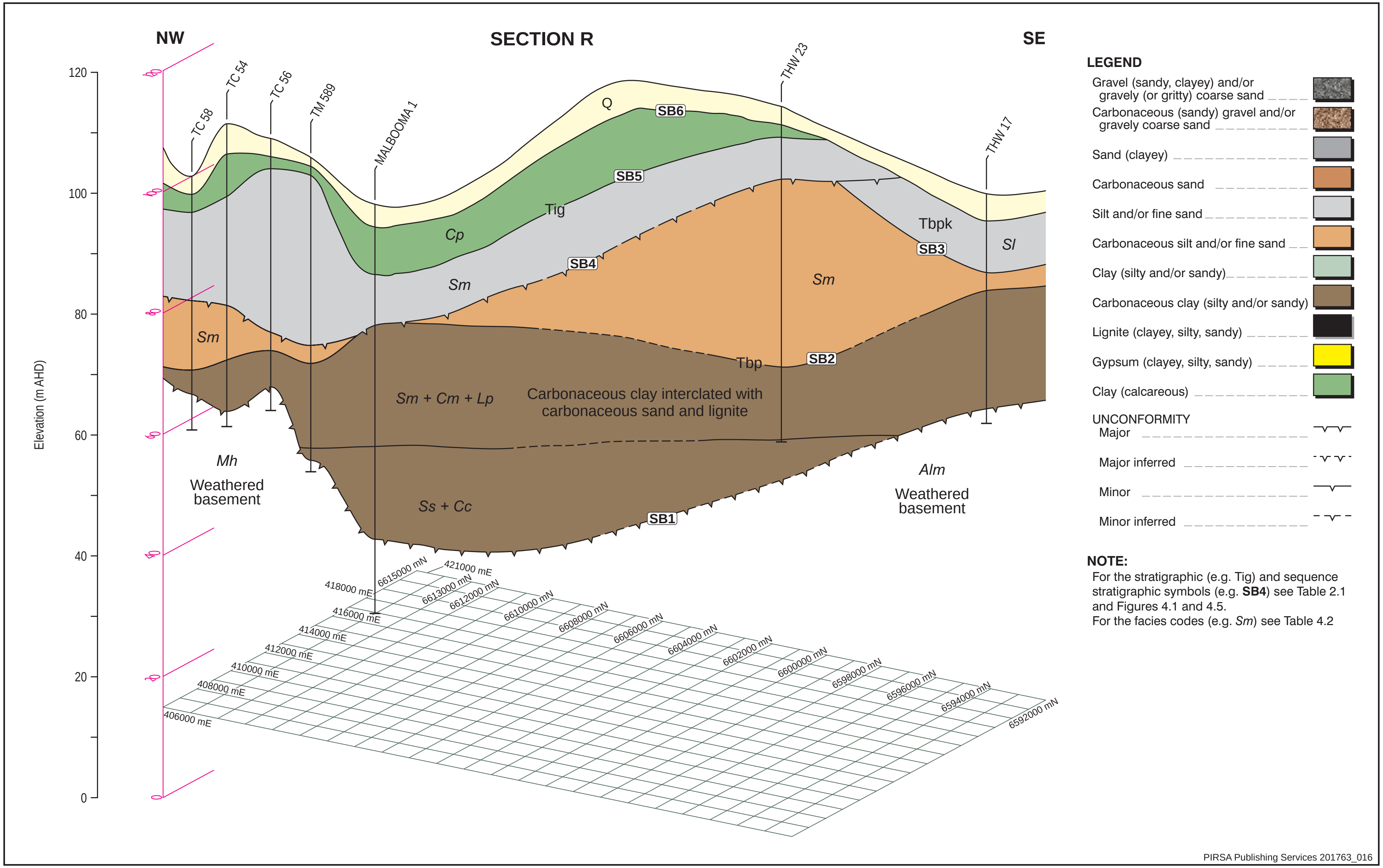

Figure 4.19 Geological cross-section R (TC 58 to THW 17) and borehole controls, illustrating lithofacies association in the channel sediments. (See Figs 3.11 and 4.5 for section location; see Table 4.2 for the facies codes).

Table 4.2 Facies types of the palaeochannel fill the HGB region

Facies*	Lithologic features	Structures, fossils	Interpretation, occurrence
Gm	Gravel, clast-supported, laterally discontinuous	Massive or crude bedding, poorly sorted, sub-angular	(Longitudinal) bedforms, lag deposits, Eocene channel
Ss	Sand, fine to coarse, minor granule and pebble, possibly lignitic	Broad, shallow scours	Scour fill, Eocene and Miocene channels
Sm	Sand, fine to coarse, possibly lignitic	Massive, or weakly laminated	Gravity flow deposits, Miocene channel dominantly
Sh	Sand, fine to very coarse, gravelly, possibly lignitic	Horizontal, poorly sorted, sub-angular, sub-rounded	Channel, transverse/point bars, Eocene and Miocene channels
Sl	Sand, fine to medium with silt, clayey, possibly lignitic	Weakly laminated, well–moderately sorted	Tidal flat, estuarine; Eocene and Miocene channels
Cc	Gritty–sandy–silty clay, possibly lignitic	Crude lamination	Basal channel, Miocene channel dominantly
Cm	(Sandy–silty) clay, very fine sand, silt, possibly lignitic	Massive, weakly laminated	Overbank and/or waning flood deposit, Eocene and Miocene channels
Cp	(Sandy–silty) clay, possibly dolomitic, calcareous	Plastic, massive	Lacustrine, Miocene channel
Lp	Lignite with plant fossils, possibly sandy and/or clayey	Plants, mud films	Vegetated (estuarine) swamp deposits, marsh/overbank, flood deposit, Eocene and Miocene channels
Ag	Gypsum, clayey, silty, sandy	Arid features: crystalline grains, filaments on top	Lacustrine chemical precipitation, Miocene channel

*G, S, coarse member deposits (gravel and sand).

C, L, D, fine member deposits (clay, coal and carbonate).

of Miocene age (e.g. cross-sections A, J, K, O; Figs 4.6, 4.12, 4.15). Several drillholes (e.g. KIN17, TLM8, WG1, TPS7, PS3, THW11, THW12, THW20, THW28) penetrated up to 144 m of Cainozoic sediments, including tens of meters of sandy gravel and/or gravelly coarser sand, overlying granitic basement. These thick zones are distinctly pyritic, weakly carbonaceous and with a very coarse basal unit, which may contain gold anomalies. The typical estuarine-mouth facies of the Khasta Formation is encountered only in the extreme western part of the KPS (cross-section Q; Figs 4.17–18).

Both vertically and laterally, two facies transitions are of particular importance within both Eocene and Miocene channel fills: the transition from fluvial (sandy) gravel and/or gravelly sand and clay to estuarine-channel sand and clay in the alluvial plain; and the transition from estuarine-channel sand and clay to marginal marine or lacustrine sandy clay in the estuarine plain. Posamentier et al. (1988) has found that the fluvial to estuarine facies transition at the landward limit of the estuary is situated in the vicinity of the bayline (nick point), which represents the junction between the low gradient estuarine plain and the more steeply sloping alluvial plain. However, the tidal currents during low-river discharge can extend landward of the bayline, resulting in tidal mud preserved in the channel sand (e.g., Lake Harris tributary; Fig. 3.1); alternatively, high-river discharge during lowstand extends seaward of the bayline resulting in fluvial sand intercalated with tidal sediments (Allen and Posamentier, 1993). The later relationship can be observed in vertical sections in places (e.g., cross-sections A, D; Figs 4.6, 4.8).

4.5 Sequence stratigraphy

4.5.1 SEDIMENTARY SURFACES

Changes in relative sea-level and sediment deposition produce several important stratigraphic surfaces (Posamentier and Vail, 1988; Allen and Posamentier, 1993) which punctuate the palaeovalley fill: the sequence boundary (SB), the transgressive surface (TS), the maximum flooding surface (MFS), the tidal ravinement surface (TRS), and wave ravinement surface (WRS). Although some sequences can be recognised unambiguously by throughgoing unconformity, others may be bounded by more subtle stratigraphic relationships, including conformable contacts.

The basal SB of the Eocene channel is expressed as an unconformity at the channel floor, and the top bounding unconformity is overlain by Middle Miocene fluvial sandy facies. The stratigraphic expression of the bounding surfaces depends on their positions within the channel (Fig. 4.20). In the thalweg, the SB separates fluvial deposits from the underlying bedrock, but it is directly overlain by estuarine sediments on the channel walls. The basal SB of the Miocene channel is expressed as an unconformity overlying the Eocene channel, and the top bounding unconformity is overlain by Quaternary sediments. In the interfluve areas, however, the basal SB of the Miocene channel is expressed as a WRS with transgressive marginal-marine sediments unconformably overlying pre-Tertiary bedrock (Allen and Posamentier, 1993). The stratigraphic expression of the major TS in the channel is characterised by onlap of transgressive estuarine sediments onto the fluvial deposits, whereas on the palaeovalley walls the TS merges with the basal SB. The MFS is expressed as the boundary between a transgressive unit and an overlying regressive unit (Posamentier and Vail, 1988; Allen and Posamentier, 1993), but it is difficult to identify MFS in the distal estuary.

4.5.2 SEQUENCE STRATIGRAPHIC INTERPRETATION

Based on the facies association presented above, systems tracts (facies stacking patterns), key bounding surfaces and sequence models have been used to build a sequence stratigraphic framework of the incised palaeovalleys. Systems tracts, characterised by intergradational and partly contemporaneous facies associations, are defined by their position in a sequence and by the stratal successions bounded by stratal geometry and the types of bounding surfaces (Fig. 4.21). The recognition of consistent vertical stacking patterns of lithofacies units in the boreholes defines each sequence as a relatively conformable succession of genetically related strata bounded by significant subaerial erosion surfaces (Myers and Milton, 1996). Because few drillholes intersect the entire (deepest part) of the Eocene (e.g. TPS9, THW11, THW20, TM207) and Miocene (e.g. TPS7) sequences, and because of erosion (e.g. in drillhole TPS 9, up to 50 m of Eocene channel fill eroded), only representative samples were chosen for the sequence-stratigraphic interpretation, combining these with the regional information (Hou et al., 2001c; Clarke et al., 2003; Hou et al., 2003a). Five major sequences bounded by key stratal surfaces (Fig. 4.21) are recognised.

SEQUENCE 1 (S1)

The basal sequence is bounded below by the basal SB (SB1), is terminated above by SB2/TS, and is predominantly composed of Middle Eocene fluvial facies. The SB1 is a weathered and eroded low-gradient Eocene incised-valley floor and is locally carbonaceous and marked by scouring features (Facies Ss, Table 4.2). This incision is interpreted to have occurred in response to a series of significant relative sea-level falls since the Cretaceous and prior to deposition during the Middle Eocene (Alley et al., 1999; Hou et al., 2003a, b). On the surface, a discontinuous veneer of lowstand conglomerate or conglomeratic sandstone units (Facies Gm, Sh, Sm) suggests that much of the palaeovalleys at this time played more important roles as transport corridors than as depositional settings. Internally, this upward-fining fluvial sequence includes lowstand deposition, thick transgressive deposition, and widespread highstand (carbonaceous) siltstone and mudstone deposited during Middle Eocene (cross-sections F, M; Figs 4.9, 4.14). The transition from the TST to the overlying HST is represented by a downlap surface, indicating the MFS (Posamentier and Vail, 1988), but lithologically this contact can be difficult to recognise (Allen and Posamentier, 1993), particularly in the upper reaches of the palaeovalleys (e.g. cross-section A; Fig. 4.6). In the estuarine channels and adjacent landward reaches, the MFS may be at the downlap surface between the highstand (sandy or carbonaceous) mudstone and/or siltstone and the underlying transgressive units (Fig. 4.21).

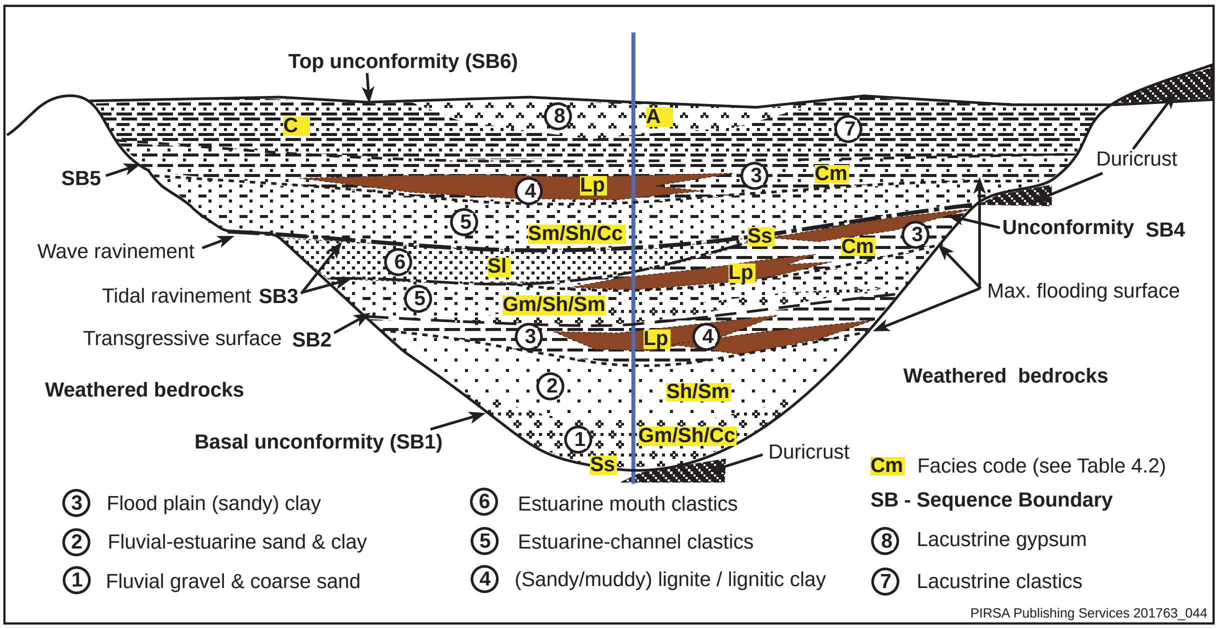

Figure 4.20 Schematic facies and sequence-stratigraphic relationships in the palaeorivers.

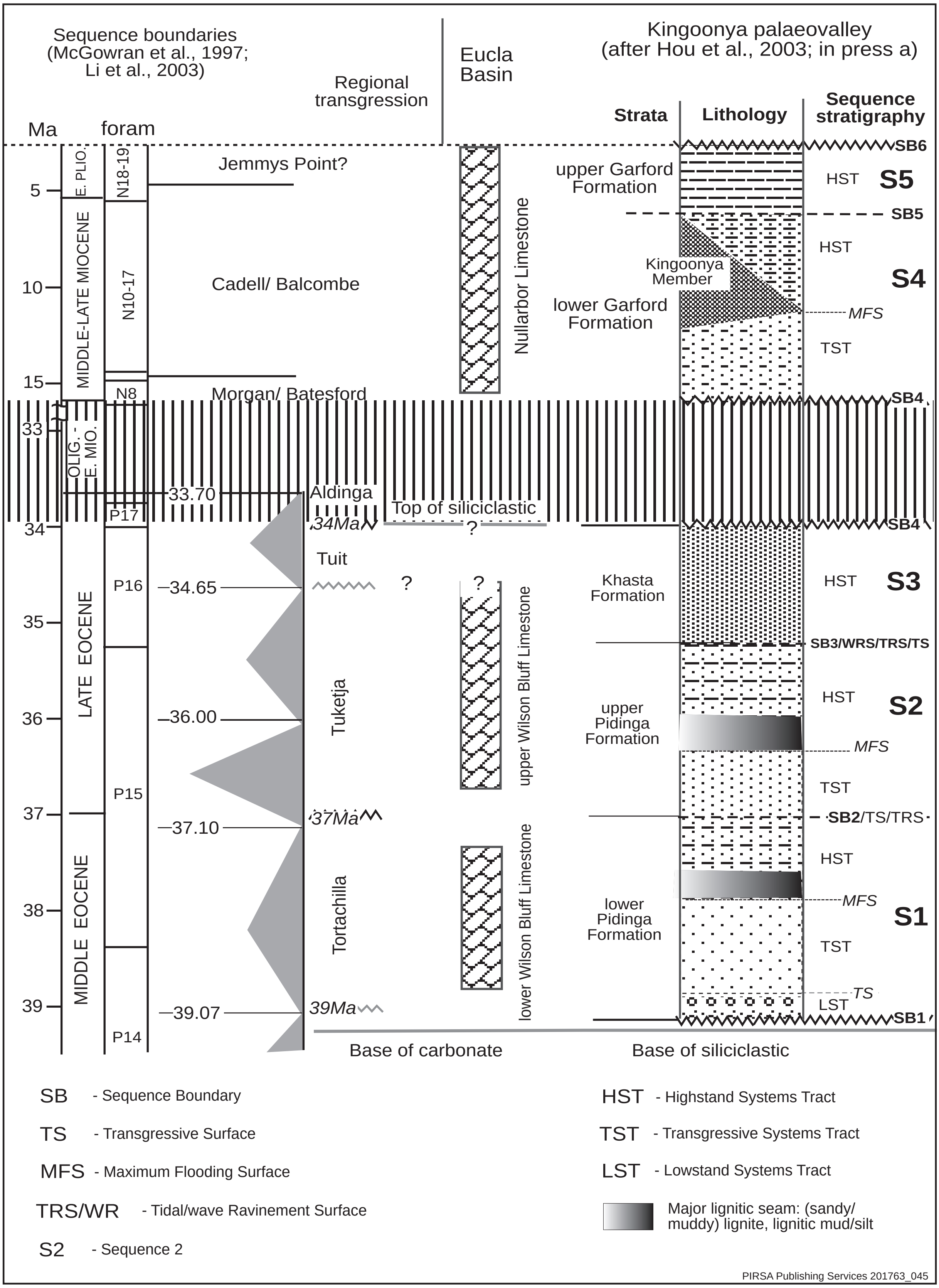

Figure 4.21 Lithotratigraphic and sequence-stratigraphic correlation of the channel sediments.

SEQUENCE 2 (S2)

This sequence is bounded at the base by SB2/TS/TRS, at the top by a major SB (SB3)/WRS/TRS (in the outer channels) or SB (in the inner channels) and is predominantly composed of estuarine-channel sediments. Across the SB2/TS/TRS there is a facies shift from underlying highstand condensed intervals (Facies Cm, Lp of S1) into transgressive coarser sandy beds (Facies Sh, Sm of S2). Locally, thin, sandy conglomerate beds (Facies Gm) within S2 also onlap onto the SB2/TS/TRS (e.g. cross-section F; Fig. 4.9). This surface, believed to be associated with a third-order sea-level event (Hou et al., 2003a; b), also roughly marks the transition from the lower part to the upper part of the Pidinga Formation (Fig. 4.21). Sequence 2 developed progressively from transgressive to highstand deposition in the estuarine-alluvial plain during the Late Eocene transgression (Hou et al., 2003b). The lack of lowstand sediments within S2 suggests that there was not a major relative sea-level fall prior to the deposition of S2; another marine transgression (relative to S1) apparently occurred shortly after the flooding deposition of S1 sediments (Fig. 4.21). The aggradational to retrogradational turnaround (Myers and Milton, 1996) at the base of S2 is a composite boundary (Reynaud et al., 1999), as this surface appears less erosional than those at the base of S1 (Posamentier and Vail, 1988). This explains the lack of LST at the base of this sequence. In this interpretation there is no need for a significant sea-level fall at this time and the channels are believed to have filled with sediment during the overall relative sea-level rise.

SEQUENCE 3 (S3)

This sequence is bounded below by the SB3/TRS/WRS/TS and at the top by SB4/TRS/WRS, and shows the strongest marine influence within the Late Eocene succession (cross-sections O, Q; Figs. 4.15, 4.17–18). The SB4 is expressed as an unconformity between Eocene and Miocene sediments, and the top of S4 has undergone deep weathering and erosion. The S3 has marginal marine – estuarine features and is a gradual transition of strata across the SB3/TRS/WRS/TS, with estuarine mouth sand wedges progressively onlapping across the surfaces towards the land. S3 is absent in the middle and upper reaches of the Kingoonya Palaeochannel (cross-sections Q; Figs 4.17–18).

SEQUENCE 4 (S4)

This sequence is bounded below by the SB4/TRS/WRS and at the top by SB5/TS, and is the marine influenced sequence within the Miocene succession. The SB5 is expressed as TS below Miocene lacustrine sediments, but it is evident that the top of S4 represents a facies transition from estuarine-channel to restricted lacustrine sediments. The TRS and WRS occur at two different locations: upon underlying channel sediments, and on interfluves of pre-Tertiary weathered bedrock. However, the erosional break at the top of the S2/S3, represented by the TRS, provides evidence for a relative sea-level rise (Hou et al., 2003b). The TRS and WRS surfaces are interpreted as time equivalent, due to the nature of the transgressive shoreline erosion (Swift, 1968; Allen and Posamentier, 1993). The S4 has estuarine features and is a gradual transition of strata across the SB3/TRS/WRS, with carbonaceous beds progressively onlapping across the Miocene channel floors towards the land. Overall, the rate of accommodation development was greater than the rate of sediment supply during the initial deposition of this sequence, thus allowing overall landward progradation. Tidal and/or wave erosion associated with retreat of the shoreline resulted in removal of several metres of the upper Pidinga sediments (e.g. cross-section F; Fig. 4.9; as per the model proposed in Demarest and Kraft, 1987). Consequently, across the estuarine plain, wave-dominated transgressive-highstand sand and clay overlie either the interfluves or the estuarine sandy and muddy facies in the palaeovalleys (cross-section Q; Figs 4.17–18; as in the model proposed in Allen and Posamentier, 1993). It is evident that the eroded (reworked) carbonaceous mudstone, siltstone and lignite from substrate Pidinga Formation were deposited in the Miocene channels, possibly along a transgressive surface (Hou et al., 2003a; b, c).

Sequence 5 (S5)

This sequence is bounded below by the SB5/TS and above by SB (SB6), and is the youngest sequence within the Tertiary succession (Fig. 4.21). The SB5 is expressed as an unconformity between Tertiary and Quaternary sediments, and the top of S5 has undergone weathering. S5 consists dominantly of highstand lacustrine clay and dolomitic carbonate (Facies Cp, Dp).

4.6 Palaeoclimate

At the time Tertiary palaeochannels first formed, and for a time thereafter, the climate of southern Australia was generally warm and wet (Alley and Beecroft, 1993; Benbow et al., 1995b; Alley et al., 1999; Frakes, 1999). Key events in the history of the Gawler Craton and the Eucla Basin margin were the apparently episodic duricrust-forming episodes in the Early to Late Eocene, the Middle Miocene and the Late Pliocene (McGowran, 1979). The evidence from Eocene megaflora and microflora remains suggests at least local warm-temperate rainforest conditions (Alley et al., 1999); this is supported by the widespread accumulation of lignites along the southern continental margin. Aridity in the region increased markedly beginning in the Late Pliocene.

Tertiary climate modelling of the Gawler Craton suggests that palaeochannel incision most likely took place by means of moderate spring runoff in the early Eocene and coincident with lowstands of sea level (Hou et al., 2001c). Any earlier drainage networks were probably ephemeral and replaced by Eocene ones (Hou et al., 2003a). In this region, the later extensive deposition of carbonaceous sediment and lignite in the palaeochannels implies wet and probably warm conditions, but relatively low evaporation for a lengthy period. The evidence of high rainfall and rainforest growth from palynological studies is indicative of much higher rainfall and runoff during the Eocene (Kemp, 1978; Pitt et al., 1978; Hos, 1978; Alley, 1985; Benbow et al., 1995b, Alley et al., 1999). Variations in Eocene runoff may have contributed to local, possibly even more extensive, erosion as well as subsequent deposition. Erosion of the latest Eocene channel fill may possibly have been caused by Oligocene runoff prior to Middle Miocene deposition (Hou et al., 2001c).

In the upper Garford Formation, calcareous clay intercalated with gypsum and halite, deposited in extensive lakes and palaeochannels during the evaporation of waterbodies, are indicators of warm and arid climates. The gypsum and ferruginous cappings formed during the Early Pliocene suggest arid conditions, and the development of silcrete may be correlated with times of major cooling in the Early Oligocene and the Early Pliocene. The ferruginisation may mark peaks of warmth (Benbow, 1982). Associated weathering resulted in widespread kaolinisation at the sequence boundaries, indicating warm and humid climates where extensive leaching could take place (Folk, 1968). Thus these systems suggest a change from humid toward arid environments since the Eocene. It might be expected that rainfall, and the resulting runoff, would have increased during times of warming, owing to the greater capacity of warm air to accept (and precipitate) water, relative to cool air (Frakes, 1999).

4.7 Environment and evolution of the palaeochannels

4.7.1 DEPOSITIONAL ENVIRONMENTS

The Eocene channels mainly developed on irregular pre-Middle Eocene landsurfaces (Fig. 3.13). Miocene incision into the Eocene sediments and adjacent weathered basement, and the irregular contact between the Eocene and Miocene sediments of the channels indicate a sequence boundary (cross-sections A–B, D–H, J–Q; Figs 4.6–18). The Pidinga Formation and the lower Garford Formation were deposited in a range of environments, from alluvial–fluvial (channel), through floodplain (overbank, swamp), estuarine to marginal marine, under terrestrial conditions characterised by plant associations growing in high-rainfall tropical–subtropical environments (Alley, 1985). The carbonaceous facies, well developed in both Eocene and Miocene channels, suggest that the floodplain in the estuarine-channel area experienced a climate suitable for the growth of abundant vegetation. The Khasta Formation was mainly deposited in the marginal marine – estuarine mouth environments of Late Eocene, while the greenish clay and carbonate sediments of the upper Garford Formation were deposited in extensive lakes and palaeorivers. The dominance of extremely fine clastic and chemical sediments of the upper Garford Formation in the palaeochannels suggests that, although water was at times plentiful, the flow was not sufficiently vigorous to flush clay out of the river system, and water was often ponded for extended periods. Subsequent drying of these lakes or channels led to deposition of regressive dolomitic clastic and chemical sediments.

The conglomerate-dominated deposits of the LST are not everywhere well developed across the incised valleys, because rates of accommodation and sediment supply varied greatly. Myers and Milton (1996) considered that on the ramp margin, the relatively thin lowstand wedge may reflect two situations: either stream incision with major sediment by-pass of the coastal plain, or the filling of incised valleys and continued shoreline progradation due to a relatively slow sea-level rise (Hou et al., 2003b). The bulk of the TST formed during the successive rapid rise of relative sea-level, as is indicated by the increase in thickness of the sequence basinward (cross-section Q; Figs 4.17–18). This favoured the formation of meandering fluvial and estuarine channels with predominantly medium to fine-grained deposits. The estuarine facies is likely to have been retrograding landward, and the grain size of sediment supplied to the marginal basin had a strong influence on sedimentary facies during marine transgressions (Myers and Milton, 1996); this explains the landward migration of the shoreline from Eocene to Miocene transgressions. As the accommodation space decreased (relative sea-level fell) and approached zero with the channel's grade reaching the final equilibrium profile in the HST, there was a change from vertical stacking into lateral grading, resulting in the deposition of condensed intervals of very-fine grained sandstone and/or mudstone in the HST (Aitken and Flint, 1995).

4.7.2 EVOLUTION OF THE KPS AND RELATED LANDSCAPE

A significant period of landscape stability occurred throughout most of the Gawler Craton during the Mesozoic, when deep chemical weathering predominated, yielding leached kaolinitic profiles to depths of >50 m (Lintern and Sheard, 1999). Thick sedimentary units like the kaolin-rich Jurassic Algebuckina Sandstone are derived for the most part from this regionally weathered landscape. The significant hiatus between the Late Cretaceous and Middle Eocene in the region documents this long interval of non-deposition and/or erosion before deposition of Pidinga Formation commenced (Alley and Beecroft, 1993). Then, although much of the HGB region was undergoing erosion, possible accelerated gorge erosion combined with subsidence of the Eucla Basin probably led to deposition of basal coarser sands in palaeoriver systems and finer grained, carbonaceous sediment in restricted swamps and lakes (Fig. 4.22a).

During the Middle Eocene (Zone P14, Fig. 4.1), estuarine conditions migrated up into the palaeochannels while freshwater sedimentation developed elsewhere in channels, swamps and lakes (Figs 4.22b–d). During the Late Eocene (Zones P15–16), the shoreline extended much further inland and led to deposition of estuarine mouth facies in the lower reaches of the palaeochannels (Fig. 4.22d). The Late Eocene depositional episode was followed by regression, judging by the erosional break between the Pidinga the Garford Formations. The regression is probably equivalent to the major sea-level lowstand of the Chinaman Gully regression (Alley et al., 1999; McGowran, 1989). Extensive silicified sand and silcrete on the top of Pidinga sediments in the region may have formed during the Oligocene to Early Miocene. The Oligocene to Early Miocene weathering and erosion were followed by the Middle Miocene transgression (Zones N9–11; Figs 4.22c–d). During the Late Miocene to Early Pliocene (Zones N18–19), lacustrine clay and dolomitic carbonate were deposited on the Middle Miocene sediments in places (Fig. 4.22d). The limited and/or isolated dolomitic carbonates with gypsum at the top of the Garford Formation suggest increasing aridity and indicate that the palaeochannels were fragmented into chains of relatively small lakes in the late arid stages of the Early Pliocene (Fig. 4.22e).

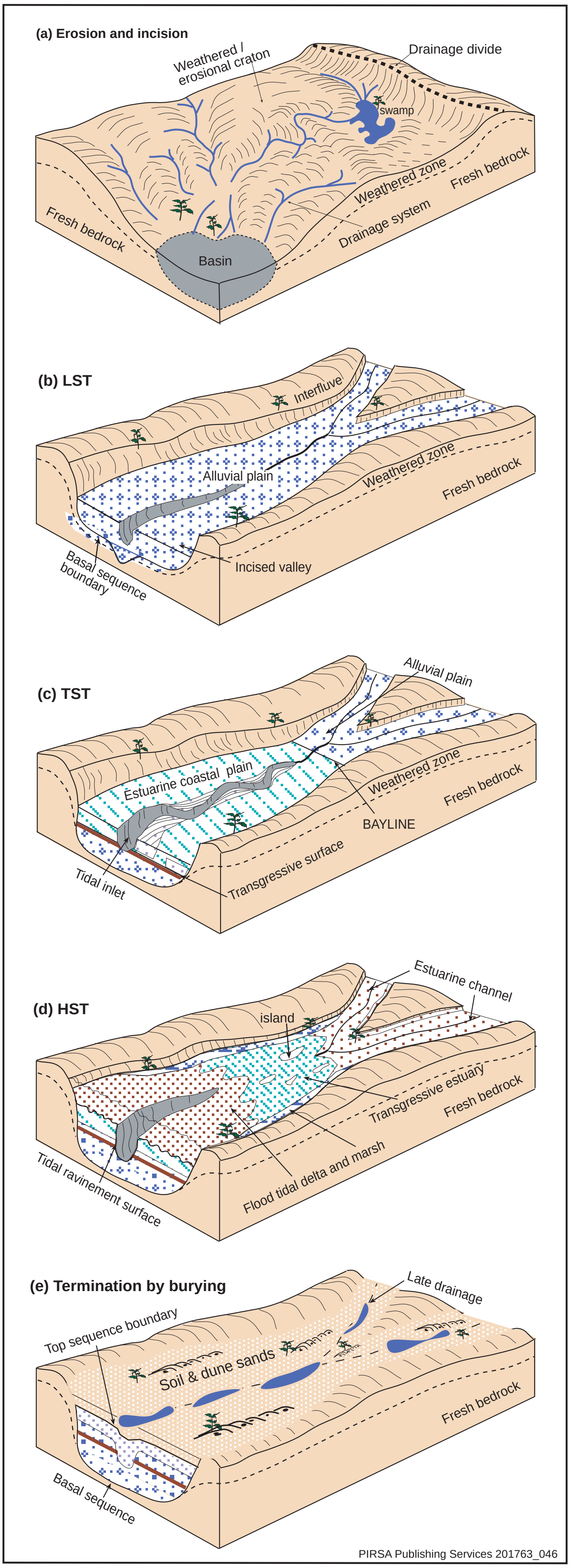

Figure 4.22 Schematic model of geological evolution of the Kingoonya Palaeochannel: (a) erosion and incision with subsidence of basin; (b) early sedimentation during LST; (c) transgressive sedimentation during TST; (d) landward migration of the estuary during HST; and (e) termination; (after Hou and Alley, 2003).

5 KPS EXPLORATION ANALOGUES AND KEY TARGETS

5.1 Preamble

The HGB region has great exploration potential, including palaeochannel mineralisation, but exploration activity is essentially model driven because of poor outcrop. A greater understanding of locally mineralised geological terrains as well as of carefully selected examples from elsewhere in Australia and internationally will encourage focussed, and thus successful exploration in the HGB region. From comparison with other mineralised provinces it can be predicted that orebodies will have a broad size range. Primary analogues in the basement rocks (e.g., compared to the Yilgarn Craton of WA) may be concealed by the extensive regolith cover, including palaeochannels. The recent discovery of Archaean granite–greenstone belts in the HGB region (see other HGB Program reports) suggests that there is potential for Archaean granite–greenstone type deposits in the Gawler Craton of South Australia. However, due to the cover in the HGB region, little exploration has been carried out for Archaean gold and komatiitic nickel deposits.

Placer analogues will be sited on channel bases adjacent to bedrock deposits that contain primary gold (Hou and Alley, 2003). The highly weathered basement zone will be altered and leached by supergene fluids and contain evidence of supergene and residual gold, implying the presence of primary gold at depth (Fig. 5.1). The uranium-rich channel sediments will have a distinct radioactive anomaly reflecting uranium within the sandstones (Fig. 5.1). The discovery of the Warrior and Narlaby uranium prospects, in the western part of the KPS and south of the KPS (Fig. 2.1), appears to fit this typical sandstone uranium model (Hou et al., 2001c). Other potential resources, such as palygorskite and groundwater also probably occur in the palaeochannels.

5.2 Gold

The palaeorivers are the main depositional environments of placer enrichment and their coarse clastic facies probably are the main lithofacies hosting placer gold mineralisation. Pre-depositional factors such as the source rock, weathering history and transport conduit to the depositional site are also important parameters in the formation of placer deposits. Because of their low transportability, detrital gold deposits occur in river channels and deeply weathered profiles near their sources (Batchelor, 1984). Concentration of gold and other minerals into alluvial sediments in several major provinces (e.g., Yukon, Alaska; California; Australia) was coincident with times of deep weathering and intensely humid palaeoclimates of the early Tertiary. The KPS is probably the type system for secondary gold mineralisation located very near the source gold orebody (Fig. 1.1). Studies of the HGB region indicate that high-grade gold associated with basement granulite facies is probably a major source for secondary gold mineralisation.

Most lode gold provinces elsewhere in the world, where erosional and preservation regimes are favourable, have some associated placer gold (Boyle, 1979). The discovery of significant gold enrichment associated with Tertiary palaeochannels within the Yilgarn Goldfields of Western Australia (e.g., Higginsville, Lady Bountiful Extended, Kanowna, Zuleika), after decades of often intense exploration by many companies, implies that similar success may come far more slowly than we would like, but it will likely happen, since traces of placer and supergene gold associated with the channels have been found throughout the HGB region. For example, gold anomalies in drillholes THW 10 and THW11 (Freytag et al, 1984; Afmeco and Aberfoyle, 1991); TPS 7–12, up to 548 ppb Au (Freytag et al., 1983, Fig. 4.9); and KRP5, up to 0.06 ppm Au, and TP13 with 7.5m @ 2.73g/t Au and 4.5m @ 3.22g/t Au (Geoex et al., 1984).

Placers often overlie old erosion surfaces representing long periods during which weathering and erosion were active. The goldfields of the HGB region have been exposed for a long period of geological time, which resulted in considerable weathering and erosion and alluvial channel deposition in the Tertiary. However, significant channel deposits have not yet been

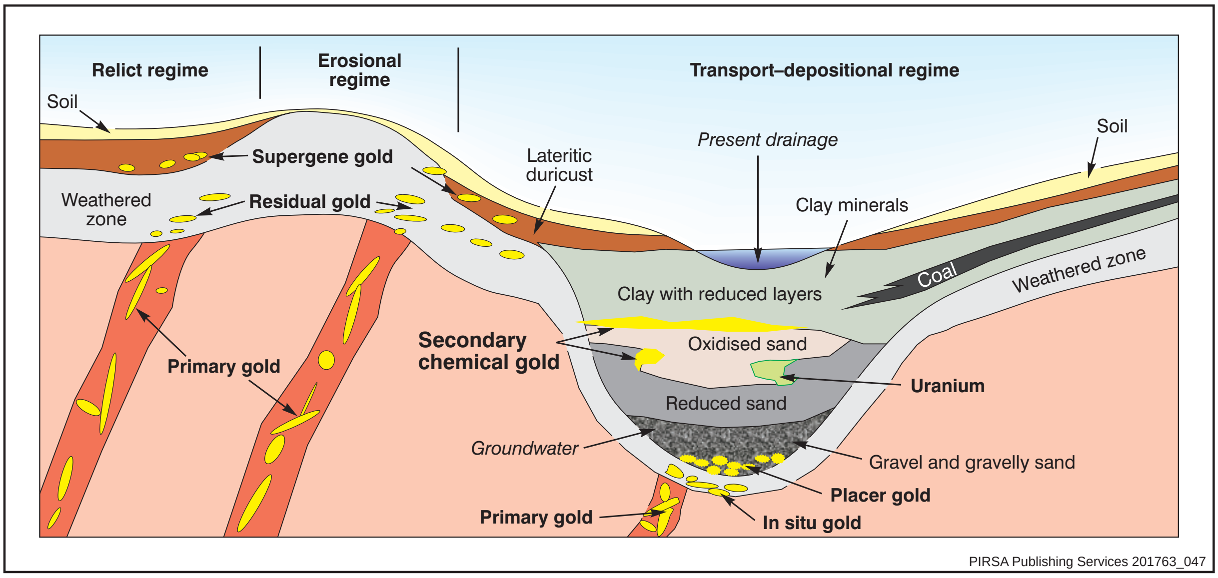

Figure 5.1 Mineralisation model in the palaeodrainage terrains (after Hou and Alley, 2003).

located, in contrast to gold placers in the Tertiary palaeochannels of Western Australia (Hou and Alley, 2003). Economic palaeochannel mineralisation probably overlies or is adjacent to economic to sub-economic primary gold mineralisation within Precambrian bedrock, and the channels tend to follow the Mesozoic to early Tertiary topographic lows. Placer deposits are most likely to accumulate immediately downstream from the juncture of tributary streams of any order (e.g., MacKay, 1921; Boyle, 1979). Also important is the angle of the juncture; placer deposits are more likely to form when the streams meet at high angles in map view. Channel bends and changes in channel gradient, because they are subject to changes in stream velocities, are also likely sites for accumulation. However, many small irregularities will not be detectable in exploration of buried channels, and this is unfortunate because experience has shown that valuable alluvial placers are often trapped in centimetre to metre-scale depressions.

5.3 Uranium

Many — perhaps most — of the known uranium ore bodies that occur in sedimentary rocks have been found in essentially undisturbed continental sandstones of Mesozoic and Cainozoic age. A general model widely used as an exploration guideline is, in the broadest and simplest sense, one in which mobilised uranium from peripheral basement areas has circulated in alkaline groundwater through porous strata and been precipitated when it entered a reducing environment such as within carbonaceous sandstone. Such mineralisation associated with redox fronts near the contact of carbonaceous and variably oxidised phases has been illustrated by a number of examples in North America (e.g., Adams, 1991) and South Australia, such as Honeymoon and Narlaby palaeochannel mineralisations (Mckay and Miezitiz, 2001). Thus, a general model of Tertiary uranium mineralisation in South Australia can be suggested in which the pre-Cainozoic 'bedrock' is at least sporadically uraniferous in places; the Cainozoic contains porous and carbonaceous sands that cover large areas and are little deformed, and a major climatic episode occurred leading to the generation of prevailing alkaline groundwater during Tertiary time (Hou and Alley, 2003).

Exploration companies (e.g., Afmeco and Aberfoyle, 1991) have found numerous uranium anomalies in channel fills, indicating high values from drillholes TCL 1–3, TCL 6–7, TCL 13, TCL 20–21 and TCL 31 (10–455 ppm U at 1–41 m), PS 6 (14 ppm U at 10–12 m), WG 1 (6–12 ppm U at 43–49 m), TPS 12 (35 ppm U; Fig. 4.9), PS 3 (10–12 ppm U at 2–8 m and 8–10 ppm U at 19–22 m) and PS 5 (6–10 ppm U at 0–12 m). Water samples from these drillholes also show uranium anomalies (e.g., 11–37 ppm U from drillholes PS 6, TLM 2, TLM 3, WG 1; Afmeco and Aberfoyle, 1991). In the NW tributaries (e.g., the upper reaches of the Malbooma Palaeochannel) of the KPS in the HGB region (Fig. 2.1), several uranium mineralisation zones were outlined in Tertiary carbonaceous strata by drilling during 1973–82 (over 540 holes, Nissho-Iwai and PNC). The strongest mineralisation occurs along the eastern channel margins where the oxidation interface intersects lignitic horizons. The Warrior uranium prospect was recognized as a low-grade resource distributed in seven discrete zones along 12 km of the palaeochannel. The indicated resource was 4000 t U_3O_8, with an average grade of 0.034% U_3O_8 and average thickness of 1.5 m (Johnson et al., 1982).

From the view-point of uranium sources, the most important rock-type in the HGB region is the Precambrian granite which is equated with the Hiltaba Suite and metamorphic Tarcoola Beds, which contain anomalous amounts of uranium at radioactivity of 3 to 10 times background with uranium equivalent of 12–26 ppm (SADM, 1977). These basement rocks are the principal sources for the main uranium occurrences found in the Tertiary palaeochannel sediments. These palaeochannels generally overlap the Tertiary topographic depressions filled with estuarine, fluvial and lacustrine sediments. The age, palaeoclimate and objective environments appear to be very similar to those at the Beverley and Honeymoon deposits in South Australia, and at the Lake Way deposit in Western Australia.

The well-developed palaeodrainage system that once drained the huge bodies of 'hot' granites (e.g., Hiltaba Suite) in the HGB region warrants specific exploration for Beverly–

Honeymoon uranium analogues. Within the Pidinga Formation, reduced carbonaceous intervals are interbedded with oxide facies both laterally and vertically. Here, sulphates in interstitial brines were reduced to sulphides, particularly in the carbonaceous layers, and precipitated with iron as pyrite. These regionally widespread sediments have special relevance because the economic deposits found so far (Beverley and Honeymoon) occur in these intervals in the Tertiary of Lake Frome area, South Australia. The geometric and geological characteristics of palaeochannels in the Beverley and Honeymoon areas are very similar to those of the palaeochannels in the Gawler Craton. The Eocene to Miocene sediments at Beverley and Honeymoon are enriched with uranium along clay horizons, at palaeochannel margins, and at oxidation–reduction interfaces, particularly in the basal parts of the sequence (Mckay and Miezitiz, 2001).

It is certain that during the Tertiary the weathered granitic basement outcrops were acting as uranium sources and the existence of organic matter in the sandy channel fill resulted in the precipitation of uranium in reduced environments (Eh barrier). In the Gawler Craton this model probably only worked during the Tertiary because now the salty groundwaters are too acid. It appears that the uranium precipitation processes in the KPS are various: redox front, evaporation, increasing groundwater salinity to the Eh barrier. The critical factor appears to be the size of the Tertiary catchment area. The presence of several hundred kilometres of palaeochannel framework across the HGB region suggests a high potential for uranium deposits.

5.4 Lignite

The presence of pyrite in the carbonaceous–lignitic sediments indicates reducing conditions and low oxygen levels (Figs 4.5–19). These organic-rich facies are directly related to sea-level highstands on both regional and local scales. In contrast to the NW Tallaringa and Garford Palaeochannels, there exist two time-intervals of potential brown coal in the KPS: Middle to Late Eocene (Pidinga Formation) and Middle Miocene to Early Pliocene (Kingoonya Member of the Graford Formation). Drilling data indicate that vertical and lateral changes in both coal thickness and quality are rapid, and in particular in the gradation of clayey lignite or lignite to carbonaceous clay (e.g., drillholes THW 16 at 40.5–46.0 m; THW 17 at 19–35 m; THW 21 at 33–41 m; THW 28 at 39–49.5 m; Figs 4.13–14). However, the development of such facies is more likely in extensive estuarine settings than in narrow alluvial plains, which makes seam correlation and coal-value calculations difficult. Therefore, the economic potential of brown coal might be classified as small scale or uneconomic in the HGB region. Lithofacies analyses and correlations derived from existing drilling records seem to suggest that most of the palaeochannels may not be prospective for lignite deposits within fluvial and estuarine geometries (Figs 4.17–18).

5.5 Palygorskite

Deposits of palygorskite have been investigated in the Garford Palaeochannel, ~150 km NW of the KPS (e.g., Robertson, 1988) and they are likely to be present in the KPS (Cowley and Martin, 1991). Although the mechanism for formation of palygorskite in the Garford Formation is uncertain, on the basis of various observations and studies it is suggested that the palygorskite may result from dissolution of illite and/or smectite in a high-Mg environment (Self et al., 1996). Palygorskite infilling void spaces between dolomite grains probably formed by direct precipitation from solution (Keeling et al., 1995). Incongruent dissolution of smectite or illite with co-precipitation of palygorskite has been proposed for similar environments in the Georgia–Florida palygorskite deposits (Weaver and Beck, 1977) and for palygorskite in the south of Spain (Galan and Ferrero, 1982). Although further work for understanding the genesis of the Garford palygorskite needs to be carried out, it is clear that the transitional zones between illitic or smectitic (underlying) and dolomitic (overlying) clays are favourable lithofacies for palygorskite mineralisation in the upper Garford Formation in the KPS.

5.6 Groundwater

Water supply is crucial to any mineral development, but particularly in this region because of the lack of surface water resources, due to the low and unreliable rainfall and high evaporation rate. Groundwater is therefore the only viable source for mineral processing and human consumption, and it is vital in assessing resources. Ancient buried channels commonly contain significant amounts of groundwater. The extensive network of Tertiary palaeochannels represents a potential source of saline groundwater suitable for mineral processing (Martin, 1998). Aquifer characteristics of the palaeochannels and the controls that determine the occurrence of groundwater in the HGB region are not well understood, but it is expected that further geophysical (e.g., TEM, AEM, night-time thermal imagery) and drilling investigations would help to clarify the pattern of groundwater. Potential aquifers with both high quality and quantity probably exist locally in the Pidinga and Garford Formations, as these strata generally show vertical and lateral rapid changes in lithology (Figs 4.5–19). Sandy facies, particularly coarser sandy facies, represent a favourable setting for groundwater resources. Although the clayey sequences also contain considerable amounts of groundwater, this water resource generally appears to be insignificant as it is not movable within the clay facies. Salinity is often very high in these waters.

6 RECOMMENDATIONS

6.1 Study model

Most channel exploration activity is focused on the potential for channels to carry economic quantities of minerals, and the study model described here is thus aimed at improving exploration procedures (Fig. 6.1). An essential part of the exploration strategy in the HGB region should be detailed studies of the geology and mineralisation combined with studies of the economics of development. Further work should concern the relative priorities of: 1) finding reserves in the palaeochannels; 2) finding deep mineralisation beneath the palaeochannels; and 3) finding additional mineralisation in other areas near the HGB. Thus, the geological framework created by the HGB Program will contribute knowledge and experience to the understanding of the entire central Gawler Craton. The best method of comprehensively verifying a model of palaeochannel evolution is by combined study of channel architecture, history, palaeoclimate, erosion and sedimentary characteristics.

6.2 Delineation of palaeochannels

Lack of cohesion of the sediments, their low density and the presence of saline groundwater are ubiquitous and provide high-contrast anomalies in the palaeochannels. Thus the combination of DEM, AEM, Landsat and Aster data, NOAA and other night-time thermal remotely-sensed imagery (e.g., ASTER data with 90 m pixels) in GIS mode represents by far the best method for palaeochannel exploration in the central Gawler Craton region. Drill samples, high-resolution DEM (e.g., processed from ASTER data with 15 m pixels), ground magnetic and gravity, shallow seismic, TEM, and test drilling, where necessary, are also important media that can be used in palaeochannel delineation.

MAGNETICS

Routine magnetic data reduction and processing methods need to be applied with rigour in the interpretation of palaeochannels. Specialised enhancements have been developed for dealing with regolith materials (Milligan and Gunn, 1997). Post-processing techniques, based on the well-known theory of magnetic fields, can be particularly useful in the interpretation of palaeochannels. These include regolith filters (Dauth, 1997; Gunn et al., 1997) which aim to specifically separate the effects of regolith materials from basement; automatic gain control (Rajagopalan and Milligan, 1995) which has great application in the identification of subtle anomalies; and textural filtering which responds to the shape, size and continuity of adjacent anomalies (Dentith et al., 2000).

GRAVITY

The gravity data in the Bouguer gravity diagrams needs to have had the regional field removed and then be modelled, so that the shapes of pronounced gravity lows over the palaeochannels can define more details of the palaeochannels. Perhaps a high-resolution (e.g., 200 or 100 m station intervals) gravity survey would resolve the issue of any possible tributaries. Also, the success rate in using the gravity method to locate palaeochannels can be greatly improved if used in combination with TEM and/or seismic surveys.

AEM/TEM

The AEM has proven to be a good guide to conductive variations in the subsurface and is one of the best techniques for detecting buried conductive anomalies. But it must always be used with caution and correlated to other (e.g., gravity, seismic and drilling) information in palaeochannel studies. Other factors should be taken into account, such as the possibility that water may be held in clay and deeply weathered layers. TEM surveys can be conducted with the purpose of detecting the depth of the palaeochannels, but these works may be complicated by the highly conductive, deeply weathered basement and extensive older sediments which are not necessarily related to palaeochannels (Hou et al., 2001c).

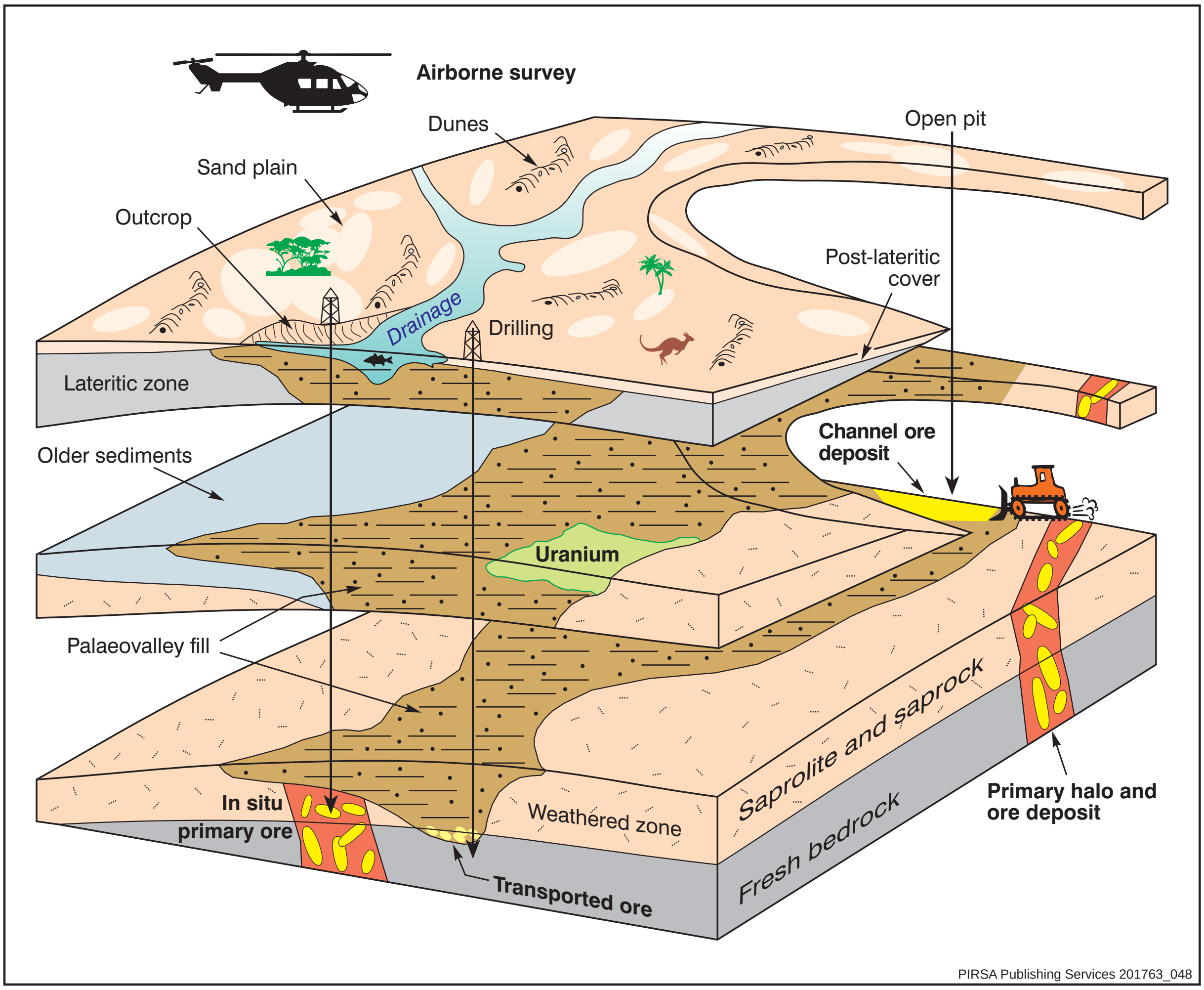

Figure 6.1 Exploration model in the palaeodrainage terrains (after Hou and Alley, 2003).

Seismic survey

Since seismic investigations yield a great variety of reliable data such as depth of various overburden layers, depth-to-bedrock, channel-fill composition and solidity, the results can be utilised for a wide range of applications in palaeochannel geology. Both seismic reflection and refraction surveys at higher resolution could be used to determine variations within the regolith, and thereby map indirectly variations in regolith density, particularly for the palaeochannel fills and underlying weathered basement. Although the relatively high cost of seismic methods makes them unsuitable for general exploration purposes, the shallow seismic surveys are suitable for alluvial gold and uranium exploration in the region. Relative to the sampling stage, seismic is more cost effective in exploration; seismic profile-sections cost much less than closely spaced drilling, while also providing more information. The drill, pit or bulk sampling is then reduced to testing significant areas.

6.3 Mineralisation related to palaeodrainage landscape

The following geological uncertainties should be addressed:

- The regolith through the palaeochannel profiles can be divided into two types, in situ and transported. The in situ unit consists of Precambrian basement rocks deeply weathered to saprolite. The transported unit consists of mainly fluvial–estuarine deposits of Tertiary age. To assess possible primary sections of supergene gold anomaly zones beneath the palaeochannel for primary gold mineralisation, and possible secondary mineralisation hosted in the channel fills, exploration strategies should be different for each type due to their dissimilar genesis, mineralogy and geochemical signatures. A combination of lithofacies analysis with PIMA II enables discrimination between transported and in situ regolith. To further assist in the discrimination between transported and in situ regolith, the use of the light rare earth elements (Ce, La, Pr, Sm, Nd) has been recommended by Lintern and Sheard (1999).
- The lithofacies in the transported regolith associated with mineralisation in the KPS are in two broad groups: reduced facies (organic material and sulphide-related, pyrite) and oxidised facies (iron-related, hematite). The use of these facies as redox front pathfinders requires detailed mineralogical and geochemical works.
- Further geochemical and geochronological studies of the different types of granitic rocks in the area should be undertaken to determine the source for the uranium anomalies. If further investigation reveals hot granites, the spatial and genetic relationships between the granites and palaeochannels should be considered.
- Because the palaeochannel fill – bedrock interface is one site where gold anomalies are located (e.g., Figs 4.5–19), the regolith geology and geological nature of this part of the stratigraphic profile and/or section should be investigated in detail. This zone (palaeosurface) may contain placers, or hide shear zones containing significant supergene gold derived from underlying primary gold mineralisation. These situations are significantly different from one another and could have substantial implications for exploration (Hou and Alley, 2003).
- The stratigraphic and/or sedimentary section positions of all mineral (e.g., gold, uranium) anomalies in palaeochannel fill should be targeted for detailed consideration. Three-dimensional modelling of palaeodrainage landscape analysis can be used as well if stratigraphic–lithological and/or lithofacies studies of the channel fill helps to locate major structures (e.g., redox front, steep floor, bends in the channel, bars and basement barriers). Test drilling and a major relogging effort of existing drillholes should be considered as further aids.
- Further test drilling should traverse across or along the palaeochannels and their tributaries and through channel fills and weathered basement, and particularly major shear zones, with the aim to gather information on weathering, erosional, transport and depositional relations, and to test for mineralisation. Palaeochannel mapping and the 3D models generated as part of this study can be used to predict the probable stratigraphic units which would be encountered in any future holes. When these predictions prove wrong, the information should be used to revise and update the 3D models.
- Future exploration might target an area to the west of the HGB region (the lower reaches of the KPS), where PNC Exploration reported that significant uranium mineralisation

occurs in Tertiary sediments of the Wynbring Palaeochannel overlying Archaean gneiss and granite (McKay et al., 1983). The Wynbring Palaeochannel is located in the Tertiary estuarine plain and contains up to 75 m of coarse to fine-grained sand with lignite, clay and silt interbeds (Hou et al., 2001c).

- **Undesirable exploration:** knowledge of the location and depth of the palaeochannels is also of interest to bedrock mineralisation explorers in the HGB region, as the deep channels (up to 140 m) can prove to be expensive barriers to bedrock drilling if their positions are not known.

7 CONCLUSION

The KPS project has greatly improved the understanding of the poorly known palaeodrainage system which overlies the basement of the HGB region and lies beneath the Quaternary cover. This palaeodrainage system may not only conceal many primary mineralised structures, but also probably contains secondary mineralisation. Among the important results of this study are included a better understanding of the architectural, and stratigraphic and lithofacies features of the palaeochannels. The best possible understanding of the geology and mineralisation requires additional integration and interpretation of required new data (including high-resolution DEM and night-time thermal imagery derived from ASTER data; ground magnetic and gravity; TEM; shallow reflection seismic along desired traverses; and mineralogical and geochemical studies of both transported and residual regoliths through the palaeochannel profiles and/or sections).

Mapping techniques

- The palaeodrainages and their related features are well defined by a combination of geophysical and geological methods. Together these methods constitute a model for exploration in palaeochannels.
- Detailed palaeochannel mapping of the HGB region has provided new information on the architecture, landscape evolution and lithofacies types of the channel fills present in the area. Because the mapping was done using accurate 2D and 3D survey controls, analysis of the palaeodrainage landscape mapping data leads to an understanding of dynamic landscape evolution. This information has provided a comprehensive, 3D geometrical framework of palaeochannels for use in exploration in the HGB region.
- The remote sensing and geophysical data and their interpretation in this report have contributed towards a number of important results and clarified problems related to the palaeochannels. The geophysical signature associated with palaeochannels is not a simple quantifiable response from one geophysical method but instead is widely variable. Certain methods are applicable for particular cases.
- Because of uncertainties in the interpretations from available (mostly low resolution) remote sensing and geophysical data sets, the details of small-scale tributaries, particularly in the complicated western part of the KPS, cannot be given. Some limited support from drilling may be required to identify these, but systematic drilling should not be necessary.

Tertiary landscape evolution

- The palaeodrainage in this region represents all of the drainage that was active during the Middle Eocene to Late Eocene and the Middle Miocene to Early Pliocene, with episodes of reactivation and modification recognisable. The KPS project may have provided the first detailed indications of packages of Neogene marine-influenced fluvial sequences of significantly different age.
- The palaeodrainages have been incised into and their fills deposited on Precambrian weathered basement of the Gawler Craton, and locally on Palaeozoic or Mesozoic sediments.
- A near complete channel sequence has been established by examining numerous geological sections with stratigraphic profiles (drillholes) of the channel fill-bearing sequence across the KPS in the HGB region.
- Sedimentation in the palaeochannels took place in environments ranging from fluvial through estuary to marginal marine.

Exploration

- The palaeochannels and their tributaries are largely unexplored and thus there is significant potential for economic mineralisation.
- Any trace of valuable minerals in the palaeochannels (e.g., gold) is of interest as a guide to the location of basement mineralisation.
- Exploration for primary bedrock mineralisation can benefit from knowing the location of undesirable channels in the study area.

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APPENDIX 1 SUMMARY OF EXAMINED SAMPLES

DHNAME	MAP_100	U_NO	LONGITUDE	LATITUDE	THICK_Q	THICK_Tertiary	THICK_Miocene	THICK_Eocene	PRE_Tertiary	ELEVATION
MALBOOMA 2	5636	6	133.969567	-30.613658	0.00-0.80 Q	0.80-5.50 Ti			5.50-7.60 Mh	145.896
MALBOOMA 5	5636	8	133.918184	-30.636484	0.00-3.40 Q	3.40-23.20 T			23.20-37.50 Mh	149.488
TM 201	5636	37	133.901853	-30.597648	0.00-9.00 Q		9.00-25.00 ?		25.00-41.70 ?M	147.799
TM 202	5636	38	133.924784	-30.599192	0.00-10.00 Q		10.00-41.00		41.00-46.50 ?M	133.648
TM 203	5636	39	133.945628	-30.600717	0.00-6.00 Q	6.00-31.00 T			31.00-40.00 ?M	124.772
TM 204	5636	40	133.966811	-30.601005	0.00-6.00 Q	6.00-36.00 T			36.00-38.10 ?M	133.618
TM 205	5636	41	133.989138	-30.603552	0.00-9.00 Q	9.00-39.00 T			39.00-43.80 Mh	135.285
TM 210	5636	42	133.987592	-30.624780	0.00-5.00 Q	5.00-26.00 T			26.00-31.50 ?M	135.728
MFRP 1	5636	133	133.840262	-30.984267	0.00-6.00 Q		6.00-41.00 ?		41.00-126.00 ?	121.000
MFRP 2	5636	134	133.844395	-30.988798	0.00-10.00 Q		10.00-75.00			119.914
STD 5636-1/W0	5636	27	133.851552	-30.691718	0.00-11.00 Q			11.00-48.00 Tbp	48.00-52.00 LM	182.702
MFS 1	5735	7	134.088657	-31.035820	0.00-13.00 Q		13.00-17.00	17.00-26.00 T s	26.00-68.00 JK	139.539
MFS 2	5735	8	134.144165	-31.038906	0.00-15.00 Q		15.00-27.00		27.00-52.00 JK	150.470
MFS 46	5735	18	134.258125	-31.072094	0.00-9.00 Q	9.00-16.00 T			16.00-48.00 JK	164.722
MFS 49	5735	20	134.311531	-31.079607	0.00-4.00 Q	4.00-10.00 T		10.00-14.00 T\s	14.00-27.00 JK	130.846
CHL 16	5735	21	134.452229	-31.041483	0.00-15.00 Q				15.00-37.70 Jk	113.507
SADME	5736	9	134.084419	-30.651007	0.00-3.70 Q		3.70-11.60 T	11.60-55.30 Tbp	55.30-67.70 ALm	114.873
KONKABY 1	5736	82	134.472872	-30.535450	0.00-8.00 Q	8.00-144.40 T	8.00-58.00 Tig	58.00-144.40 Tb	144.40-147.40	129.332
KONKABY 5	5736	83	134.383705	-30.518393	0.00-9.00 Q	9.00-126.90 T	9.00-47.00 Tig	47.00-126.90 Tb	126.90-127.00	113.875
MALBOOMA 1	5736	95	134.040134	-30.652566	0.00-3.70 Q		3.70-11.60 T	11.60-55.30 Tbp	55.30-67.70 Alm	100.929
TUN 77	5736	101	134.459643	-30.841202		0.00-24.00 T			24.00-38.00 M-	129.036
TUN 86	5736	104	134.498251	-30.857598		0.00-28.00 T			28.00-38.00 Ll	155.089
PWP 21	5736	106	134.442522	-30.727434	0.00-3.50 Q	3.50-7.00 TQ			7.00-50.00 LM	124.994
PWP 71	5736	108	134.404714	-30.760655	0.00-5.00 Q				5.00-15.00 ?LM	119.499
THW 11	5736	109	134.381370	-30.816488	0.00-3.00 Q	3.00-83.00 T	3.00-43.00 Tig	43.00-83.00 Tbp		113.276
THW 12	5736	110	134.436859	-30.803207	0.00-7.00 Q	7.00-71.00 T	7.00-27.00 Tig	27.00-71.00 Tbp		95.617
THW 13	5736	111	134.459058	-30.759087	0.00-5.00 Q	5.00-68.80 T	5.00-14.00 Tig	14.00-68.80 Tbp	68.80-71.00 Mh	107.107
THW 15	5736	112	134.478540	-30.827745	0.00-6.00 Q	6.00-68.00 T	6.00-38.00 Tig	38.00-68.00 Tbp	68.00-71.00 LM	121.980
THW 16	5736	113	134.331177	-30.818045	0.00-2.00 Q	2.00-46.00 T	2.00-22.00 Tig	22.00-46.00 Tbp	46.00-82.00 Alm	100.773
THW 17	5736	114	134.155761	-30.792658	0.00-4.50 Q	4.50-35.50 T	4.50-13.00 Tig	13.00-35.50 Tbp	35.50-38.00 Alm	100.202
THW 18	5736	115	134.125093	-30.832155	0.00-2.00 Q	2.00-17.00 T	2.00-13.00 Tig	13.00-17.00 Tbp	17.00-29.50 Alm	102.911
THW 20	5736	117	134.188031	-30.808204	0.00-3.00 Q	3.00-86.50 T	3.00-25.00 Tig	25.00-86.50 Tbp		99.208
THW 21	5736	118	134.188153	-30.793768	0.00-7.00 Q	7.00-71.50 T	7.00-19.00 Tig	19.00-71.50 Tbp		98.491

DHNAME	MAP_100	U_NO	LONGITUDE	LATITUDE	THICK_Q	THICK_Tertiary	THICK_Miocene	THICK_Eocene	PRE_Tertiary	ELEVATION
THW 23	5736	120	134.098625	-30.755280	0.00-3.00 TQ	3.00-55.50 T	3.00-12.00 Tig	12.00-55.50 Tbp		119.033
THW 24	5736	121	134.188530	-30.748654	0.00-16.00 Q	16.00-34.50T	16.00-33.00Tig	33.00-34.50Tbp		125.648
THW 25	5736	122	134.259680	-30.734642	0.00-7.00 Q	7.00-35.50 T	7.00-27.00 Tig	27.00-35.50 Tbp		113.842
THW 26	5736	123	134.296034	-30.762817	0.00-9.00 Q	9.00-14.50 T	9.00-11.00 Tig	11.00-14.50 Tbp		116.904
THW 27	5736	124	134.187402	-30.758573	0.00-7.50 Q	7.50-31.00 T	7.50-31.00 Tig		31.00-54.00 Mh	119.295
THW 28	5736	125	134.359078	-30.709905	0.00-14.00 Q	14.00-95.50 T	14.00-36.00Tig	36.00-95.50 Tbp		124.126
THW 29	5736	126	134.296512	-30.696949	0.00-3.00 Q	3.00-20.50 T	3.00-20.50 Tig			109.380
C 91	5736	127	134.009570	-30.523638	0.00-3.00 Q	3.00-42.50 T	3.00-25.00 Tig	25.00-42.50 Tbp	42.50-45.00 ?LM	106.268
C 92	5736	128	134.016584	-30.551663	0.00-8.00 Q	8.00-69.00 T	8.00-20.00 Tig	20.00-69.00 Tbp	69.00-73.00 ?LM	100.673
C 93	5736	129	134.042044	-30.613210	0.00-4.00 Q	4.00-34.40 T	4.00-25.00Tig	25.00-34.40 Tbp	34.40-35.50 ?LM	102.704
TC 53	5736	132	134.035846	-30.606938	0.00-7.00 ?Q	7.00-32.00 T	7.00-12.00? Tig			105.494
TC 54	5736	133	134.034177	-30.607016	0.00-5.00 Q	5.00-47.50T	5.00-30.00Tig	30.00-47.50 Tbp	47.50-50.10 ?M	110.451
TC 55	5736	134	134.041577	-30.607524	0.00-4.00 Q	4.00-38.00T	4.00-18.00Tig	18.00-38.00 Tbp	38.00-43.70 ?M	110.463
TC 56	5736	135	134.043680	-30.616472	0.00-3.00 ns	3.00-41.00T	3.00-18.00Tig	18.00-41.00 Tbp	41.00-45.00 ?M	107.604
TC 57	5736	136	134.038646	-30.598027	0.00-4.00 Q	4.00-51.50T	4.00-21.00Tig	21.00-51.50 Tbp		115.581
TC 58	5736	137	134.031146	-30.597160	0.00-3.00 ns	3.00-36.00T	3.00-25.00 Tig	25.00-36.00 Tbp	36.00-42.60 ?Mh	101.249
TC 59	5736	138	134.028655	-30.606344	0.00-10.00 n	10.00-36.00T	10.00-20.50Tig	20.50-36.00 Tbp	36.00-38.80 ?M	124.292
TC 60	5736	139	134.028658	-30.605983	0.00-10.00 n	10.00-39.50T	10.00-18.00Tig	18.00-39.50 Tbp	39.50-41.00 ?M	124.057
TM 208	5736	142	134.061344	-30.608912	0.00-6.00 Q	6.00-9.00 T	6.00-9.00 Tig?		9.00-14.40 ?Mh	138.281
TM 209	5736	143	134.077580	-30.609715	0.00-4.50 Q	4.50-23.00 T	4.50-23.00 Tig?		23.00-27.00 ?M	141.396
TM 211	5736	144	134.010894	-30.627533	0.00-9.00 Q	9.00-28.50 T	9.00-28.50 Tig?		28.50-32.00 ?M	119.475
TM 301	5736	155	134.099752	-30.633926	0.00-9.00 Q	9.00-31.00 T	9.00-31.00 Tig?		31.00-34.50 ?M	127.606
TM 306	5736	156	134.099459	-30.609109	0.00-4.00 Q	4.00-14.00 T	4.00-14.00 Tig?		14.00-16.00 ?M	147.346
TM 311	5736	157	134.101270	-30.582504	0.00-12.00 Q	12.00-32.00T	12.00-32.00Tig?		32.00-40.00 ?M	149.343
TM 318	5736	158	134.088574	-30.632937	0.00-7.00 Q	7.00-28.00 T	7.00-20.00 Tig?		20.00-40.00 ?Mh	120.051
TM 319	5736	159	134.109660	-30.634446	0.00-4.50 Q	4.50-24.00 T	4.50-24.00 Tig?		24.00-34.00 ?M	133.096
TM 501	5736	165	134.008299	-30.581016	0.00-17.00 Q	17.00-32.00T	17.00-32.00Tig?	32.00-40.00 Tbp	40.00-51.00 ?M	121.480
TM 502	5736	166	134.012327	-30.580830	0.00-12.00 Q	12.00-50.00 T	12.00-30.00Tig?	30.00-50.00 Tbp	50.00-52.00 ?M	116.613
TM 503	5736	167	134.014258	-30.580755	0.00-10.00 Q	10.00-48.00T	10.00-16.50Tig	16.50-48.00 Tbp	48.00-52.00 ?M	109.477
TM 504	5736	168	134.017921	-30.580322	0.00-12.00 Q	12.00-24.00T	12.00-17.00Tig	17.00-24.00 Tbp		109.799
TM 505	5736	170	134.030458	-30.581383	0.00-3.00 Q	3.00-22.50T	3.00-12.00Tig	12.00-22.50 ?Tbp		116.468
TM 506	5736	171	134.036052	-30.581991	0.00-4.50 Q	4.50-51.00T	4.50-15.00Tig	15.00-51.00 Tbp		118.539
TM 507	5736	172	134.038054	-30.582024	0.00-6.00 Q	6.00-46.00T		6.00-46.00 Tbp	46.00-51.00 ?M	119.380
TM 508	5736	173	134.031399	-30.587416		0.00-24.00T	0.00-9.00Tig	9.00-24.00 Tbp	24.00-51.00 ns	105.501
TM 510	5736	175	134.037955	-30.587808	0.00-2.00 Q	2.00-48.00T	2.00-9.00Tig	9.00-48.00 Tbp	48.00-51.00 ?M	120.726

DHNAME	MAP_100	U_NO	LONGITUDE	LATITUDE	THICK_Q	THICK_Tertiary	THICK_Miocene	THICK_Eocene	PRE_Tertiary	ELEVATION
TM 511	5736	176	134.041330	-30.588249	0.00-4.50 Q	4.50-13.50T	4.50-11.00Tig?	11.00-13.50Tbp	13.50-24.00 ?M	124.225
TM 512	5736	177	134.035549	-30.587430		0.00-52.00T	0.00-1.50Tig?	1.50-52.00 Tbp		115.990
TM 513	5736	178	134.035502	-30.596505	0.00-1.00 Q	0.00-42.00T	1.00-7.50Tig?	7.50-42.00 Tbp		107.696
TM 514	5736	179	134.037930	-30.596769	0.00-3.00 Q	3.00-47.20T	3.00-10.50Tig?	10.50-47.20 Tbp		114.512
TM 515	5736	180	134.039510	-30.597069	0.00-4.50 Qs	4.50-47.20T		4.50-47.20 Tbp		117.471
TM 517	5736	182	134.045480	-30.597835	0.00-1.50 Q	1.50-17.00T	1.50-4.50T\	4.50-17.00 Tbp	17.00-21.00 ?M	118.987
TM 519	5736	184	134.028902	-30.603530	0.00-6.00 Q	6.00-51.00T	6.00-12.00Tig?	12.00-51.00 Tbp	51.00-56.30 ?M	122.244
TM 520	5736	185	134.028705	-30.604522	0.00-3.00 Q	3.00-52.00T	3.00-9.00Tig?	9.00-52.00 Tbp		123.078
TM 521	5736	186	134.028699	-30.604938	0.00-7.50 Q	36.00-14.00T	7.50-14.00 Tig	14.00-36.00 Tbp	36.00-51.70 ?M	123.327
TM 522	5736	187	134.028571	-30.605369	0.00-6.00 Q	6.00-29.00T	6.00-13.50 Tig	13.50-29.00 Tbp	29.00-42.00 ?M	123.798
TM 523	5736	188	134.028658	-30.605902	0.00-12.00 Q	12.00-30.00T	12.00-18.00Tig?	18.00-30.00 Tbp	30.00-42.40 Mh	124.005
TM 524	5736	189	134.028124	-30.606233	0.00-9.50 Q	9.50-33.00 T	9.50-18.00 Tig	18.00-33.00 Tbp	33.00-42.60 ?M	124.846
TM 526	5736	191	134.027091	-30.606180	0.00-9.00 Q	9.00-30.00 T	9.00-16.50 Tig?	16.50-30.00 Tbp	30.00-42.60 ?M	124.872
TM 527	5736	192	134.026705	-30.606185	0.00-10.50 Q	10.50-33.00 T	10.50-18.00Tig?	18.00-33.00 Tbp	33.00-42.60 ?M	124.898
TM 528	5736	193	134.024985	-30.606110	0.00-1.50 Q	1.50-19.50 T	1.50-14.50 Tig	14.50-19.50 Tbp	19.50-33.50 ?M	124.595
TM 529	5736	194	134.016244	-30.604997	0.00-13.50 Q	13.50-46.20 T	13.50-24.00 Tig	24.00-46.20 Tbp		119.503
TM 530	5736	195	134.013555	-30.605760	0.00-10.50 Q	10.50-42.60 T	10.50-19.50 Tig	19.50-42.60 Tbp		120.537
TM 531	5736	196	134.011427	-30.605719	0.00-7.50 Q	7.50-22.50 T	7.50-16.50 Tig?	16.50-25.50 Tbp	25.50-38.00 ?M	121.460
TM 532	5736	197	134.028713	-30.606697	0.00-4.50 Q	4.50-33.00 T	4.50-13.50 Tig	13.50-33.00 Tbp	33.00-38.00 ?M	124.431
TM 533	5736	198	134.028746	-30.607583	0.00-1.50 Q	1.50-16.50 T	1.50-7.50 Tig	7.50-16.50 Tbp	16.50-18.00 ?M	125.032
TM 537	5736	202	134.032302	-30.606813	0.00-1.50 Q	1.50-25.50 T	1.50-7.50 Tig?	7.50-25.50 Tbp	25.50-42.60 ?M	116.356
TM 538	5736	203	134.035771	-30.607102	0.00-1.50 Q	1.50-52.00 T	1.50-4.50 T\	4.50-52.00 Tbp		105.966
TM 539	5736	204	134.040285	-30.607594	0.00-3.00 Q	3.00-49.00 T	3.00-9.00 Tig?	9.00-49.00 Tbp	49.00-52.00 ?M	106.017
TM 540	5736	205	134.042410	-30.607727	0.00-4.50 Q	4.50-42.00 T	4.50-18.00 Tig	18.00-42.00 Tbp	42.00-52.00 ?M	111.571
TM 541	5736	206	134.046071	-30.607927	0.00-3.00 Q	3.00-33.00 T	3.00-15.00 Tig?	15.00-33.00 Tbp	33.00-42.60 ?M	119.441
TM 542	5736	207	134.045855	-30.617083		0.00-52.00 T	0.00-4.50 Tig	4.50-52.00 Tbp		113.779
TM 543	5736	208	134.044552	-30.617002		0.00-50.00 T	0.00-7.00 Tig	7.00-50.00 Tbp	50.00-52.00 ?M	110.051
TM 544	5736	209	134.043999	-30.616944	0.00-3.00 TQ	3.00-52.00 T	3.00-7.50 Tig	7.50-52.00 Tbp		108.477
TM 545	5736	210	134.043552	-30.616922	0.00-3.00 TQ	3.00-52.00 T	3.00-6.00 Tig	6.00-52.00 Tbp		107.210
TM 546	5736	211	134.043008	-30.616963	0.00-4.50 Q	4.50-42.50 T	4.50-12.00 Tig?	12.00-42.50 Tbp		105.687
TM 547	5736	212	134.038758	-30.616327	0.00-6.00 TQ	6.00-24.00 T		6.00-24.00 Tbp	24.00-33.50 ?M	103.639
TM 548	5736	213	134.034746	-30.615899	0.00-3.00 TQ	3.00-33.00 T	3.00-7.50 Tig	7.50-33.00 Tbp	33.00-33.50 ?M	118.515
TM 549	5736	214	134.026863	-30.627002	0.00-1.50 Q	1.50-21.00 T	1.50-18.00 Tig?	18.00-21.00 Tbp	21.00-24.30 Alm	111.198
TM 550	5736	215	134.026913	-30.628105	0.00-10.50 Q	10.50-36.00 T	10.50-16.50 Tig?	16.50-36.00 Tbp	36.00-42.60 ?M	108.825
TM 551	5736	216	134.026985	-30.630235	0.00-7.50 Q	7.50-33.00 T	7.50-13.50 Tig?	13.50-30.00 Tbp	30.00-38.00 ?M	105.391

DHNAME	MAP_100	U_NO	LONGITUDE	LATITUDE	THICK_Q	THICK_Tertiary	THICK_Miocene	THICK_Eocene	PRE_Tertiary	ELEVATION
TM 554	5736	217	134.024474	-30.628960	0.00-3.00 Q	3.00-50.00 T	3.00-12.00 Tig?	12.00-50.00 Tbp	50.00-56.30 nd	108.541
TM 555	5736	218	134.019513	-30.628410	0.00-3.00 Q	3.00-19.50 T	3.00-9.00 Tig?	9.00-19.50 Tbp	19.50-29.00 nd	110.468
TM 556	5736	219	134.029333	-30.629430	0.00-6.00 Q	6.00-19.50 T	6.00-15.00 Tig?	15.00-19.50 Tbp	19.50-28.00 ?M	105.393
TM 558	5736	221	134.035574	-30.630091		0.00-28.50 T	0.00-7.50 Tig?	7.50-28.50 Tbp		101.120
TM 568	5736	222	134.077660	-30.629593	0.00-7.50 Q	7.50-39.00 T	7.50-16.50 Tig?	16.50-39.00 Tbp	39.00-42.00 ?M	118.233
TM 569	5736	223	134.077680	-30.627662	0.00-9.00 Q	9.00-42.60 T	9.00-22.50 Tig?	22.50-42.60 Tbp		118.534
TM 570	5736	224	134.077605	-30.624621	0.00-7.50 Q	7.50-46.20 T	7.50-24.00 Tig?	24.00-46.20 Tbp		120.340
TM 571	5736	225	134.075255	-30.624657	0.00-12.00 Q	12.00-40.50 T	12.00-24.00 Tig?	24.00-40.50 Tbp	40.50-46.20 ?M	121.213
TM 572	5736	226	134.074119	-30.624532	0.00-6.00 Q	6.00-38.00 T	6.00-19.50 Tig?	19.50-38.00 Tbp		121.966
TM 586	5736	227	134.055658	-30.629319	0.00-1.50 Q	1.50-13.50 T		1.50-13.50 Tbp	13.50-15.00 ?M	118.927
TM 588	5736	228	134.047130	-30.630635	0.00-4.50 Q	4.50-30.00 T		4.50-30.00 Tbp	30.00-35.00 ?M	114.585
TM 589	5736	229	134.042135	-30.630427	0.00-1.50 Q	1.50-50.00 T	1.50-3.00 Tig?	3.00-50.00 Tbp	50.00-52.00 ?M	106.118
TM 590	5736	230	134.040385	-30.622674	0.00-3.00 Q	3.00-46.00 T	3.00-4.50 Tig?	4.50-46.00 Tbp	46.00-56.30 ?M	101.890
TM 591	5736	231	134.045077	-30.623160	0.00-1.50 Q	1.50-56.30 T	1.50-4.50 Tig?	4.50-56.30 Tbp		109.742
TM 592	5736	232	134.042988	-30.617008	0.00-3.00 Q	3.00-45.00 T	3.00-12.00 Tig?	12.00-45.00 Tbp	45.00-56.30 ?M	105.648
TM 593	5736	233	134.041988	-30.616722	0.00-1.50 Q	1.50-21.00 T	1.50-6.00 Tig?	6.00-21.00 Tbp	21.00-33.50 ?M	102.637
W 1	5736	234	134.166469	-30.678134	0.00-1.00 Q	1.00-8.00 T	1.00-6.00 T\	6.00-8.00 T gr.	8.00-152.00 Lt	171.231
TAR 63	5736	385	134.472529	-30.793718	0.00-2.00 Q	2.00-18.00 T	2.00-18.00 Tig			102.921
TAR 64	5736	386	134.477736	-30.795318	0.00-2.00 Q	2.00-34.00 T	2.00-20.00 Tig?	20.00-34.00 Tbp?	34.00-54.00 Mh?	104.769
TAR 65	5736	387	134.443327	-30.791666	0.00-2.00 Q	2.00-26.00 T	2.00-26.00 Tig		26.00-50.00 Mh?	100.000
TAR 66	5736	388	134.447272	-30.785339	0.00-2.00 Q	2.00-20.00 T	2.00-20.00 Tig?		20.00-50.00 Mh?	101.000
TAR 68	5736	390	134.456379	-30.767899	0.00-2.00 Q	2.00-24.00 T	2.00-24.00 Tig?		24.00-60.00 Mh?	104.000
KONKABY 3	5737	53	134.331822	-30.468081	0.00-21.00 Q				21.00-47.00 CP-JK	133.170
KONKABY 4	5737	140	134.268215	-30.482107	0.00-18.00 Q				18.00-60.00 CP-JK	124.714
G 1	5737	282	134.475698	-30.385577	0.00-6.00 TQ	6.00-36.00 T			36.00-150.00 JK	134.157
COMM RW 9/73,	5836	28	134.519769	-30.665301	0.00-9.00 Q	9.00-37.34 T	9.00-22.00 T	22.00-37.34 T		120.264
TD 5 SADME	5836	41	134.604972	-30.648868	0.00-15.70 n	15.70-20.60			20.60-99.06 Lt	124.824
TUN 95	5836	96	134.572569	-30.844331	0.00-30.00 T				30.00-33.00 Alm	131.181
TUN 97	5836	97	134.584158	-30.824517	0.00-5.00 TQ				5.00-30.00 ALm	126.800
COMM RW 10/73	5836	98	134.523569	-30.569394	0.00-8.00 Q	8.00-32.00 T	8.00-25.60 Tig?	25.60-32.00 Tbp		127.481
MWP 1	5836	99	134.595763	-30.800192	0.00-2.50 Q				24.00-42.60 L	132.271
THW 4	5836	102	134.523971	-30.732272	0.00-5.00 Q	5.00-57.20 T	5.00-57.20 Tig?		57.20-72.00 Lt	107.202
THW 5	5836	103	134.528110	-30.740136	0.00-3.00 Q	3.00-117.00 T	3.00-66.00 Tig?	66.00-117.00 Tbp	117.00-131.00	103.804
THW 6	5836	104	134.532257	-30.746919	0.00-3.00 Q	3.00-72.80 T	3.00-23.00 Tig?	23.00-72.80 Tbp	72.80-81.50 Lt	106.610
THW 7	5836	105	134.537438	-30.755780	0.00-5.00 Q	5.00-69.20 T	5.00-69.20 Tig?		69.20-77.00 Lt	110.165

DHNAME	MAP_100	U_NO	LONGITUDE	LATITUDE	THICK_Q	THICK_Tertiary	THICK_Miocene	THICK_Eocene	PRE_Tertiary	ELEVATION
THW 8	5836	106	134.541582	-30.763014	0.00-5.00 Q	5.00-38.00 T	5.00-38.00 Tig?		38.00-60.00 Mh	109.302
THW 9	5836	107	134.550899	-30.781997	0.00-6.00 Q	6.00-33.00 T	6.00-15.00 Tig?	15.00-33.00 Tbp	33.00-36.00 Lt	110.684
THW 10	5836	108	134.558160	-30.793753	0.00-10.00 Q	10.00-64.00 T	10.00-31.00 Tig?	31.00-64.00 Tbp	64.00-85.00 Mh	114.278
THW 14	5836	109	134.567502	-30.808219	0.00-6.00 Q	6.00-56.50 T	6.00-25.00 Tig?	25.00-56.50 Tbp	56.50-91.00 Lt	118.808
TLM 5	5836	110	134.798674	-30.742012	0.00-3.00 Q	3.00-78.40 T	3.00-14.40 Tig?	14.40-78.40 Tbp	78.40-81.60 Mh	132.558
TLM 6	5836	111	134.808068	-30.745637	0.00-1.00 Q	1.00-60.00 T	1.00-6.00 Tig?	6.00-60.00 Tbp?	60.00-64.00 Mh	128.140
TLM 7	5836	112	134.818507	-30.750162	0.00-8.80 Q	8.80-46.00 T		8.80-46.00 Tbp	46.00-52.80 Mh	126.727
TLM 8	5836	113	134.816322	-30.801592	0.00-2.00 Q	2.00-95.00 T	2.00-38.00 Tig	38.00-75.00 Tbp?	75.00-97.00 Mh	127.023
TLM 9	5836	114	134.789175	-30.787115	0.00-9.00 Q	9.00-47.20 T	9.00-47.20 Tig?		47.20-54.00 Mh	122.452
TLM 10	5836	115	134.807873	-30.843992	0.00-8.50 Q	8.50-17.00 T		8.50-17.00 Tbp	17.00-23.00 Mh	132.691
TLM 12	5836	117	134.750448	-30.807799	0.00-8.00 Q	8.00-42.00 T	8.00-21.00 Tig?	21.00-42.00 Tbp	42.00-54.00 Ma	131.628
TLM 13	5836	118	134.710737	-30.803204	0.00-9.00 Q	9.00-16.60 T	9.00-14.50 Tig?	14.50-16.60 Tbp	16.60-39.00 Alm	136.738
TLM 15	5836	120	134.910415	-30.785450	0.00-1.00 Q	1.00-18.00 T	1.00-18.00 Tig?		18.00-25.00 Ma	125.625
TLM 16	5836	121	134.896813	-30.800780	0.00-4.00 Q	4.00-11.50 T	4.00-11.50 Tig?		11.50-14.00 Mh	133.841
TLM 17	5836	122	134.835069	-30.841323	0.00-6.00 Q	6.00-33.00 T	6.00-15.50 Tig?	15.50-33.00 Tbp?	33.00-54.00 LM	132.555
TLM 18	5836	123	134.846575	-30.840434	0.00-7.50 Q	7.50-30.00 T	7.50-30.00 Tig?		30.00-36.00 Mh	137.617
TLM 19	5836	124	134.751467	-30.817726	0.00-6.50 Q	6.50-18.00 T	6.50-18.00 Tig?		18.00-31.00 Mh	132.175
TPS 7	5836	126	134.872923	-30.685258	0.00-11.00 Q	11.00-126.00T	11.00-83.00 Tig	83.00-126.00 Tbp	126.00-154.70	123.862
TPS 8	5836	127	134.863526	-30.685247	0.00-16.00 Q	16.00-63.20 T	16.00-43.20 Tig	43.20-63.20 Tbp	63.20-75.60 Mh	125.214
TPS 9	5836	128	134.868745	-30.685252	0.00-16.80 Q	16.00-124.00T	16.80-42.80 Tig	42.80-124.00 Tb	124.00-125.00	122.662
TPS 10	5836	129	134.896933	-30.686179	0.00-5.00 Q	5.00-76.40 T	5.00-61.00 Tig	61.00-76.40 Tbp	76.40-100.00 M	130.002
TPS 11	5836	130	134.905286	-30.686188	0.00-10.00 Q	10.00-32.80 T	10.00-32.80 Tig		32.80-57.20 Mh	133.248
TPS 12	5836	131	134.910508	-30.686190	0.00-14.00 Q	9.00-90.00 T	9.00-57.60 Tig	57.60-90.00 Tbp	90.00-107 Mh	135.010
TPS 13R	5836	132	134.839771	-30.528207	0.00-1.00 Q	1.00-86.50 T	1.00-35.00 Tig	35.00-86.50 Tbp		132.542
TPS 14	5836	133	134.642820	-30.511573	0.00-3.00 Q	3.00-26.60 T	3.00-26.60 Tig?			124.688
TPS 15	5836	134	134.638617	-30.520584	0.00-2.00 Q	2.00-15.00 T	2.00-15.00 Tig		15.00-16.50 LM	132.370
TPS 16	5836	135	134.645964	-30.506167	0.00-3.00 Q	3.00-8.00 T	3.00-8.00 Tig		8.00-36.00 Mak	127.452
TPS 17	5836	136	134.821875	-30.622933	0.00-4.00 Q	4.00-88.00 T	4.00-79.00 T	79.00-88.00 Tbp	88.00-89.50 Mh	127.856
TTS 1	5836	137	134.589520	-30.694596	0.00-10.00 Q	10.00-71.00 T				120.561
TTS 2	5836	138	134.609990	-30.693485	0.00-11.00 Q	11.00-48.00 T				128.956
TTS 3	5836	139	134.598712	-30.693902	0.00-63.00 n					125.043
WPS 1	5836	140	134.639191	-30.646918	0.00-5.50 Q				5.50-41.50 Ltt	140.731
WPS 2	5836	414	134.706938	-30.676867	0.00-5.00 Q				5.00-32.00 L	161.458
TAR 94	5836	694	134.568037	-30.715225	0.00-3.00 Q	3.00-13.00 T	3.00-13.00 Tig?		13.00-63.00 JK?	116.000
TAR 97	5836	697	134.784914	-30.819499	0.00-6.00 Q	6.00-22.00 T	6.00-22.00 Tig?		22.00-36.00 Mh?	125.000

DHNAME	MAP_100	U_NO	LONGITUDE	LATITUDE	THICK_Q	THICK_Tertiary	THICK_Miocene	THICK_Eocene	PRE_Tertiary	ELEVATION
TAR 98	5836	698	134.778168	-30.816005	0.00-6.00 Q	6.00-24.00 T	6.00-24.00 Tig?		24.00-80.00 JK?	126.000
TAR 99	5836	699	134.774305	-30.813688	0.00-6.00 Q	6.00-28.00 T	6.00-28.00 Tig?		28.00-31.00 JK?	127.000
TAR 100	5836	700	134.769711	-30.811442	0.00-10.00 Q	10.00-24.00 T	10.00-24.00 Tig?		24.00-28.00 JK?	127.000
TAR 104	5836	704	134.766257	-30.808648	0.00-4.00 Q	4.00-30.00 T	4.00-30.00 Tig?		30.00-60.00 Mh?	128.000
TAR 108	5836	708	134.763399	-30.806080	0.00-4.00 Q	4.00-26.00 T	4.00-26.00 Tig?		26.00-41.50 ALm?	129.000
TAR 111	5836	711	134.758749	-30.801145	0.00-2.00 Q	2.00-28.00 T	2.00-28.00 Tig?		28.00-35.00 Mh?	129.300
TAR 114	5836	714	134.755517	-30.797773	0.00-4.00 Q	4.00-28.00 T	4.00-28.00 Tig?		28.00-56.00 Mh?	129.500
COMM RW (A37)	5837	84	134.524181	-30.420107	0.00-4.00 Q	4.00-93.00 T	4.00-72.00 Tig	72.00-93.00 Tbp		142.568
KIN 37	5935	265	135.125648	-31.000634	0.00-2.00 Q	2.00-22.00 T	2.00-22.00 Tig		22.00-24.00 BIF	129.561
WEST 5 MILE B	5936	42	135.379404	-30.687697	0.00-0.60 Q	0.60-29.90 T		0.60-29.90 Tbp		141.174
ERD-1	5936	108	135.191189	-30.702051	0.00-9.00 Q	9.00-21.00 T	9.00-21.00 Tig		21.00-39.50 Ma	137.678
ERD-2	5936	109	135.206681	-30.718271	0.00-2.50 Q	2.50-5.50 T	2.50-5.50 Tig		5.50-17.00 Mcl	130.671
ERD-3	5936	110	135.214011	-30.727643	0.00-3.00 Q	3.00-9.50 T	3.00-9.50 Tig		9.50-48.00 M	134.770
ERD-4	5936	111	135.325358	-30.758184	0.00-8.00 Q	8.00-10.50 T	8.00-10.50 Tig		10.50-18.00 Ma	152.914
ERD-5	5936	112	135.289055	-30.743201	0.00-4.00 Q	4.00-80.00 T	4.00-38.00 Tig	38.00-80.00 Tbp	80.00-91.60 Mc	130.126
ERD-7	5936	114	135.383074	-30.768311	0.00-2.00 Q	2.00-10.00 T		2.00-10.00 Tbp	10.00-34.00 JK	139.339
ERD-9	5936	116	135.224592	-30.741162	0.00-5.00 Q	5.00-6.00 T	5.00-6.00 Tig		6.00-24.30 N-g	142.439
BB-1	5936	117	135.374468	-30.726722	0.00-8.00 Q	8.00-42.00 T	8.00-32.00 Tig	32.00-42.00 Tbp	42.00-66.00 JK	137.396
BB-2	5936	118	135.383220	-30.652044	0.00-11.00 Q	11.00-41.00 T		11.00-41.00 Tbp	41.00-66.00 JK	137.979
BB-3	5936	119	135.441046	-30.591240	0.00-6.00 Q				6.00-55.00 JK-	150.890
KRP-7	5936	127	135.191138	-30.639032	0.00-8.00 Q	8.00-18.00 T	8.00-18.00 Tig?		18.00-80.00 Ma	129.424
KRP-8	5936	128	135.191563	-30.642704	0.00-4.00 Q	4.00-22.00 T	4.00-22.00 Tig?		22.00-138.00 M	127.790
PK 6	5936	134	135.034716	-30.724839	0.00-3.00 Q				3.00-22.00 Mae	140.710
PK 10	5936	138	135.152861	-30.686366	0.00-16.00 Q	16.00-24.00 T		16.00-24.00 Tbp		124.868
PK 11	5936	139	135.218539	-30.730182	0.00-2.00 Q	2.00-30.00 T		2.00-30.00 Tep2		136.739
PK 12	5936	140	135.218564	-30.732104	0.00-2.00 Q	2.00-16.00 T		2.00-16.00 Tep2	16.00-20.00 Mc	137.763
PK 14	5936	142	135.321497	-30.731320	0.00-6.00 Q	6.00-27.00 T		6.00-27.00 Tep2		137.172
PK 15	5936	143	135.321283	-30.729722	0.00-9.00 Q	9.00-26.00 T		9.00-26.00 Tep2		136.265
PK 16	5936	144	135.306085	-30.730853	0.00-12.00 Q	12.00-30.00 T		12.00-30.00 Tep		132.625
PK 17	5936	145	135.306027	-30.732206	0.00-12.00 Q	12.00-24.00 T		12.00-24.00 Tep		132.819
PK 18	5936	146	135.305602	-30.729409	0.00-12.00 Q	12.00-33.00 T		12.00-33.00 Tep		132.204
PK 27	5936	155	135.204947	-30.624790	0.00-18.00 Q	12.00-33.00 T		18.00-21.00 Tep		136.902
PK 31	5936	159	135.366693	-30.695342	0.00-20.00 Q	12.00-33.00 T		20.00-32.00 Tep	32.00-42.00 Ma	143.443
PK 35	5936	163	135.390764	-30.683063	0.00-11.00 Q	12.00-33.00 T		11.00-30.00 Tep		139.897
DD87ME-1	5936	167	135.024307	-30.661270		0.00-30.00 T	0.00-9.00 Tig	9.00-30.00 Tep	30.00-51.00 JK	122.826

DHNAME	MAP_100	U_NO	LONGITUDE	LATITUDE	THICK_Q	THICK_Tertiary	THICK_Miocene	THICK_Eocene	PRE_Tertiary	ELEVATION
KIN 15	5936	183	135.253097	-30.710718	0.00-2.00 Q	2.00-48.00 T	2.00-33.00 Tig?	33.00-52.00 Tbp	52.00-68.00 Mc	124.414
KIN 16	5936	184	135.259019	-30.704001	0.00-4.00 Q	4.00-55.00 T	4.00-55.00 Tig		55.00-56.00 Mc	125.547
KIN 17	5936	185	135.262127	-30.690785	0.00-2.00 Q	2.00-82.00 T	2.00-46.00 Tig?	46.00-82.00 Tbp	82.00-92.00 Mc	128.540
KIN 18	5936	186	135.265124	-30.682640	0.00-2.00 Q	2.00-43.00 T	2.00-43.00 Tig			130.949
KIN 19	5936	187	135.267605	-30.678140	0.00-8.00 Q	8.00-49.00 T	8.00-48.00 Tig	48.00-50.00 Tbp		132.532
KIN 20	5936	188	135.269422	-30.673751	0.00-7.00 Q	7.00-77.00 T	7.00-44.00 Tig	44.00-72.00 Tbp	72.00-77.00 Mh	133.906
KIN 21	5936	189	135.271627	-30.667990	0.00-6.00 Q	6.00-38.00 T	6.00-38.00 Tig		38.00-41.00 Mc	135.685
KIN 22	5936	190	135.272696	-30.661706	0.00-6.00 Q	6.00-64.00 T	6.00-40.00 Tig	40.00-64.00 Tbp	64.00-65.00 Mh	137.395
KIN 38	5936	205	135.125688	-30.999696	0.00-2.00 Q	2.00-22.00 T	2.00-22.00 Tig?		22.00-24.00 Mc?	129.445
KIN 39	5936	206	135.125979	-30.997584	0.00-2.00 Q	2.00-22.00 T	2.00-22.00 Tig?		22.00-33.00 Mc?	129.229
KIN 40	5936	207	135.126153	-30.994552	0.00-6.00 Q	6.00-20.00 T	6.00-20.00 Tig?		20.00-25.00 Mc?	128.924
KIN 41	5936	208	135.126149	-30.991981	0.00-2.00 Q	2.00-24.00 T	2.00-24.00 Tig?		24.00-26.00 Mc?	128.692
KIN 42	5936	209	135.126158	-30.990771	0.00-4.00 Q	4.00-24.00 T	4.00-24.00 Tig?		24.00-30.00 Mc?	128.598
KIN 43	5936	210	135.124630	-30.983229	0.00-2.00 Q	2.00-24.00 T	2.00-24.00 Tig?		24.00-28.00 Mc?	128.170
KIN 44	5936	211	135.124966	-30.919669	0.00-11.00 Q	11.00-29.00 T	11.00-29.00 Tig?			137.900
KIN 45	5936	212	135.124663	-30.936254	0.00-6.00 Q	6.00-46.00 T	6.00-42.00 Tig?	42.00-46.00 Tbp?		133.990
KINPC 1	5936	223	135.104390	-30.968549	0.00-2.00 Q	2.00-33.00 T	2.00-29.00 Tig?	29.00-33.00 Tbp?	33.00-53.00 Mc?	132.000
KINPC 2	5936	224	135.035919	-30.917956	0.00-2.00 Q	2.00-33.00 T	2.00-30.00 Tig?		30.00-50.50 Kmb?	131.000
KINPC 3	5936	225	135.019872	-30.855608	0.00-2.00 Q	2.00-8.00 T	2.00-8.00 Tig?		8.00-22.00 Mh?	136.000
STUART HWY B9	6036	119	135.522557	-30.778527	0.00-6.00 Q	6.00-20.00 T		6.00-2.00 Tbp?	20.00-27.00 JK	135.642
STUART HWY B4	6036	124	135.681031	-30.898784	0.00-9.00 Q	9.00-42.00 T		9.00-42.00 Tbp?		133.497
STUART HWY B1	6036	125	135.682748	-30.901490	0.00-6.00 Q	6.00-42.00 T	6.00-30.00 Tig?	30.00-42.00 Tbp		134.492
STUART HWY B2	6036	135	135.550735	-30.876096	0.00-9.00 Q	9.00-26.00 T	9.00-19.00 Tig?	19.00-27.00 Tbp		135.849
WG 1	5836	75	134.827045	-30.738010	0.00-4.00 Q	4.00-72.00 T	4.00-36.00 Tig?	36.00-72.00 Tbp	72.00-86.00 Mh	129.000
PS 3	5836	80	134.727914	-30.571968		0.00-144.00 T	0.00-50.00 Tig?	50.00-144.00 Tbp	144.00-152.00 Mh	126.000
PS 4	5836	81	134.728462	-30.562475	0.00-2.00 Q	2.00-40.00 T	2.00-40.00 Tig		40.00-50.00 Mh	125.000
PS 5	5836	82	134.727259	-30.578598	0.00-6.00 Q	6.00-60.00 T	6.00-60.00 Tig	60.00-92.00 Tbp	92.00-109.00 Mh	127.000
PS 6	5836	83	134.727407	-30.585394	0.00-20.00 Q	20.00-31.00 T	20.00-31.00 Tig		31.00-40.00 Mh	127.000

APPENDIX 2 DESCRIPTION OF LOGGED DRILLHOLES

(**THW 11**: drollhole name; **5736-109**: map-100 & unit number; **m:** depth metre; for the stratigraphic symbols see Table 2.1)

MFRP 1; (5636-133). (SA_GEODATA)

Q	**0 - 6 m**	Red sand with minor silcrete horisons.
Tig	**6 - 41 m**	Light brown sand with minor clay & mica fragments.
Alm?	**41 - 126 m**	Metamorphosed granitoid.

MFRP 2; (5636-134). (SA_GEODATA)

Q	**0 - 6 m**	Red sand.
Tig?	**6 - 10 m**	Silcrete with minor calcrete.
	10 - 20 m	Light red sand with minor silcrete horizons.
	20 - 28 m	Limonitic sand w minor calcrete horizons & mica frags.
	28 - 42 m	Whitish very fine sand.
Tbp	**42 - 46 m**	Dark brown carbonaceous clay.
	46 - 75 m	Interlayered black lignite in a dark brown carbonaceous clay.

TM 201; (5636-37).

Q	**0 - 3 m**	Pale brown calcrete.
	3 - 7 m	Reddish brown sand, ferricrete.
	7 - 9 m	Pale brown calcrete.
Tig	**9 - 12 m**	Yellowish brown clay.
	12 – 16.5 m	Pale brown clay, sandy.
	16.5 - 35 m	Pale brown clay.
Mh	**35 – 41.7 m**	Weathered granite.

TM 202; (5636-38).

Q	**0 - 6 m**	Pale brown calcrete.
	6 - 10 m	Reddish brown sand, ferricrete.
Tig	**10 - 12 m**	Pale brown fine sand.
	12 – 16 m	Brown clay.
	16 - 18 m	Greyish white coarse sand.
	18 – 20 m	Whitish brown silt.
	20 – 31.5 m	Yellowish brown clay.
	31.5 - 41 m	Pale brown clay, sandy.
Mh	**41 – 46.5 m**	Weathered granite.
	46.5 – 51.9 m	Fresh granite.

TM 203; (5636-39).

Q	**0 - 3 m**	Pale brown calcrete.
	3 - 6 m	Reddish brown sand, ferricrete.
Tig	**6 - 11 m**	Pale brown clay.
	11 – 14.5 m	Brown fine sand.
	14.5 - 21 m	Brown clay.
	21 – 31 m	Off-white, pale grey medium to coarse sand.
Mh	**31 – 40 m**	Weathered granite.
	40 – 51 m	Fresh granite.

<u>TM 204;</u> (5636-40).

Q	**0 - 4 m**	Pale brown sand & calcrete.
	4 - 6 m	Reddish brown sand, ferricrete.

Tig	**6 - 10 m**	Pale brown fine sand, silt at top..
	10 – 20 m	Pale brown clay with sand lens at base.
	20 – 21.5 m	Pale grey coarse sand.
	21.5 – 24 m	Pale green clay.
	24 – 36 m	Pale grey coarse sand.

Mh	**36 – 38.1 m**	Weathered granite.

<u>TM 205;</u> (5636-41).

Q	**0 – 5.5 m**	Pale brown sand & calcrete.
	5.5 - 9 m	Reddish brown sand, ferricrete.

Tig	**9 - 11 m**	Yellowish white silt.
	11 – 18 m	Off-white clay.
	18 – 21 m	Pale brown fine sand.
	21 – 28.5 m	Pale brown clay.
	28.5 – 36 m	Pale grey medium sand.
	36 – 39 m	Pale grey coarse sand.

Mh	**39 – 43.8 m**	Weathered granite.

<u>TM 206;</u> (5636-42).

Q	**0 – 9 m**	Pale brown sand & calcrete.

Tig	**9 - 15 m**	Yellowish grey clay..
	15 – 20.5 m	Brownish grey fine to medium sands.

Tbp?	**20.5 – 22.5 m**	Dark grey clay, carbonaceous.
	22.5 – 30 m	Black lignite, sandy, clayey.
	30 – 34 m	Pale grey fine to medium sands, clayey.
	34 – 40 m	Pale grey coarse sand.

Mh	**40 – 76.5 m**	Weathered granite.
	76.5 – 84.4 m	Fresh granite.

<u>TM 207;</u> (5636-43).

Q	**0 – 2 m**	Pale brown sand & calcrete.

Tig	**2 – 4.5 m**	Greyish brown clay..
	4.5 – 7 m	Pale grey very fine sand.
	7 – 9 m	Pale grey clay.
	9 – 13.5 m	Brownish grey very fine sand.
	13.5 – 16.5 m	Brownish grey medium sand.
	16.5 – 22 m	Brown-grey fine to very fine sands.
	22 – 28.5 m	Brownish grey medium sand.

Tbp?	**28.5 – 38 m**	Dark grey fine to medium sands, carbonaceous.
	38 – 45 m	Black lignite, sandy, clayey.
	45 – 55 m	Pale grey fine to medium sands.
	55 – 61.5 m	Pale grey coarse sand.

Mh	**61.5 – 65 m**	Weathered granite.
	65 – 69.5 m	Fresh granite.

<u>MALBOOMA 1;</u> (5736-95).

Q	**0 - 3.7 m**	Calcareous sand.

Tig	**3.7 - 11.6 m:**	Green, pale green calcareous clay.

Tbp	**11.6 - 15.6 m**	Brownish grey fine sand.
	15.6 - 17.7 m	Brownish grey, pinkish silt.
	17.7 - 20.1 m	Greyish brown fine sand.
	20.1 - 36.9 m	Black lignitic clay and clayey lignite **(Palynological analysis: 24 m: Middle Eocene, estuarine; 28 m: Middle Eocene, fluvio-lacustrine; 33m: Middle Eocene, weak marine).**
	36.9 - 55.3 m:	Grey clay and dark grey lignitic clay.

Alm	**55.3 - 67.7 m**:	Mulgathing Complex grey clay, gneiss.

<u>KONKABY 1;</u> (5736-82).

Q	**0 - 8 m**	Reddish brown calcareous sands.

Tig	**8 - 16 m**	Pale grey, brown silty to sandy clay, weakly calcareous.
	16 - 32 m	Greenish grey clays, calcareous, sandy towards base.
(Tigk)	**32 - 44 m**	Dark grey, carbonaceous clay **(Palynological analysis: 32 - 34 m & 42 - 44 m: barren; 38 - 40 m: Late Miocene, marginal marine).**
	44 - 48 m	Dark grey sandy clays, carbonaceous. **(Palynological analysis**: **44-46 m: barren**)
	48 - 52 m	Dark grey, fine to coarse sand, carbonaceous, clayey **(Palynological analysis: 48 - 50 m: barren).**
	52 - 58 m	Black/dark grey, carbonaceous gravel & gravely very coarse sand **(Palynological analysis: 52-54 m: Middle-Late Miocene, Marginal marine).**

Tbp	**58 - 66 m**	Dark grey gritty sand, carbonaceous with wood fragments **(Palynological analysis: 64 – 66 m: Middle Eocene, non marine).**
	66 - 68 m	Dark grey sandy clay, carbonaceous with black wood fragments.
	68 - 74 m	Black/dark grey clayey, sandy lignite to lignitic clay.
	74 - 114 m	Black/dark brown, carbonaceous gravel & coarse sand **(Palynological analysis**: **74 – 76 m: Middle Eocene, non marine: fluvial – lacustrine; 86 – 88 m: Middle Eocene, non marine).**
	114 - 128 m	Grey gravely coarse sand, rare carbonaceous clay & wood fragments.
	128 - 136 m	Grey clayey very coarse sand - gravel, with black carbonaceous matrix. **(Palynological analysis: 128 – 130 m: Middle Eocene, non marine).**
	136 - 138 m	AA but white/pale grey colour, clayey, feldspar fragments.

Mh	**138 - 146 m**	Saprolite.
	146 - 147.40 m	Granite

<u>KONKABY 5;</u> (5736-83).

Q	**0 - 9 m**	Reddish brown calcareous sands, minor calcrete

Tig	**9 - 16 m**	Greenish grey, pale brown sandy clay, calcareous.
	16 - 24 m	Greenish grey, pale green calcareous clay with minor white dolomite **(Palynological analysis: 16-18 m: Barren).**
	24 - 34 m	Dark grey, greyish green clay.
	34 - 37 m	Grey sandy gravel and gravely very coarse sand.
	37 - 47 m	Grey, dark grey, gritty, sandy clays.

Tbp	**47 - 55 m**	Brown, dark brown, coarse to very coarse clayey sands, carbonaceous **(Palynological analysis: 51 – 53 m: Middle-Late Eocene, marginal marine).**
	55 - 75 m	Dark brown, blackish clayey gravel with minor sand, carbonaceous **(Palynological analysis: 57 - 59: Middle Eocene, marginal marine – estuarine; 63 - 65 m: Middle Eocene, fluvial-lacustrine, non marine).**
	75 - 81 m	Black medium to very coarse sand, carbonaceous, pyritic **(Palynological analysis: 77 - 79 m: Middle Eocene, weak marine influence).**
	81 - 97 m	Black, dark brown fine to very coarse sand, clayey, carbonaceous, pyritic **(Palynological analysis: 85 - 87 m: Middle Eocene, weak marine influence).**

	97 - 115 m	Dark brown fine sand, silty, gravely, carbonaceous, pyritic **(Palynological analysis: 97 - 99 m: Middle Eocene, estuarine; 111 - 113 m: Middle Eocene, estuarine).**
	115 – 126.9 m	Light brown fine sand, silty, gravely, minor carbonaceous, red stained.

Mh	**126.9 - 127 m**	Granite, pinkish feldspar qtz biotite.

<u>THW 11;</u> (5736-109).

Q	**0 - 1 m**	Red-brown clay + sands +50% gypsum, minor calcareous;

Tig	**3 - 9 m**	Greenish grey clay, sandy, plasticky.
(Tigk)	**9 - 14m**	Black sandy clay, carbonaceous minor gypsum.
	14 - 22 m	Grey, light brown clay, sandy at base.
	22 - 32 m	Pale grey, light brown fine to medium sands, clayey.
	32 - 43 m	Pale grey, brownish grey clay, gravely at base.

Tbp	**43 - 45 m**	Black sandy clay, carbonaceous.
	45 - 48 m	Black medium to coarse sands, carbonaceous, clayey.
	48 - 52 m	Black sandy clay, carbonaceous.
	52 - 60 m	Black medium to coarse sands, carbonaceous, pyritic.
	60 - 75 m	Light grey coarse sand, with lignite at 71-73 m.
	75 - 81 m	Light grey, grey very coarse sand, **<u>with Au anomalies: 14-127 ppb at 73-82m.</u>**
	81 - 83 m	grey medium to coarse sand, gravel at base, some carbonaceous.

<u>THW 12;</u> (5736-110). **(SA_GEODATA)**

Q	**0 - 7 m**	Pale orange clay, with hematite, clayey sand at base.

Tig	**7 - 13 m**	Pale grey clay.
(Tigk)	**13 - 16 m**	Black carbonaceous clay, minor pyrite.
	16 - 22 m	Grey clay, minor pyrite.
	22 - 27 m	Brownish grey sandy clay, minor red oxidised Fe stones.

Tbp	**27 - 38 m**	Pale grey clay, **<u>with uranium anomalies: 4-15 ppm at 34-41m.</u>**
	38 - 47 m	White fine sand, clayey, minor HMs**.**
	47 - 61 m	White medium to coarse sand, clayey.
	61 - 71 m	grey coarse sand, clayey, **<u>with Au anomalies: 7-81 ppb at 61-70m.</u>**

<u>THW 13;</u> (5736-111).

Q	**0 - 5 m**	Pale red clay + sands, calcareous

Tig	**5 - 14 m**	White, brown, light grey clay, sandy.
	14 - 21 m	Whit clay, minor oxidised Fe stone.

Tbp	**21 - 40 m**	Brown clay.
	40 - 68.8 m	Pale grey, brownish grey, grey, brown clay, sandy.

Mh	**68.8 - 71 m**	Weathered granite basement.

THW 16; (5736-113).

Q.	**0 - 1m**	White gypsum, sand.
	1 - 2 m	Light brown clay + sand.

Tig	**2 - 10 m**	Whitish grey, pale green clay.
(Tigk)	**10 - 16 m**	Dark grey clay, carbonaceous **(Palynological analysis: 12-13 m, 13-14 m: barren)**.
	16 - 22 m	Grey clay, sandy.

Tbp	**22 - 27 m**	Brownish grey fine sand, clayey & silty, carbonaceous at base.
	27 - 33 m	Grey-brown coarse to very coarse sands, clayey.
	33 - 38 m	Dark grey-black clay, carbonaceous **(Palynological analysis: 35-36 m: barren)**.

	38 - 41 m	Dark brown sand + minor black carbonaceous clay **(Palynological analysis: 38 – 39 m: Late Oligocene-early Miocene, lacustrine-estuarine)**.
	41 - 46 m	Black lignite w minor pyrite, sandy, more sandy towards the base **(Palynological analysis: 41 – 42 m: Middle-early Late Eocene, lacustrine)**.

Alm	**46 - 82 m**	Light blue- green-dark green-greyish clay
	82 - 90.5 m	Uralitised gabbro.

THW 17; (5736-114).

Q	**0 - 4.5 m**	Red clayey sands, calcareous.

Tbk	**4.5 - 13 m**	Yellowish white very fine to fine sand, minor HMs, light brown medium at base.

Tbp	**13 - 16 m**	Light brown silt, clayey, minor carbonaceous.
	16 - 19 m	Dark brown clay, silty, carbonaceous.
	19 - 24 m	Black lignite, silty, pyritic.
	24 - 32 m	Black-dark brown silts, carbonaceous.
	32 – 35 m	Black lignite, sandy.
	35 - 35.5m	Dark brown very coarse sand, carbonaceous.

ALm	**35.5 - 38 m**	Granite Saprolite.
	>38 m	Fresh Granite,

THW 18; (5736-115).

Q	**0 -2m**	Red/orange clayey calcareous sands.

Tig	**2 - 8 m**	Clay – various pale brown, pale grey, white, yellowish green, silts at base.

Tbk	**8 - 13 m**	WS, fg, white to buff, fine to medium sands.

Tbp	**13 - 16.5 m**	Brown fine to coarse sands, clayey, minor carbonaceous.

Alm	**16.5 - 29.5m**	Weathered Christie Gneiss saprolite. **Sample**
	29.50 - 42m	Fresh Christie Gneiss.

THW 20; (5736-117).

Q	**0 -3 m**	Reddish brown, clayey, sands and silts, calcareous s.

Tig	**3 - 9 m**	Brownish white fine to coarse sands, clayey.
	9 - 11 m	Pale brown clay.
	11 - 25 m	White, brownish white medium to coarse sands, clayey.
	25 - 31 m	Brownish white coarse to very coarse sands.

Tbp	**31 - 35m**	Grey fine sand, minor carbonaceous.
	35 - 42 m	Dark grey-black medium to coarse sands carbonaceous.
	42 - 60 m	Black medium to coarse sands, gravely, carbonaceous.
	60 - 67 m	Brown silty clays, carbonaceous.
	67 - 77 m	Light brown clay, sandy.
	77 - 80 m	Grey medium to coarse sands, minor clay.
	80 - 82m	Pale brown silty clay.
	82 – 86.5 m	Black gravel & very coarse sand, carbonaceous.

THW 21; (5736-118).

Q	**0 - 7 m**	Red clay + sand, minor ferricrete.

Tig	**7 - 15 m**	Pale orange fine sand, clay.
	15 - 23 m	White fine to coarse sands, gravely.

Tbp	**23 - 31 m**	Brown fine to medium sands, clayey.
	31 - 33 m	Black-dark brown silt, clay, carbonaceous.

	33 - 41 m	Dark brown/black silty /clayey lignite **(Palynological analysis: 33 – 34 m, 35 m: Middle-early Late Eocene, swamp-lacustrine-estuarine)**.
	41 - 46 m	Black fine to medium sands, clayey, carbonaceous **(Palynological analysis: 41 – 42 m: Middle-early Late Eocene, swamp-lacustrine-estuarine)**.
	46 - 50 m	Greyish black medium to coarse sands, pyritic, carbonaceous.
	50 - 65 m	Black-dark grey coarse to very coarse sands, pyritic, carbonaceous**.**
	65 – 70.5 m	Dark grey coarse to very coarse sands, pyritic, carbonaceous**.**

THW 23; (5736-120).

Q.	**0 - 3 m**	Red clayey calcareous sands and silts.

Tig	**3 –9 m**	Whitish yellow, pale brown clays, off-white fine sands at base.
	9 – 11 m	Fg-granule sand, SR-SA, orange stained qrtz sand + vf. clayey sands. **Samples**
	11 – 12 m	Brownish white clayey silts & very fine sands, reddish oxidised Fe-stain.
	12 – 13 m	Brown very coarse sand & gravel , Fe- stained, clayey.

Tbp	**13 – 14 m**	Reddish brown fine sands, clayey, silty, ferricrete grains.
	14 – 19 m	Off-white medium to coarse sands.
	19 – 29 m	Grey fine to coarse sands, gravely.
	29 – 39 m	Greyish white fine to coarse sands, clayey, minor carbonaceous at base.
	39 – 40 m	Black-dark brown medium sand, carbonaceous.
	40 – 43 m	Black gravel & very coarse sand, sandy, carbonaceous.
	43 – 48 m	Black-dark brown fine to medium sands, very coarse at base, carbonaceous.
	49 – 55.5 m	Black gravel & very coarse sand, sandy, carbonaceous, wood fragments.

THW 24; (5736-121). **(SA_GEODATA)**

Q	**0 - 16 m**	Surficial alluvial red clay + sand, ferricrete.

Tig	**16 - 20 m**	Mottled greenish-reddish brown clay, sandy.
	20 - 33 m	White fine sand.
	33 - 34.5 m	Brown fine sand, gravely, minor carbonaceous, silcrete-microconglomerate.

THW 25; (5736-122).

Q	**0 - 7m**	Red medium sands, calcareous, ferricrete.

Tig	**7 - 11 m**	Pale green – pale brown fine to medium sand, clayey.
	11- 16 m	White/orange medium to coarse sands, silty, clayey.
	16 - 18 m	White-pinky buff sandy clay.
	18 - 27 m	ye-white medium to very coarse sands, gravely.

Tbp	**27 - 33 m**	Dark grey-black medium to coarse sands, carbonaceous.
	33 - 35 m	Black gravel, clayey, sandy, carbonaceous.

THW 26; (5736-123). **(SA_GEODATA)**

Q	**0 - 9 m**	Reddish brown clay + sand.

Tig	**9 - 11 m**	Mottled whitish brown clay, sandy.
	11 - 14m	White fine to coarse sands.
	14 – 14.5m	Silcrete.

THW 27; (5736-124).

Q	**0 – 7.5 m**	Reddish brown clay + sand.

Tig	**7.5 –14 m**	Light yellow-white-yellowish green clay, silty, gypsum, sandy at base.
	14 – 20 m	Greyish white clay, sticky, pale mottled, sandy at base.
	20 – 22 m	Brownish grey clay.
	22 – 24 m	Brownish grey fine to coarse sands sand, clayey.
(Tigk)	**24 – 31m**	Dark grey-grey-dark brown sandy clay, carbonaceous.

	31 - 34m	Pale grey gravel, clayey, sandy, ferruginised fragments.

Mh	**34 - 54 m**	Weathered GRVL, clay.
	54 - 71.5 m	Hiltaba Suite FINT Qtz-fspar-mica in clay with sulphide trace.

THW 28; (5736-125).

Q	**0 – 14 m**	Reddish brown clay + sand, ferricrete.

Tig	**14 – 17 m**	Pale green-brown-(white-pale grey-pink) clays, mottled.
	17 – 26 m	Pale grey- greyish white fine to coarse sands, clayey.
	26 – 36 m	White medium to very coarse sands, clayey, gravel at base.

Tbp	**36 – 39 m**	Brownish grey clay, limonitic.
	39 – 49 m	Dark grey-dark brown-black lignite, clayey, silty.
	49 – 62 m	Dark brown clay, silty, carbonaceous.
	62 – 68 m	Dark brown-black medium to very coarse sands, gravely, clayey, carbonaceous.
	68 – 75 m	Dark grey coarse to very coarse sands, gravely, pyritic, carbonaceous.
	75 – 92 m	Grey-brown coarse sand, clayey, gravely, minor lignitic, tr pyrite.
	92 – 95 m	Greyish white coarse sand, gravely.

THW 29; (5736-126).

Q	**0 – 3 m**	Reddish brown clayey silts and sands, calcareous.

Tig	**3 – 7 m**	Pale green sandy clay.
	7 – 16 m	Pale greyish green, pale grey, grey clay, silty.
	16 - 21m	grey & brown clay, sandy, silcrete at base**.**

TC 54; (5736-133).

Q	**0 - 5 m**	Brownish red sand, calcareous.

Tig	**5 – 12 m**	Brownish green, brownish grey, off-white clay, silty.
	12 – 18 m	Grey fine sand, lamination.
	18 – 30 m	Pale brown-grey fine to medium sands **(Palynological analysis: 29.2 m: Miocene-Pliocene, terrestrial)**.

Tbp	**30 – 33 m**	Dark brown silt-very fine sands, carbonaceous **(Palynological analysis: 32-34 m: Late Eocene-Early Oligocene, estuarine-weak marine)**.
	33 – 39 m:	Black lignitic clay + lignite **(Palynological analysis: 39.1-39.3 m: Middle Eocene, lacustrine-estuarine)**.
	39 - 47.5 m:	Dark grey clay, carbonaceous **(Palynological analysis: 46-46.4 m: Middle Eocene**, **lacustrine-estuarine).**

Mh?	**47.5-50.1**	Hiltaba Suite Kaolin w minor qtz & pyrite.

TC 56; (5736-135).

Q	**0 - 3 m**	No sample.

Tig	**3 - 5 m**	Grey-green clay.
	5 - 12.5 m	Off-white, pale brown silt-very fine sand.
	12.5 – 18 m	Brown fine to medium sands, cross-bedding + lamination.
	18 – 26 m	Off-white medium to coarse sands, trough cross-bedding.
	26 - 32 m	Grey coarse to very coarse sands.

Tbp	**32 - 35 m**	Brown fine sand , carbonaceous.
	35 – 38 m	Dark grey- black lignite, sandy.
	38 – 41 m	Black silt, clayey, carbonaceous.

Mh	**41 - 45 m**	Weathered Hiltaba Suite Kaolin w minor qtz & pyrite.

TC 58; (5736-137).

Q	**0 - 3 m**	Reddish brown sand, calcareous.

Tig	**3 - 6 m**	Green, yellowish brown caly.
	6 - 7.5 m	Pale brown, off white fine- to coarse sands.
	7.5 –12 m	Brown-off white silt, clayey, lamination.
	12 – 26 m	Off white, pale grey medium to coarse sands.
	26 – 32 m	Pale grey coarse to very coarse sands.

Tbp	**32 – 34 m**	Black lignite, silty **(Palynological analysis: 32.5-33 m: Middle – early Late Eocene, estuarine-lacustrine)**.
	34 – 36 m	Black-dark grey coarse sand, carbonaceous.

Mh?	**36 - 42.6 m**	Weathered Hiltaba Suite GRNT Kaolinised granite w fg pyrite.

TM 589; (5736-229).

Q	**0 - 1.5 m**	Reddish brown sand, calcareous.

Tig	**1.5 – 3 m**	Brownish green clay.
	3 – 24 m	Yellowish brown, off-white fine sand.
	24 – 31 m	Grey medium to coarse sands.

Tbp	**31 – 34 m**	Dark brown fine to medium sands, carbonaceous.
	34 – 48 m	Dark brown-black fine to coarse sands + lignite, silt, clay.
	48 – 50 m	Grey clay.

Mh	**50 – 52 m**	Weathered Hiltaba Suite Granite, saprolite.

TAR 65; (5736-387).

Q	**0 – 2 m**	SAND, red, silty to clayey, fine-grained, gypsiferous.
	2 – 4 m	SILCRETE, pink-red, coarse-grained.

Tig	**4 – 14 m**	CLAY, mottled orange to grey-green-dark grey, puggy.
	14 – 18 m	CLAY, mottled orange to greenish grey, sandy, ironstone nodules.
	18 – 26 m	CLAY, mottled pale grey - grey to orange, massive.

Alm	**26 – 46 m**	SAPROLITE, mottled pale grey-red-olive-khaki-dbn-blue-oran, granite.
	46 – 50 m	AMPHIBOLITE, dark green, major amphibole, quartz & feldspar.

TAR 66; (5736-388).

Q	**0 – 2 m**	SAND, red, silty to clayey, gypsiferous.
	2 – 4 m	SILCRETE, pink-red, medium-grained, clayey.

Tig	**4 – 10 m**	CLAY, mottled orange to grey-green, sandy.
	10 – 16 m	CLAY, pale-dark grey, puggy.
	16 – 20 m	CLAY, pale grey, massive.

Mh	**20 – 48 m**	SAPROLITE, pale-dark grey, weathered granite.
	48 – 50 m	Fresh granite.

TAR 68; (5736-390).

Q	**0 – 4 m**	SAND + CLAY, red, silty to clayey, gypsiferous.

Tig	**4 – 14 m**	CLAY, mottled orange to grey-green-yellow-brown.
	14 – 24 m	CLAY, pale grey, grey, green, sandy, SILCRETE at base.

Mh	**24 – 60 m**	SAPROLITE, mottled pale grey to yellow-brown-dark grey-dark green.

Commonwealth Railways 10/73 (Bore 20); (5836-98).

Q	**0 – 8 m**	Reddish brown fine sand & clay, calcareous.

Tig	**8 – 11 m**	White to yellowish grown sandy clays, calcareous.
	11 – 14 m	Whitish grey medium sand, clayey, calcareous.
	14 – 20 m	Grey-brown-green clays, sandy, calcareous.
(Tigk)	**20 – 25.6 m**	Dark grey-dark brown clays, sandy, carbonaceous.

Tbp?	**25.6 – 32 m**	Whitish grey medium to very coarse sands.

TTS 1; (5836-137).

Q	**0 – 10 m**	Reddish brown sandy clay, calcareous

Tig	**10 – 14 m**	Greyish green clay, sandy.
	14 – 16 m	Pinkish white medium to coarse sands, minor Fe stained.

JK-a/CP-b?	**16 – 71 m**	Moist brown-pink-red-grey-cream brown clays, sandy.

TTS 2; (5836-138).

Q	**0 – 11 m**	Reddish brown haematitic clay + sand.

Tig	**11 – 14 m**	Pale brown, greyish green clays, sandy.
	14 – 17 m	Pale brown medium to coarse sands, clayey.

JK-a/CP-b?	**17 – 48 m**	Moist brownish red-yellow-white-cream brown clays, sandy.

THW 04; (5836-102). (SA_GEODATA)

Q	**0 – 5 m**	Pale red clay, weathered calcrete.

Tig	**5 – 15 m**	White-off white clays, minor green clay.
	15 – 30 m	Pale brown clay.
	30 – 44 m	Yellowish white clay.
	44-57.2m	Brownish white sandy clay.

Ltt	**57.2 – 72 m**	Tarcoola Formation: weathered silicified QTZT, greyish white.

THW 05; (5836-103).

Q	**0 – 3 m**	Reddish brown sandy clay.

Tig	**3 – 10 m**	Off white – pale green clays.
	10 – 45 m	AA. with HMs hematite/ilmenite (25%).
	45 – 66 m	white sandy clay w oxidised Fe stone-limonite? Increasing ilmenite downwards.

Tbp	**66 – 78 m**	Dark grey clay, sandy, carbonaceous.
	78 – 100 m	Black-dark grey clays, carbonaceous, plant material.
	100 – 117 m	Black-dark grey clays, sandy, carbonaceous, large plant material.

Ltt	**117 – 131 m**	Weathered basement qtzt.

THW 06; (5836-104).

Q	**0 – 3 m**	Pale red sand, calcrete.

Tig	**3 – 23 m**	Pale yellow clay.
	23 – 37 m	Yellowish white clay, sandy.
	37 – 62 m	AA. Minor small rounded oxidised Fe stones.

Tbp	**62 – 72 m**	Dark grey clay, carbonaceous, some plant material.

Ltt	**72 - 81.5 m**	Weathered basement quartzite – grey-black clay & angul. qtz.
	81.5 – 94 m	Basement Quartzite, varicoloured.

THW 07; (5836-105). **(SA_GEODATA)**

Q	**0 – 5 m**	Orange sandy clay, calcrete.
Tig	**5 – 21 m**	Pale grey clay.
	21 – 41 m	Yellowish white clay.
	41 – 50 m	Pinkish grey, grey clay, sandy.
Tbp?	**50 - 69.2 m**	Dark grey-black clay, carbonaceous, plant material.
Ltt	**69.2 – 77 m**	Weathered basement schist & clay.

THW 08; (5836-106).

Q	**0 – 2 m**	Orange sand, calcrete.
Tig	**2 – 5 m**	White sandy clay.
	5 – 13 m	Off-white clay + gypsum.
	13 – 19 m	Pale grey clay.
	19 – 24 m	White very fine sand, with gypsum chips.
	24 – 38 m	Greyish yellow clay, gypsum.
Mh	**38 – 60 m**	Weathered granite.
	60 – 61 m	Fresh granite.

THW 09; (5836-107). **(SA_GEODATA)**

Q	**0 – 6 m**	Pale red sandy clay, calcareous.
Tig	**6 – 15 m**	Pale grey clay.
	15 – 23 m	Pale brown fine to medium sand, clayey.
	23 – 30 m	Pale grey, pale brown clays, sandy.
	30 – 33 m	Pale brown medium sand.
Ltt	**33 – 36 m**	Weathered basement schist.

THW 10; (5836-108).

Q.	**0 - 10m**	Reddish brown clay + sand, calcrete
Tig	**10 – 20 m**	Pale grey-green-pale brown clays, sandy.
	20 – 31 m	Pale brown, off-white fine sands, yellowish coarse-grained at base.
Tbp	**31 – 48 m**	Yellowish brown/pale orange medium sands, clayey.
	48 – 54 m	Brown-pale brown medium to coarse sands, clayey, very coarse-grained at base.
Mh	**64 – 85 m**	Weathered granitic basement**.**
	85 – 86 m	Fresh granitic basement.

THW 14; (5836-109).

Q	**0 – 3 m**	Reddish brown clay + sand.
	3 – 6 m	Ferricrete + calcrete.
Tig	**6 – 8 m**	Mottled pale green-yellow silty clays + minor clayey silts.
	8 – 23 m	Pale green, off-white clays, plasticky and massive, minor gypsum.
	23 – 25 m	Yellowish green coarse to very coarse sands, gravely at base.
Tbp	**25 – 33 m**	Greyish white fine to medium sands, silcrete top.
	33 – 36 m	Grey clayey medium to coarse sands, clayey.
	38 – 42 m	AA, coarse to very coarse grained.
	42 – 51 m	Grey gravel + medium to very coarse sand.

	51 – 53 m	Grey fine to very coarse sands, clayey.	
	53 – 56.5 m	AA. ferricreted grains.	

Labyrinth Formation?		**56.5 – 90 m**	Multicoloured clays, gritty.

Konkaby Basalt?		**90 – 91 m**	Grey-black ultrabasic crystalline basement rock - fresh rock.

<u>TLM 01; (5836)</u>

Tig	**0 – 2 m**	Pale brown clay, gypsum.
	2 – 8 m	Pale grey, pale brown fine sand, clayey.
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	8 – 14 m	Off-white clayey gypsum.
Tbp	**14 – 26 m**	Pale grey, grey clay.

Alm	**26 – 36 m**	Deeply weathered gneiss.

<u>TLM 02; (5836).</u>

Tig	**0 – 4 m**	Pale brown gypsum.
	4 – 6 m	Pale grey clay.
	6 – 8 m	Grey fine sand, clayey.

Tbp	**8 – 14 m**	Pale grey gypsum.
	14 – 24 m	Grey, pale grey clays.

Alm	**22 – 26 m**	Weathered gneiss.

<u>TLM 03 (5836).</u>

Tig	**0 – 4 m**	Pale brown silty sand + gypsum.
	4 – 8 m	Pale grey sandy gypsum.
	8 – 10 m	Pale brown sandy clay.
	10 – 14 m	Pale brown, pale grey fine sands, clayey.

Tbp	**14 – 18 m**	Pale brown gypsum, sandy.
	18 – 20 m	Pale grey clay.

Alm	**20 – 26 m**	Weathered gneiss.

<u>TLM 08;</u> (5836-113).

Q	**0 – 2 m**	Reddish brown fine sand + clay, calcareous.

Tig	**2 – 5 m**	White-yellowish white clay.
	5 – 14 m	Orange-pale brown clay, sandy.
	14 – 20 m	Greenish grey clay + gypsum.
	20 – 23 m	Grey clay, minor gypsum.
(Tigk)	**29 – 38 m**	Dark grey clay, carbonaceous.

Tbp	**38 – 41 m**	Pale grey clay, sandy.
	41 – 43 m	Pale grey fine to very coarse sands + clay.
	43 – 49 m	Pale grey medium to very coarse sands.
	49 – 51 m	Pale grey medium to very coarse sands, clayey.
	51 – 54 m	Pale grey medium to very coarse sands sand, gravel at base.

Mh	**75 – 95 m**	Saprolite?
	95 – 97 m	Fresh biotite granite. Dk gn bt pink-orange fs, clear qtz.

<u>TLM 09;</u> (5836-114). **(SA_GEODATA)**

Q	**0 – 9 m**	Reddish brown clay + sand.

Tig	**9 – 13 m**	Greenish brown clay + fine to coarse sands.
	13 – 17 m	Off-white gypsum, minor greenish brown clay.

(Tig)	**17 – 21 m**	Dark grey clay, carbonaceous.
	21 – 25 m	Grey clay + fine to medium sands.
	25 – 29 m	Green, brown clays, mottled?
	29 – 32 m	Brownish white clay, sandy.
	32 – 43 m	Pale green-pale yellow-greenish blue clays, mottled?
	43 – 45 m	Grey sand, clayey.
	45-47.2m	Pale green clay.

Mh	**47.2 – 54 m**	Weathered granite.
	54 – 59 m	Fresh granite

<u>TLM 15;</u> (5836-120).

Q	**0 - 1 m**	Reddish brown clayey sand.

Tig	**1 – 5 m**	Brown medium to coarse sands, clayey.
	5 – 8 m	Sandy clay, mottled reddish brown – green.

Tbp?	**8-9m**	Pale grey gypsum.
	9 – 12 m	Dark grey-black clay, carbonaceous.
	12 – 18 m	Pale grey clay .

Mae	**18 – 25 m**	Ealbara Rhyolite, thin laterite weathering profile over clay.
	25 - 25.5 m	Porphyritic rhyolite.

<u>TLM 16;</u> (5836-121). **(SA_GEODATA)**

Q	**0 – 4 m**	Reddish brown clay & sand.

Tig	**4 – 8 m**	Pale green, greenish white clay, sandy.
	8 – 10 m	Green clay & fine sand.
	10 - 11.5 m	Brown clayey gravel, sandy.

Mh	**11.5 – 14 m**	Weathered granite.

<u>WG 1;</u> (5836-75).

Q	**0 – 4 m**	Reddish brown clayey sand.

Tig	**4 – 12 m**	Pale brown coarse to very coarse sands, clayey, gravely at base.
	12 – 18 m	Pale brown, pale grey fine to coarse sands, clayey.
	18 - 28 m	Pale brownish grey medium to coarse sands, silty, minor carbonaceous.
	28 - 32 m	Pale grey fine to medium sands, clayey.
	32 - 36 m	Pale brownish grey coarse to very coarse sands, silty, minor carbonaceous.
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	36 - 50 m	Pale grey, off-white fine to medium sands, silty, Fe-staining at top..
	50 - 60 m	Pale grey, off-white medium to coarse sands, silty.
	60 - 70 m	Dark grey coarse sands, silty, carbonaceous, pyritic.
	70 - 72 m	Pale grey very coarse sands, gravely.

Mh	**72 – 84 m**	Weathered granite.
	78 – 86 m	Fresh granite.

<u>PS 1;</u> (5836-78).

Q	**0 – 2 m**	Pale brown fine to medium sands, gypsum.

Tig	**2 – 4 m**	Off-white fine-grained sandy gypsum.
	4 – 6 m	Off-white, pale grey sandy clay & fine sand.
	6 - 12 m	Pale brown clay, sandy.
	12 – 14 m	Brown gypsum, clayey.
	14 – 20 m	No samples.

<u>PS 2;</u> (5836-79).

Q	**0 – 2 m**	Pale brown fine to medium sands, gypsum.

Tig	**2 – 10 m**	Pale brown, pale grey clay, massive.
	10 – 14 m	Grey, pale grey clay, minor dark grey carbonaceous material.
	14 - 18 m	Grey, brown clay, gypsum.
	18 – 24 m	Brown, pale grey clay & fine to medium sands.
	24 – x m	Brown fine to medium sands, clayey.

<u>PS 3;</u> (5836-80).

Tig	**0 – 2 m**	Pale brown clayey gypsum.
	2 – 8 m	Brown clay, silty, gypsum, **with 10-12 ppm uranium**.
	8 - 12 m	Pale brown clayey gypsum.
	12 – 18 m	No samples.
	18 - 22 m	Greenish grey clay, gypsum, **with 8-10 ppm uranium.**
	22 – 28 m	Greenish pale grey clay.
	28 - 30 m	Dark grey clay.
	30 – 34 m	Greenish dark grey clay.
	34 - 36 m	Dark grey fine to coarse sands.
	36 – 50 m	Dark grey medium to very coarse sands, minor carbonaceous & reddish gypsum.

Tbp	**50 - 62 m**	Grey fine to coarse sands, clayey, silty, minor carbonaceous.
	62 – 64 m	Grey coarse sands.
	64 - 72 m	Pale grey fine to coarse sands,
	72 – 82 m	Grey fine sands.
	82 - 86 m	Grey fine to medium sands, minor carbonaceous.
	86 - 100 m	Grey fine to coarse sands, minor carbonaceous.
	100 - 128 m	Grey coarse to very coarse sands, pyritic, minor carbonaceous.
	128 - 136 m	Grey fine to coarse sands, minor carbonaceous.
	136 - 144 m	Pale grey fine to coarse sands, pyritic.

Mh	**144 – 152 m**	Weathered granite.
	152 – 158.2 m	Fresh granite.

<u>PS 4;</u> (5836-81).

Tig	**0 – 2 m**	Pale brown fine sands, clayey, silty.
	2 – 8 m	Pale brown fine to medium sands, silty, gypsiferous.
	8 – 12 m	Pale brown clay.
	12 - 24 m	Pale brown clay, gypsum, sandy at base.
	24 – 32 m	Greenish pale grey clay sandy at base.
	32 – 36 m	Pale greenish-pale grey clay, minor gypsum.
	36 – 40 m	Greenish pale grey clay sandy at base.

Mh	**40 – 48 m**	Weathered granite.
	48 – 50 m	Fresh granite.

<u>PS 5;</u> (5836-82).

Tig	**0 – 6 m**	Pale brown fine to coarse sands, clayey, **with 6-10 ppm uranium**
	6 – 14 m	Pale brown clay, sandy, gypsum, **with 6-8 ppm uranium**.
	14 - 18 m	Grey clayey gypsum, minor carbonaceous.
	18 - 20 m	Grey medium to coarse sands, clayey, gypsum**.**
	20 – 24 m	Pale grey clay, sandy.
	24 - 52 m	Pale grey-brown-grey medium to coarse sands, clayey, carbonaceous at base.
	52 - 60 m	Grey coarse to very coarse sands, kaolinitic, gravel at base.

Tbp	**60 - 82 m**	Pale grey fine to coarse sands, pyritic.
	82 – 92 m	Grey fine to very coarse sands, silty at base.

Mh	**92 – 106 m**	Weathered granite.
	106 – 109 m	Fresh granite.

PS 6; (5836-83).

Tig	**0 – 20 m**	Pale brown fine to very coarse sands, clayey, silty.
	20 – 22m	Pale grey clay, silty, sandy.
	22 – 24 m	Pale brown fine to very coarse sand, silty.
	24 - 31 m	Off-white silicified clay, sandy at base.

Mh	**31 – 37 m**	Weathered granite.
	37 **– 40 m**	Fresh granite.

TPS 7; (5836-126). **PIMA II_Log**

Q	**0 – 11 m**	Reddish brown medium to coarse sands, hematite.

Tig	**11 – 16 m**	Pale brown clay, sandy.
	16 – 41 m	Grey-pale green clay, minor gypsum & sand **(Palynological analysis: 22-23 m: Miocene-Pliocene, terrestrial, weak marine).**
	41 – 45 m	Pale grey clay **(Palynological analysis: 44-45 m: Miocene-Pliocene, terrestrial)**
	45 – 54 m	Greenish grey, off-white clays, silty.
	54 – 57 m	grey clay & fine sand.
	57 – 61 m	Dark grey-brown medium to coarse sands, carbonaceous **(Palynological analysis: 58-59 m: Miocene-Pliocene, terrestrial)**
	61 – 64 m	Pale Grey-grey coarse to very coarse sands.
	64 – 66 m	Pale grey-whitish gravel granules (2-4 mm).
	66 – 72 m	Pale brown fine to medium sands.
	72 – 77 m	Pale brown medium to coarse sands, minor carbonaceous.
(TigK)	**77 – 83 m**	Black lignitic sands, coarse to very coarse-granules, with black granules + pebbles at 82 – 83 m **(Palynological analysis: 77-78 m: Miocene-Pliocene, terrestrial; 79-80 m: Miocene-Pliocene, terrestrial).**

PIMA II-K4a		
Tbp	**84 – 88 m**	Black coarse to very coarse sands, carbonaceous **(Palynological analysis: 87-88 m: late Middle Eocene, marginal marine).**
	89 – 90 m	Brown medium sand, carbonaceous **(Palynological analysis: 89-90 m: late Middle Eocene, marginal marine).**
	90 – 90.5 m	Pale grey – whitish medium sand.
	90.5 – 92 m	Pale gy – whitish gravel, granules.
	92 – 98 m	pale grey fine to very coarse sands, gravel & minor carbonaceous at base.
	98 - 101m	Pale grey medium to coarse sands, minor carbonaceous at base.
	101 – 108 m	Dark brown gravel, silty, carbonaceous **(Palynological analysis: 101-102 m: late Middle Eocene, marginal marine).**
	108 – 112.5 m	Grey gravel, minor carbonaceous **(Palynological analysis: 109-110 m: late Middle Eocene, marginal marine).**
	112.5 – 122 m	Grey coarse sand, gravely, minor carbonaceous.
	122 – 126 m	Pale grey medium to very coarse sands, silty **(Palynological analysis: 125-126 m: late Middle Eocene, marginal marine)**

Mh	**125 – 150 m**	Hiltaba Suite clay with medium-very coarse sand and feldspar fragments.
	126 – 139.5 m	White-pale grey clay, sandy, **with Au anomalies: 20-548 ppb at 133-137m.**
	139.5 –145 m	White-pale grey fine to coarse sands, pyritic.
	145 – 150 m	Green-grey clays & coarse to very coarse qtz & feldspar.
	150-154.7	Hiltaba Suite Fresh granite.

TPS 8; (5836-127).

Q	**0 – 8 m**	Reddish brown clay & sand.
	8 – 16 m	Brown clay, sandy.

Tig	**16 – 30 m**	Dark greyish green clay, gypsum.
	30 – 36 m	Pale green-grey-yellowish green-brown clays, minor sand.
(Tigk)	**36 - 43.2 m**	Dark grey-black clays, minor medium-coarse sands at base, carbonaceous.

Tbp	**43.2 – 46 m**	Greyish brown medium sand.
	46 – 49 m	Dark grey clay & coarse sand, minor carbonaceous.
	49 – 50 m	Pale grey-greyish brown fine to coarse sands.
	55 – 60 m	Pale brown medium sand.
	60 - 63.2 m	Off-white clay + minor medium to very coarse sands.

Mh	**63.2 - 75.6 m**	Weathered granite. **with Au anomalies: 20-200 ppb at 70-82m.**
	75.6 – 80 m	Hiltaba Suite Fresh granite.

<u>TPS 9;</u> (5836-128). **PIMA II_Log**

Q	**0 – 6 m**	Red clay + white calcrete.
	6 – 16.8 m	Red clay + white calcrete + sand.

Tig	**16.8 42.8 m**	Pale green-pale grey clays, dark brown-yellow-grey colours at base.

Tbp	**42.8 - 45m**	Pale brown-grey medium to coarse sands.
	45 – 48 m	Pale brown coarse to very coarse sands**.**
	48 – 53 m	Pale grey medium to coarse sands.
	53 – 58 m	Greyish brown gravel, sandy.
	58 – 63 m	Brownish grey medium to coarse sand, carbonaceous.
	63 – 70 m	Greyish brown gravel, minor carbonaceous.
	70 – 71 m	Black gravel, carbonaceous.
	71 – 73 m	Black-dark grey clays, sandy, carbonaceous.
	73 – 75 m	Black-brown fine sand, carbonaceous.
	75 – 98 m	Pale grey-pale brown fine to medium sands.
	98 – 100 m	Dark grey-black fine to medium sands, carbonaceous.
	100 – 105 m	Brownish grey coarse sand, very coarse grained at base, minor carbonaceous.
	107 – 124 m	Brownish grey gravel & coarse to very coarse sands, minor dark Grey carbonaceous matter at base, with **Au anomalies: 11-105 ppb at 114-124m.**

Mh	**124 – 125 m**	Hiltaba Suite granite.

<u>TPS 10;</u> (5836-129).

Q	**0 – 5 m**	Reddish brown clay + sand.

Tig	**5 - 15.9 m**	Greenish yellow or yellowish green clays, sandy at base.
	15.9 – 25 m	Grey-green clays.
	25 –26 m	Pale brown fine sand.
	26 - 49.6 m	Greenish grey clay.
	49.6 - 59 m	White- pale green-grey clays, sandy.
	59 – 61 m	Pale brown clay + minor medium to coarse sands.

Tbp	**61 – 62 m**	Dark brown-black clays, sandy, carbonaceous.
	62 – 63 m	Black clayey lignite.
	63 - 73.2 m	Black-dark brown sandy lignite.
	73.2 – 75 m	Black medium to very coarse sands, carbonaceous.
	75 - 76.4 m	Black-dark brown sandy clay, carbonaceous.

Mh	**76.4 - 100m**	Weathered granite.
	100 – 118 m	Fresh granite.

<u>TPS 11</u>; (5836-130).

Q	**0 – 10 m**	Red clay + sands.

Tig	**10 – 14 m**	Pale brown – pale green sandy clays.
	14 – 18 m	Greenish grey clay , calcareous.
	18 – 20 m	Pale brown fine to coarse sands, minor clay.
	20 – 24 m	Pale green –pale brown sandy clays.
	24 – 29 m	Pale grey-pale brown clays, sandy at base.
	29 – 30 m	Whitish brown gravel, minor sand & clay.
	30 - 32.8 m	Pale brown clay, minor gravel & coarse sand.

Mh	**32.8 - 57.2 m**	Weathered granite.
	57.2 – 66 m	Fresh granite.

<u>TPS 12</u>; (5836-131). **PIMA II_Log**

Q	**0 – 9 m**	Reddish brown clay + sands.

Tig	**9 – 14 m**	Pale brown – pale green sandy clays.
	14 – 30 m	Greenish brown sandy clay, calcareous.
	30 – 32 m	Pale green clay.
	32 – 36 m	Yellowish grey sandy clays.
	36 – 48 m	Off-white fine to medium sands, silty, clayey.
	48 - 57.6 m	Whitish grey medium to very coarse sands, clayey, white clay & calcrete at base.

Tbp	**57.6 - 60.8 m**	Greyish brown medium to very coarse sands, **with U: 9-35 ppm at 54-63m.**
	60.8 - 72.8 m	Greyish brown -black lignitic clays + clayey lignite **(Palynological analysis: 62-63 m: late Middle Eocene, fluvial-lacustrine; 68-69 m: late Middle Eocene, estuarine; 69-70 m: late Middle Eocene, estuarine)**
	72.8 – 78 m	Dark grey- brown lignitic clay, silty.
	78 – 82 m	Dark grey -grey medium to coarse sands, gritty, minor carbonaceous.
	82 – 84 m	Dark grey-black medium to very coarse sands, carbonaceous.
	85 – 90 m	Pale grey gravel & coarse to very coarse sands pyritic, minor grey clay at base.

Mh	**90 – 104 m**	Weathered granite, **with Au anomalies: 38-71 ppb at 100-103 m.**
	104 – 107 m	Hiltaba Suite Fresh granite.

<u>TPS 14</u>; (5836-133).

Q	**0 – 3 m**	Reddish brown sand + clay, calcrete + ferricrete
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Tig	**3 – 8 m**	Pale green sandy clays, gravely at base.
	8 – 11 m	Pale grey gravel, minor pale green-brown clay.
	11 – 13 m	pale brown medium to coarse clayey sand.
	13 – 23 m	Brown-grey-pale green-pale grey sandy clays **(Palynological analysis: 17-18 m: Miocene-Pliocene, weak marine).**
	23 – 26.6 m	Pale grey-green clayey sands, silcrete at base.

<u>TPS 15</u>; (5836-134).

Q	**0 – 2 m**	Reddish brown sand + clay, calcrete.

Tig	**2 – 6 m**	Pale green clay, calcareous, sandy at base.
	6 – 9 m	Pale grey gravel, minor brown clay.
	9 – 12 m	Brow silty clay. Lim **(Palynological analysis: 11-12 m: barren).**
	12 – 13 m	Dark grey to black clays, sandy, carbonaceous **(Palynological analysis: 12-13 m: Miocene)**

LM	**15 - 16.5 m**	'Porphyritic qtz – trachyte, flow textured' Basement.

<u>TPS 16</u>; (5836-135).

Q	**0 – 3 m**	Red-brown clay + sand.

Tig	**3 – 6 m**	Off-white, pale green clays, sandy, calcareous.
	6 – 8 m	Pale green clay.

Mak	**8 – 36 m**	Konkaby Basalt, Weathered basement, mottled clay.
	36 – 40 m	Altered scoriaceous basalt.

<u>TPS 17</u>; (5836-136).

Q	**0 – 4 m**	Reddish brown clayey dune sands, gypsum, calcareous.

Tig	**4 – 6 m**	White/pink/pale brown fine to coarse clayey sands, calcareous.
	6 – 10 m	White, brownish white clays, sandy.
	10 – 15 m	Green-pale green-pale brown-off-white silty clays.
	15 – 17 m	Green massive clay **(Palynological analysis: 16-17 m: barren).**

(Tigk)	**17 – 27 m**	Dark grey sandy clay, carbonaceous **(Palynological analysis: Late Miocene-Early Pliocene, 17-18 m: non-marine; 20-21 m: marginal marine).**
	27 – 31 m	Green massive clay.
(Tigk)	**31 – 34 m**	Black-dark grey clays, plasticky **(Palynological analysis: 32-33 m: barren).**
	34 – 39 m	Grey-green massive clay **(Palynological analysis: 37-38 m: barren).**
	39 - 43m	Grey sandy clays **(Palynological analysis: 40-42 m: barren).**
(Tigk)	**43 – 48 m**	Dark grey silty clay, carbonaceous **(Palynological analysis: 45-46 & 47-48 m: barren).**
	48 – 55 m	Dark grey fine to very coarse sands, clayey , silty, carbonaceous, gravel at base **(Palynological analysis: Upper to Lower middle Miocene, 48-49 m, estuarine; 49-50 m: barren; Upper to Lower middle Miocene, 50-51 m: non-marine).**
	55 – 69 m	Black-dark grey-dark brown fine to coarse sands, clayey, silty, carbonaceous, pyritic **(Palynological analysis: 56-57 m: Middle Miocene estuarine; Upper Lower to middle Miocene, 67-68 m: minor marine).**
	69 – 79 m	Grey-pale brown fine to very coarse sands, clayey, gravel at base **(Palynological analysis: 77-78 m: Middle Miocene estuarine).**

Tbp	**79 – 81 m**	Grey-brown coarse gravely sands, carbonaceous **(Palynological analysis: 80-81m: Middle Eocene, weak marine).**
	81 – 83 m	Grey-brown silts, carbonaceous.
	83 – 84 m	Brown fine to coarse sands, clayey, weakly carbonaceous.
	85 – 88 m	AA but gravel, clayey (brown) coated grains, silcicified at base.

Mh	**88 - 89.5 m**	Weathered granite.

<u>BB 1.</u> (5936-117).

Q	**0 – 8 m**	Reddish brown clayey sand, calcareous silts, calcrete.

Tig	**8 – 14 m**	Off-white, pale brown very fine sands, slightly clayey and silty.
	14 – 16 m	Pale brown, yellowish green sandy clays.
	16 – 20 m	Pale brown medium sand, clayey.
	20 – 28 m	Pale brown, off-white fine sands, clayey sand.
	28 – 32 m	Pale brown coarse to very coarse sands, ferricrete grains.

Tbp	**32 – 34 m**	Whitish grey sandy clay.
	34 – 36 m	Off-white coarse sand.
	36 – 38 m	Pale grey fine sand, clayey.
	38 – 42 m	Off-white medium to coarse sands.

JK-a	**42 – 66 m**	Algebuckina Sandstone fg-grenu.

M-p	**66 – 72 m**	Pandurra Formation SHLE SLST.

Mae	**72 – 94 m**	Ealbara Rhyolite RHYD RHYODACITE.

<u>KRP 8;</u> (5936-128).

Q	**0 – 4 m**	Red silt, calcareous, clayey.

Tig	**4 – 8 m**	Grey, green clayey silts.
	8 – 16 m	Brown very fine sand, silty, calcareous.
	16 – 22 m	Grey clays - sticky + minor off-white dolomite, silicified.

Mak	**22 – 138 m**	Konkaby Basalt.

<u>PK 18;</u> (5936-146).

Q	**0 – 4 m**	Reddish brown sand, calcareous, clayey.

Tig	**4 – 6 m**	Brownish green clay, sandy.
	6 – 10 m	Yellowish grey clay.
	10 – 12 m	Brownish grey clay, sandy.
	12 – 17 m	Brownish grey, pale green clay.

Tbp?	**17 – 25 m**	Pale brown, greyish white fine to medium sands, clayey.
	25 – 28 m	Pale grey medium to coarse sands.
	28 – 33 m	Dark grey, dark brown clays, carbonaceous.

<u>DD87ME-2;</u> (5936-167).

Tig	**0 – 3 m**	Yellowish green-green clay.
	3 – 9 m	Yellowish brown fine sand.

Tbp	**9 – 30 m**	Pale brown, off-white fine to medium sands.
	30 – 51 m	off-white medium to coarse sands, Fe-staining.

JK-a?	**51 – 69 m**	Pale brown medium to coarse sands.

Mai	**69 – 81 m**	Weathered GRV.
	81 – 302.5 m	Fresh GRV.

<u>KIN 15;</u> (5936-183).

Q	**0 – 4 m**	Reddish, pale brown sandy silts and gypsum.

Tig	**4 – 20 m**	Pale brown, pale grey, pale green, green clays, silty, sandy, sticky.
	20 – 28 m	Brownish grey, pale grey, medium to coarse sands, clayey.
	28 – 33 m	Brownish white mottled sandy clays.

Tbp	**33 – 38 m**	Pale grey silicified fine to coarse sands, clayey, silcrete.
	38 – 46 m	Grey, pale grey, brown fine to coarse sands, silty.
	46 – 52 m	Pale grey gravel, clayey.

Mcl	**52 – 56 m**	Weathered basement.
	56 – 68 m	Siltstone-sandstone.

<u>KIN 16;</u> (5936-184).

Q	**0 – 4 m**	Brown silty sand, calcareous.

Tig	**4 – 12 m**	Pale brown, grey, clays, silty, sandy.
	12 – 20 m	Grey, greyish green clay, sticky.
	20 – 26 m	Greenish grey sandy clays.
	26 – 48 m	Green, pale grey silty clays, massive.
	48 – 55 m	Pale grey-yellow sandy clay, silicified at base.

Mh	**55 – 56 m**	Weathered basement.

<u>KIN 17.</u> (5936-185).

Q	**0 – 2 m**	Brown sand, calcareous.

Tig	**2 – 12 m**	Pale brown, pale grey clays, massive.
	12 – 18 m	Grey, pale grey, green clays, sandy.
(Tigk)	**18 – 20 m**	Dark grey sandy clay, carbonaceous.
	20 – 26 m	Grey, green clays, gypsiferous.
	26 – 46 m	Grey, pale grey, clays, sandy.
	46 – 50 m	Grey, pale brown medium to coarse sands, silcrete pebbles at base.

Tbp	**50 – 52 m**	Dark brown silty, clayey lignite.
	52 – 54 m	Dark brown clay, lignitic.
	54 – 60 m	Dark brown, greyish black medium to coarse sands, lignitic.
	60 – 68 m	Pale brown sandy clays, lignitic laminations.
	68 – 72 m	Dark brown medium sand & clay, lignitic.
	72 – 76 m	Pale grey silty clay.
	76 – 82 m	Grey medium to coarse sands, clayey, Fe stained.

Mcl	**82 – 92 m**	Labyrinth Formation SAND CLYU.

<u>KIN 18;</u> (5936-186).

Q	**0 - 2m**	Brown calcareous sands.

Tig	**2 – 12 m**	Pale brown-grey clays, sandy, silty.
	12 – 18 m	Dark grey-green clays, sandy, sticky.
(Tigk)	**18 – 24 m**	Black-dark grey sandy clays.
	24 – 28 m	Pale green-grey clays, gypsum bands.
	28 – 38 m	Pale grey-green clays.
	38 – 42 m	Pale yellow sandy clay, very fine sand at base.
	42 – 43 m	Pale grey silicified fine sandstone & silcrete.

<u>KIN 19;</u> (5936-187).

Q	**0 – 8 m**	Brown calcareous silty sands.

Tig	**8 – 18 m**	Pale brown-pale green clays.
	18 – 24 m	Pale brown-pale green-dark grey clays, w bands of gypsum.
	24 – 40 m	Dark grey-green-pale grey clays.
	40 – 46 m	Pale grey-white sandy clays.
	46 – 48 m	Pale grey-yellow fine sands, minor ferricrete.

Tbp	**48 – 50 m**	Grey fine to medium sands, ferricrete.

<u>KIN 20;</u> (5936-188).

Q	**0 – 7 m**	Brown calcareous sand + clay.

Tig	**7 – 16 m**	Pale brown clay, sandy.
	16 – 20 m	Grey clay, silty.
	20 – 28 m	Grey-green clays, sandy **(Palynological analysis: 24-26 m: Miocene-Pliocene, estuarine).**
	28 – 38 m	Pale grey-green clays, w minor gypsum bands.
	38 – 40 m	Pale grey-green clays, sandy.
	40 – 44 m	Pale grey medium sands, gritty.

Tbp	**44 – 46 m**	Pale grey-brown sandy clay, with 30 cm band of silcrete.
	46 – 56 m	Pale grey, grey very fine sands, silty.
	56 – 64 m	Pale grey fine to medium sands, silty.
	64 – 68 m	Dark brown lignitic clay **(Palynological analysis: 66-68 m: Middle-early Late Eocene, fluvio -lacustrine).**
	68 – 70 m	Black-dark brown lignite, clayey **(Palynological analysis: Middle-early Late Eocene, fluvio -lacustrine).**.
	64 – 68 m	Dark brown lignitic clay, silty.

Mh	**72 – 77 m**	Weathered granite.

<u>KIN 21;</u> (5936-189).

Q	**0 – 6 m**	Reddish brown calcareous silty sands.

Tig	**6 – 14 m**	Pale brown clay.
	14 – 18 m	Pale grey clay, silty.
	18 – 38 m	Grey-green clays, sandy, fine sand and ferricrete at base **(Palynological analysis: 24-26 m: Miocene-Pliocene, estuarine; 26-28 m: Miocene-Pliocene, marginal marine).**

Mcl	**38 – 41 m**	Labyrinth Formation pale brown fine gravel, weakly ferruginised basalt.

<u>KIN 22;</u> (5936-190).

Q	**0 – 6 m**	Reddish brown calcareous sands.

Tig	**6 – 16 m**	Pale brown clay, sandy, silty.
	16 – 20 m	Pale grey, white clays, silty.
	20 – 38 m	Grey-green clays, sandy, minor gypsum **(Palynological analysis: 20-22 m: Miocene-Pliocene, non-marine).**

	38 – 40 m	Pale grey, off-white clays, silty fine sand at base, weakly silicified.

Tbp	**40 – 44 m**	Off-white fine silty sand.
	44 – 62 m	Pale grey clay, silt, sandy.
	62 – 64 m	Pale grey clay.

Mcl	**64 – 65 m**	Weathered granite.

KIN 38; (5936-205).

Q	**0 – 2 m**	Reddish brown clay, minor calcrete.

Tig	**2 – 18 m**	Pale brown, pale yellow, greenish brown, pale grey clays.
	18 – 22 m	Pale yellow-brown-grey clays, fine to coarse sandy.

Tbp?	**22 – 26 m**	Brown to yellowish brown silcrete.

KIN 40; (5936-207).

Q	**0 – 2 m**	Pale red fine to medium sands, clayey.

Tig	**2 – 6 m**	Pale brown clay.
	6 – 18 m	Pale brown, brownish grey clays, fine to coarse sandy.
	18 – 20 m	Pale grey clay

GRV?	**22 – 25 m**	IGNEOUS ROCK.

KIN 42; (5936-209).

Q	**0 – 2 m**	Pale red clay, fine sandy.

Tig	**2 – 12 m**	Pale brown, grey clays.
	12 – 16 m	Brownish green clay, sandy.
	16 – 24 m	Greenish brown, reddish grey mottled clays.

GRV?	**24 – 30 m**	IGNEOUS ROCK.

KIN 43; (5936-210).

Q	**0 – 2 m**	Pale red fine to medium sands, clayey.

Tig	**2 – 6 m**	Greenish brown, greyish brown clays.
	6 – 12 m	Greenish brown clay, fine sandy.
	12 – 14 m	Brownish grey clays.
	14 – 18 m	Greenish grey clay, fine to very coarse sandy.
	18 – 20 m	Pale grey clay.
	20 – 24 m	Pale grey clay, fine to very coarse sandy & sand, clayey.

GRV?	**24 – 28 m**	IGNEOUS ROCK.

TAR 97; (5836-697).

Q	**0 – 6 m**	Reddish brown sand, clayey.

Tig	**6 – 14 m**	Brown fine sandy clay, sticky
	14 – 18 m	Green, grey, brownish green, plastic clay.
(Tigk?)	**18 – 22 m**	Dark grey sand, clayey, carbonaceous.

Mh	**22 – 36 m**	Saprolith**,** weathered granite, lower saprolite to saprock.

TAR 98; **(5836-698).**

Q	**0 – 6 m**	Reddish brown sand, clayey.

Tig	**6 – 14 m**	Pale brown very fine to medium sands, clayey.
	14 – 18 m	Brownish green, dark grey clays, silty to very fine sandy.
(Tigk?)	**18 – 24 m**	Dark grey, black fine sands, clayey to silty, carbonaceous.

Mh?	**24 – 80 m**	Saprolith? clays, sands, gravels, greenish grey, sandy.

TAR 100; **(5836-700).**

Q	**0 – 6 m**	Reddish brown sand, clayey.
	6 – 8 m	Reddish brown clay, silty.
	8 – 10 m	Reddish brown gravel, minor clay.

Tig	**10 – 16 m**	Pale brown clay, silty-sandy.
(Tigk)	**16 – 24 m**	Black-dark grey clay, silty-sandy, gravel at base, carbonaceous.

Mh	**24 – 28 m**	SAPROCK?, deeply weathered granite?.

TAR 104; **(5836-704).**

Q	**0 – 2 m**	Reddish brown sand, clayey.
	2 – 4 m	Reddish brown gravel, silty.

Tig	**4 – 8 m**	Greenish brown, pale brown clays, silty to vf sandy.
	8 – 16 m	Pale brown-brown sands, clayey and silty.
(Tigk)	**16 – 20 m**	Dark grey clay, silty, carbonaceous.
	20 – 24 m	Dark grey fine to medium sands, clayey to silty, carbonaceous.
	24 – 28 m	Pale green-grey clays.
	28 – 30 m	Pale grey gravel, clayey, dominantly very coarse to gravel.

Mh?	**30 – 36 m**	Deeply weathered basement, clays, sands, gravels.
	36 – 46 m	SAPROLITE mottled yellow-brown to pale grey to pale olive green.
	48 – 56 m	SAPROCK olive gn, rare rock fragments.
	56 – 60 m	BASIC ROCK dark green, fine-grained, weakly weathered.

TAR 108; **(5836-708).**

Q	**0 – 4 m**	Reddish brown sand, clayey.

Tig	**4 – 6 m**	Greenish-greyish brown clay.
	6 – 8 m	SAND pale brown, dominantly coarse, minor pebble.
	8 – 10 m	CLAY pale brown , silty to very fine sandy
	10 – 12 m	SAND pale brown, clayey to silty, dominantly very fine.
	12 – 18 m	CLAY pale brown, silty to very fine sandy
(Tigk)	**18 – 20 m**	CLAY black-dark grey, silty to very fine sandy, carbonaceous.
	22 – 26 m	SAND dark grey, clayey to silty, dominantly very fine to fine, carbonaceous..

Alm?	**26 - 41.5 m**	GNEISS pale green, feldspar-qtz-garnet?

TAR 111; **(5836-711).**

Q	**0 – 2 m**	SAND, reddish brown, clayey to silty.

Tig	**2 – 4 m**	SAND and CLAY, pale brown-pale grey.
	4 – 8 m	CLAY and GRAVEL, pale brown.
	8 – 12 m	SAND, pale brown, medium to coarse.
	12 – 16 m	SAND, pale brown, clayey to silty to dominantly very fine.
	16 – 18 m	CLAY, dark red.
(Tigk)	**18 – 24 m**	CLAY, black, dark grey, silty, carbonaceous.
	24 – 28 m	SAND, dark grey, clayey to silty, dominantly very fine to fine-grained.

Mh?	**28 – 35 m**	Weathered GRANITE.

TAR 114; (5836-714).

Q	**0 – 2 m**	SAND, pale brown, clayey, silty to fine.
	2 – 4 m	GRAVEL, pale brown, clayey, silty.

Tig	**4 – 8 m**	CLAY, brownish green.
	8 – 12 m	GRAVE, greenish, pale brown.
	12 – 18 m	SAND, pale brown, clayey, very fine.
(Tigk)	**18 – 22 m**	CLAY, black, carbonaceous.
	22 – 28 m	CLAY, dark grey-dark brown, minor silty-sandy

Mh?	**28 – 56 m**	GRANITE pink, gneissic.

KINPC 1; (5936-223).

Q	**0 – 2 m**	SAND, reddish brown, slightly clayey, calcareous.

Tig	**2 – 10 m**	Pale brown - yellowish green silty/sandy clays**,** gritty at base.
	10 – 18 m	Brown-yellowish green-brownish green puggy clays, plastic.
(Tigk?)	**18 – 27 m**	Dark grey-green-dark greenish grey clays, carbonaceous.
	27 – 29 m	Pale grey-brown clays, gritty.

Tpb?	**29 – 33 m**	Grey medium sands, clayey.
	33 – 47 m	Pale grey, pale yellow, brown clays.

?GRV	**47 – 53 m**	Reddish-brown & brownish grey fine-grained felsic rock ?

KINPC2; (5936-224).

Q	**0 – 2 m**	SAND, pale red-brown, silty to medium.

Tig	**2 – 4 m**	CLAY, brownish green, greenish brown, silty, sandy.
	4 – 13 m	CLAY, pale red-brown, silty.
	13 –16 m	CLAY, brownish green-grey.
(Tigk)	**16 – 24 m**	CLAY, dark grey-black, silty **(Palynological analysis: L. Miocene-E. Pliocene, 16-17m; 17-18 m; 18-19 m; 21-22 m).**
	24 – 28 m	CLAY, greenish grey **(Palynological analysis: L. Miocene-E. Pliocene, 24-25 m; 26-27m).**
	28 – 30 m	CLAY, brownish grey **(Palynological analysis: barren).**

Alm?	**30 – 55.5 m**	Saprolite? deeply weathered Kenella Gneiss.

KINPC 3; (5936-225).

Q	**0 – 2 m**	Reddish brown sands, calcrete**.**
	2 – 4 m	SILT, pale brown, clayey, CALCRETE.

?Tig	**4 – 5 m**	CLAY, pale brown, silty, sandy.
	5 – 8 m	GRAVEL, brownish grey, clayey, sandy..

Mh?	**8 – 22 m**	Weathered granite.