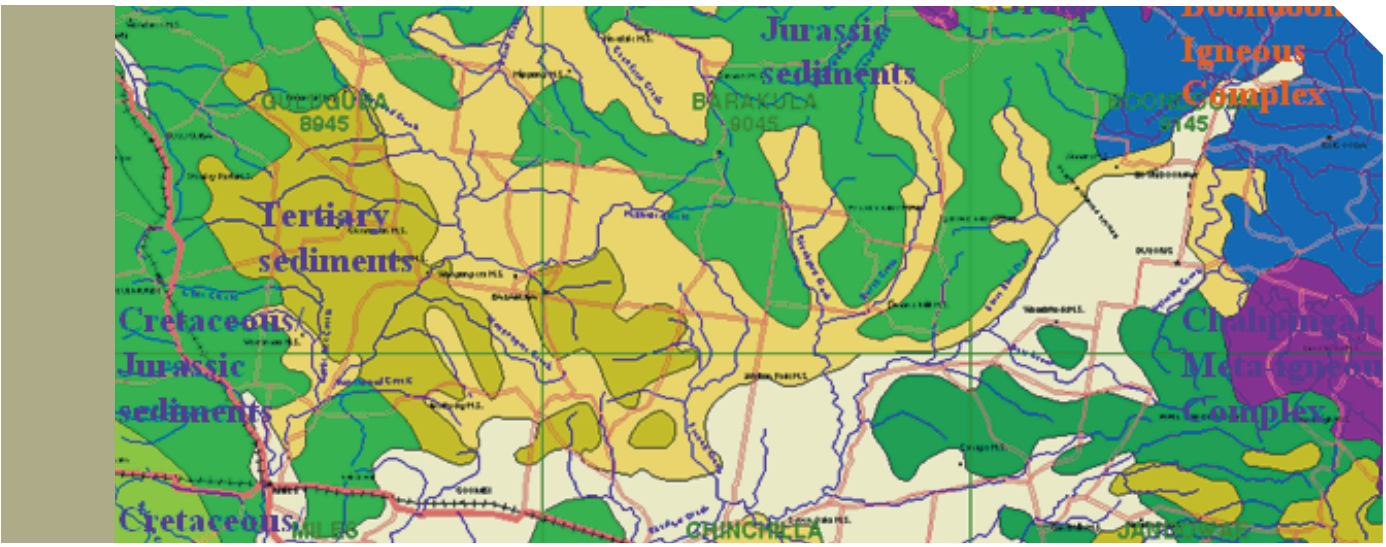
QUEENSLAND GEOLOGICAL RECORD 2008/03

A summary of company exploration results for minerals, coal and coal seam gas in the Chinchilla 1:250 000 (SG56-9) Sheet area, south-east Queensland

J S Lam & J Hodgkinson



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SUMMARY

This report summarises company exploration in the Chinchilla 1:250 000 (SG56-9) Sheet area for mineral commodities, coal and coal seam gas other than water. Exploration for minerals, coal, and coal seam gas was conducted under Permits for minerals (EPM), coal (EPC) and coal seam gas (ATP) at or near the contact of the Yarrol Province, the Wandilla Province (Yarraman Subprovince), the north-western part of the Clarence–Moreton Basin, the central Surat Basin and the overlapping eastern edge of the Surat and the Bowen Basin at depth.

The Jurassic Orallo Formation and the underlying Injune Creek Group comprises freshwater fluviatile and paludal sediments derived largely from volcanism. Both units are being explored for commercial bentonite resources around the Miles and Gurulmundi areas. Shallow drilling has outlined a thin, eight kilometres long bentonite unit occupying the top section of the Orallo Formation west of Gurulmundi in the L Tree Creek area. An indicated resource calculation was 7 800 000t of bentonite. Commercial grade deposits were also located in the Ramyard Creek area, and the Paddy Creek area five kilometres south-west of Miles.

Tin exploration was focused on the southern margin of the Permo-Triassic granitoids of the Boondooma Igneous Complex, mainly along the course of Rocky Creek. No new deep lead discoveries were made and the precise source rock for the cassiterite was not determined.

Gold exploration was undertaken close to the contact of the Maronghi Creek beds where it was intruded by Triassic granitoids of the Toondahra Granite. Exploration was mainly focused around the Golden Whip workings and drilling beneath the old workings intersected grades up to 1.05g/t Au, 6.7% Zn. The Boondooma Igneous Complex and the overlying Mooga Sandstone were also tested for uranium, but no significant anomalies were found.

Rutile occurs in the Chahpingah Meta-igneous Complex in the Jumma Creek area. Surface mapping by the Geological Survey of Queensland in the late 1990s and by an exploration company led to the discovery of many small occurrences of rutile in the form of scattered crystal fragments up to 20mm in size at Mannuen Creek. There is also potential for exploitation of feldspar included in the schist and leucogranite of the Chahpingah Meta-igneous Complex.

Several diamonds were reported to have been found in the Brigooda area. Drilling of a breccia pipe near Garnet Gully intersected diamond indicator minerals possibly sourced from diamond eclogite facies rocks.

The potential of the oil shale occurrence in Jurassic and Cretaceous sediments east of Condamine township was assessed. Shallow drilling intersected inferior coaly carbonaceous shale which yielded up to 51 litres/tonne.

Extensive coal exploration in the 1970s and 1980s focused primarily on the Jurassic Taroom and Juandah Coal Measures of the Walloon Subgroup in the

Surat Basin. This phase of exploration established measured and indicated resources at Kogan Creek, Glen Wilga, Horse Creek, Haystack Road, Rywung, Cameby Downs, Glen Laurel, Stanley Park, Guluguba, Burunga and Colllingwood. Inferred resources were also established at Columboola, Lallilindi and Baking Board. The resource areas follow a north-west–south-east trend across the Chinchilla (1:250 000) map sheet area coincident with the subcrop/outcrop limit of the Walloon Subgroup. The Taroom and Juandah Coal Measures incorporate high volatile perhydrous, and bituminous rank coal, which typically has high ash content. The Kogan Creek deposit is currently the only commercially exploited resource, providing coal to the adjacent Kogan Creek power plant. Total established resources of thermal coal currently amount to 2.56 billion tonnes.

Coal seam gas exploration commenced with drilling of the first Peat and Burunga wells in the early 1990s. The Permian coal measures in the underlying Bowen Basin were the primary exploration target. The wells produced gas flow rates from 1.27 to 2.5 million cubic feet per day, and coal seam tests produced gas contents from 5.7m^3/t to 12m^3/t. In 2000, the Peat field, drawing gas from the Baralaba Coal Measures, began production. The Berwyndale and Argyle-Kenya field development followed with the younger Walloon Subgroup coals being exploited.

Keywords: Chinchilla 1:250 000 (SG56-9), Boondooma 9145, Barakula 9045, Guluguba 8945, Jandowae 9144, Chinchilla 9044, Miles 8944, Exploration Permits for Minerals (EPM), Exploration Permits for Coal (EPC), Authorities to Prospect for Coal Seam Gas (ATP), mineral exploration, coal exploration, coal seam gas exploration, airborne radiometric, magnetic and gravity data, base metals, bentonite, cassiterite, clay, coal, coal seam gas, diamond, feldspar, gold, ilmenite, platinum, oil shale, rutile, uranium, coal resources, coal seam gas resources, Yarrol Province, Wandilla Province (Yarraman Subprovince), Clarence–Moreton Basin, Surat Basin, Bowen Basin, Bundamba Group, Clematis Group, Injune Creek Group, Rockhampton Group, Walloon Subgroup, Maronghi Creek beds, Baralaba Coal Measures, Ipswich Coal Measures, Juandah Coal Measures, Rangal Coal Measures, Taroom Coal Measures, Evergreen Formation, Moolayember Formation, Orallo Formation, Rewan Formation, Westbourne Formation, Boondooma Igneous Complex, Chahpingah Meta-igneous Complex, Mount Warning Complex, Lamington Volcanics, Main Range Volcanics, Toondahra Granite, Hutton Sandstone, Mooga Sandstone, Precipice Sandstone, Springbok Sandstone.

INTRODUCTION

This review presents summaries of mineral exploration surveys carried out under Exploration Permits for Minerals (EPM), Exploration Permits for Coal (EPC), and Authorities to Prospect for Coal Seam Gas (ATP) in the Chinchilla 1:250 000 Sheet area. The summaries encompass open-file company exploration reports from 1957 up to 2007. These reports have been submitted as a requirement of holding Exploration Permits for Coal or Minerals or Authorities to Prospect for Coal Seam Gas; and can be viewed at the Department of Mines and Energy (DME) Information Centre located at

41 George Street, Brisbane or in the department's online digital company report system (QDEX) (www.dme.qld.gov.au).

Summaries for each of the historical EPMs, EPCs and EPPs (*note: the data base structure for ATPs*) by different ten year time periods (*eg* 1980–1989) can be accessed at the same web site under the 'Interactive Resource and Tenure Maps'.

The company exploration report summary table (**Table 1**) produced herein provides a convenient reference to exploration techniques employed by companies to carry out their search for ore, coal and coal seam gas deposits in the area.

Company exploration results for mineral commodities are summarised under commodities, and subdivided into geographic locations, and are sequential for coal and coal seam gas.

LOCALITY

The Chinchilla 1:250 000 Sheet area lies between latitude 26°00'S to 27°00'S and longitude 150°00'E to 151°30'E in south Queensland and consists of six 1:100 000 Sheet areas (Boondooma 9145, Barakula 9045, Guluguba 8945, Jandowae 9144, Chinchilla 9044, Miles 8944) (**Figures 1 and 2**).

REGIONAL AND ECONOMIC GEOLOGY

The Chinchilla 1:250 000 Sheet area encompasses the overlapping southern tip of the Yarrol Province, the west central portion of the Wandilla Province (northern Yarraman Subprovince), the eastern edge of the Surat and Bowen Basins, the north-western portion of the Clarence Moreton Basin and the central portion of the Surat Basin (**Figure 3**).

LATE DEVONIAN TO EARLY CARBONIFEROUS

Yarrol Province

The Yarrol Province rocks comprise a thick sequence of Devonian to Early Carboniferous age deep water sedimentary and volcanic rocks of the Rockhampton Group which are in general steeply dipping, structurally complex, and sparsely fossiliferous. The Rockhampton Group is known to host intrusive-related base metals and gold mineralisation in the Brovinia homestead area to the north of Allies Creek homestead (outside Chinchilla 1:250 000 Sheet area).

Wandilla Province

Rocks of the Wandilla Province (Yarraman Subprovince) are represented by accretionary wedge assemblage of the ?Late Devonian to Early Carboniferous

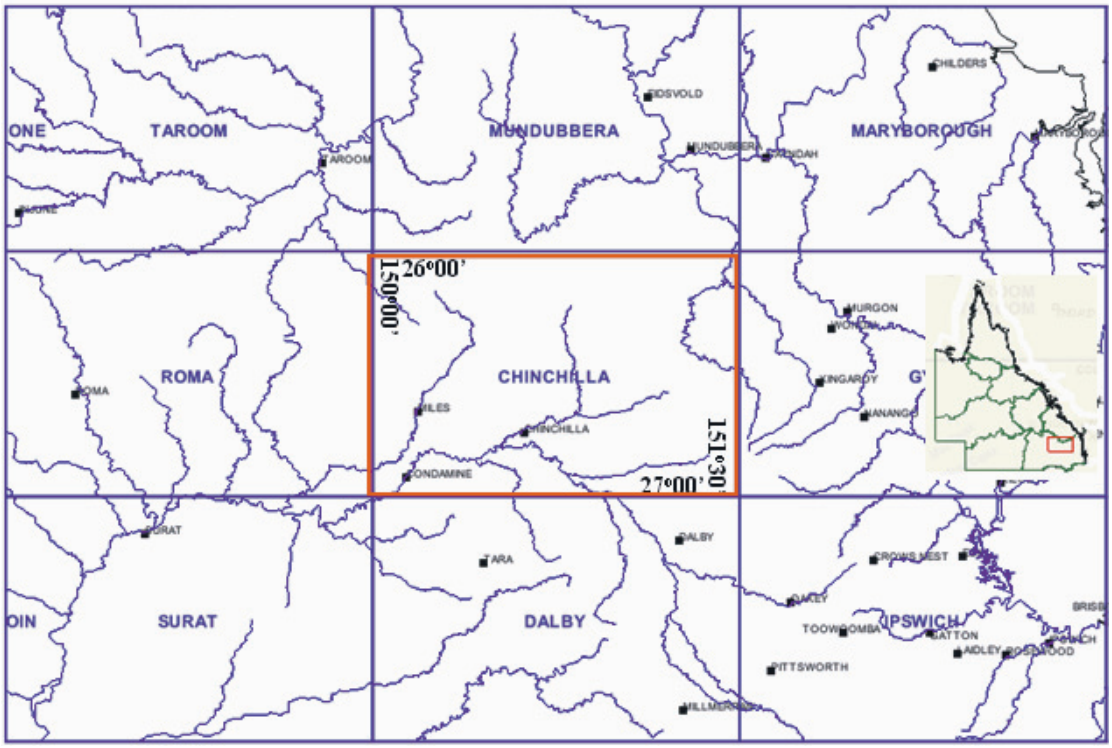

Figure 1: Locality of Chinchilla 1:250 000 (SG56-9) Sheet area

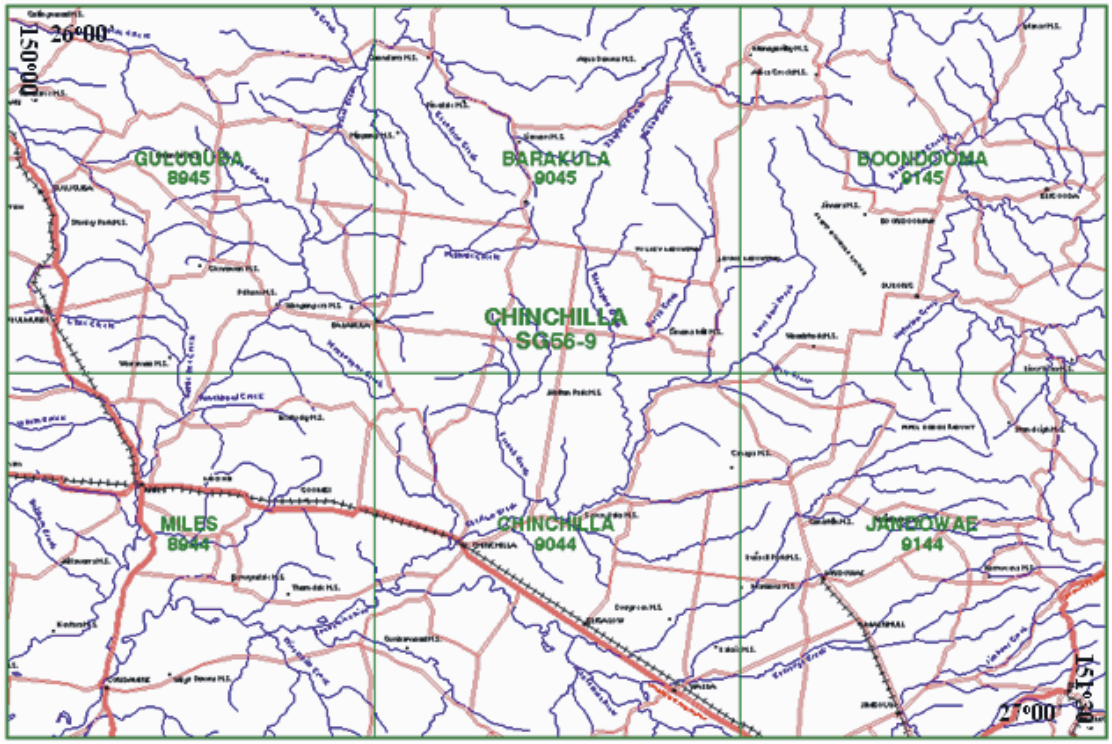

Figure 2: Index of 1:100 000 Sheet area

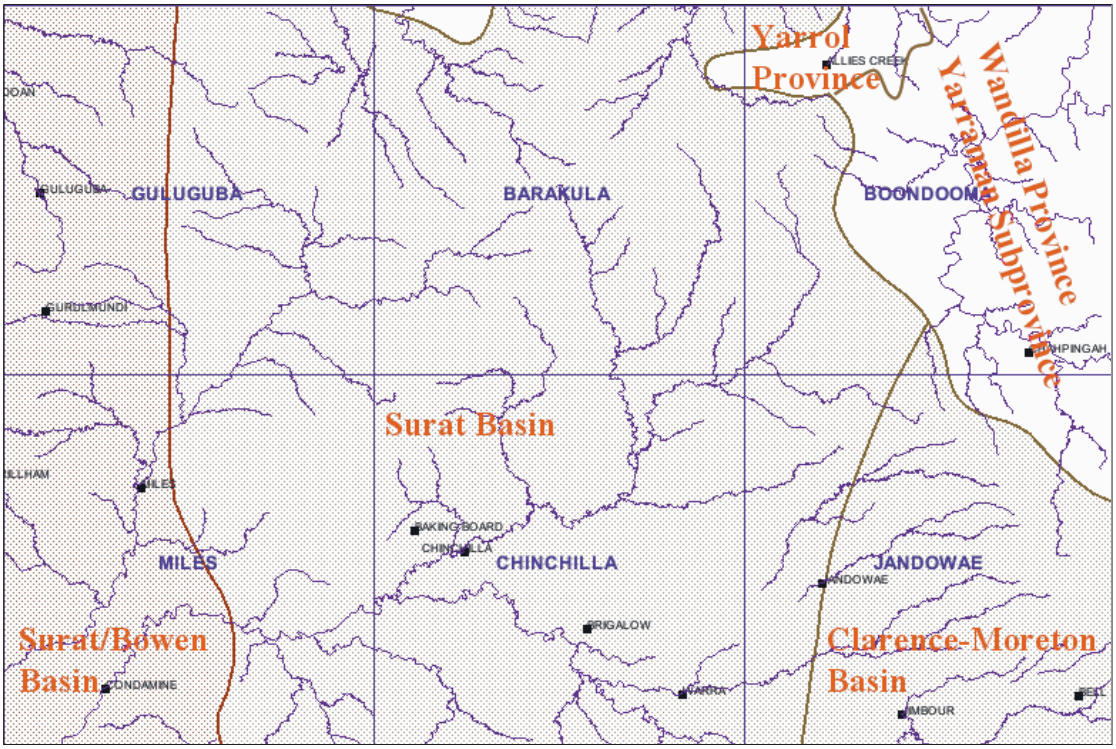

Figure 3: Tectonic Element (reproduced from IRTM, Department of Mines and Energy, Queensland)

Maronghi Creek beds. This assemblage consists of highly structurally deformed dark grey mudstone, siltstone, felsic volcaniclastic sandstone, polymictic conglomerate, ooid-bearing sandstone, conglomerate with mudstone rip-up clasts, and oolitic and pisolitic limestone. The Late Devonian–Early Carboniferous Maronghi Creek beds are intruded by the Permo-Triassic Boondooma Igneous Complex.

These Carboniferous volcanic rocks and sediments were identified as part of the accretionary wedge of the New England Fold Belt (Cranfield & others, 2001). Minor gold and copper have been mined from the Golden Whiptail where mineralisation appears to be confined to narrow north-north-west trending shear zones in metasediments of the Maronghi Creek beds which were intruded by Triassic granitoids of the Toondahra Granite.

The Carboniferous rocks of the Chahpingah Meta-igneous Complex consist of strongly-foliated and banded granitic gneiss, with zones of gneissic rocks more enriched in biotite and grading to biotite amphibolite with trace amounts of fine-grained (0.05mm) rutile intergrown with biotite. Rutile crystals were identified in vein quartz. The Chahpingah Meta-igneous Complex of the Yarraman Subprovince is a unit of cream to grey, fine- to medium-grained, strongly foliated, banded granitic to granodioritic, biotite gneissic rocks enriched in biotite and grading to biotite amphibolite. Trace amounts of fine-grained (0.05mm) rutile as well as small discrete crystals in vein quartz have been found as intergrowths with biotite in the biotite amphibolite.

LATE PERMIAN TO LATE TRIASSIC

South-east Queensland Volcanic and Plutonic Province

Rocks of the Wandilla and Yarrol Provinces are intruded or locally overlain by Late Permian to Late Triassic rocks of the South-east Queensland Volcanic and Plutonic Province (SEQVP). Most occurrences of recent alluvial cassiterite and deep lead alluvial deposits have been discovered near or at the contact margins of granite and sediments in the Rocky Creek area. Some granitoids host lode cassiterite deposits and are the source of deep lead alluvial tin deposits. Minor gold and base metals deposits occur in the Late Devonian–Early Carboniferous volcanic rocks and sediments within north-north-east trending shear zones.

PERMIAN TO MID-TRIASSIC

Bowen Basin

To the west of Chinchilla is the subsurface extension of the Permian rocks of the Bowen Basin. The Burunga Fault is the most prominent structure in this basin with fault displacement of 1000–2000m along this structure and a large hanging wall forming the Burunga Anticline between the towns of Miles and Taroom. The southern half of the Bowen Basin is covered by the Surat Basin.

The Bowen Basin received fluvial, lacustrine and marine sediments and volcanic rocks, and non-marine clastic rocks. The topmost Permian coals are the Baralaba Coal Measures, the eastern equivalent of the Rangal Coal Measures. The Rewan Formation unconformably overlies the coal measures although the contact is interpreted as conformable in some areas (J. Draper & J. McKellar, personal communication, 2007). The overlying sandstones of the Clematis Group and Moolayember Formation are terminated by a major regional unconformity at the base of the Jurassic sequence.

The Bowen basin has vast resources of coal and coal seam gas.

LATEST TRIASSIC TO CRETACEOUS

Surat and Clarence–Moreton Basins

The Surat and Clarence–Moreton Basins contain latest Triassic fluvial and lacustrine sediments overlain by Jurassic fluvial sediments, with Cretaceous continental and marine clastic sediments restricted to the Surat Basin. These basin fill sediments are covered by a thin veneer of Cainozoic continental sediments. The sediments of the Surat Basin are generally flat-lying and contain bentonite occurrences mainly in the Jurassic Orallo Formation and also in minor amounts in the older Injune Creek Group. Both basins are mainly of freshwater origin and consist of similar fluviatile and paludal sediments derived largely from volcanism. Commercial oil and gas fields have been found in the Surat Basin where it is adjacent to the Clarence–Moreton Basin. The most significant

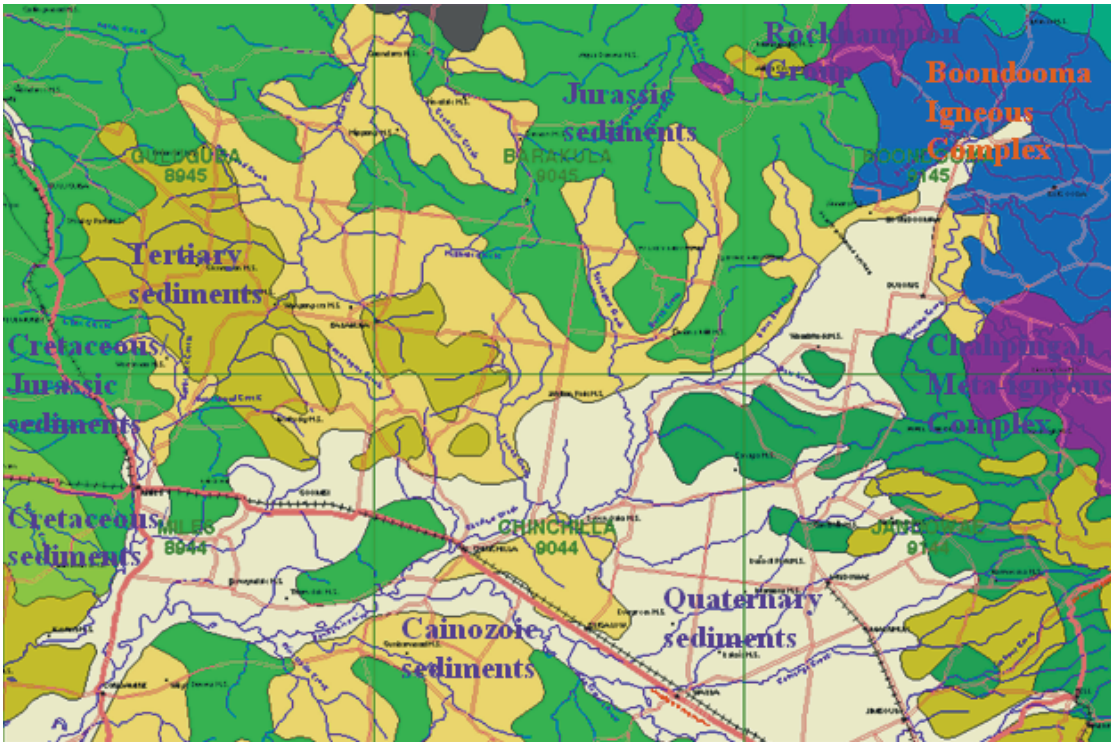

Figure 4: Simplified surficial regional geology (reproduced from Exon & others, 1971)

structural feature in the Surat Basin is the Mimosa Syncline which the axial portion of the underlying asymmetric Taroom Trough is west of the Burunga Fault. A simplified surface geology is presented as **Figure 4**.

Clarence–Moreton Basin

The Clarence–Moreton Basin is an intra-cratonic Mesozoic sedimentary basin. The basin consists of continental Triassic–Jurassic sediments that unconformably overlie Ordovician to Triassic sedimentary rocks, and metasediments and igneous intrusions.

The oldest sedimentary rocks in the basin are the Ipswich Coal Measures which consist of shale, conglomerate, sandstone, coal, siltstone, basalt, and tuff confined to the Ipswich and Brisbane areas. Uplift in the Late Triassic resulted in an unconformity between the Ipswich Coal Measures and the Bundamba Group. The Bundamba Group is a thick sequence of mainly conglomerate and sandstone. The overlying Walloon Subgroup consists of grey siltstone, thick banded coal horizons and fine- to medium-grained lithic sandstone which extend across the Clarence–Moreton, Surat and Eromanga Basins.

Tertiary intrusive and extrusive rocks occur throughout the basin and are well-represented by the Mount Warning Complex and the Lamington Volcanics in the Gold Coast hinterland area and the Main Range Volcanics in the eastern Darling Downs from south of Toowoomba to near Proston.

The basin has been explored for coal seam gas and petroleum. Although small reservoirs have been found, the basin is mainly considered to be gas-prone (Wells & O'Brien, 1994).

Surat Basin

The Surat Basin is a large Jurassic–Cretaceous intra-cratonic basin containing fluvial, lacustrine and marginal marine sediments, and coal-bearing successions. Rock-types include mudstone, shale, and sandstone, with minor conglomerate, coal seams and oolitic ironstone. The sediments of the Surat Basin have not undergone any major tectonism and are essentially undeformed by major folding, but have been affected by fault structures. After sedimentation ceased in the Early Cretaceous, the area underwent a period of intense weathering, which caused kaolinisation, silicification and ferruginisation. Outcrop of the basin succession is generally poor, blanketed by Holocene alluvium.

The oldest rocks in the basin are the Early Jurassic Precipice Sandstone and the overlying Evergreen Formation. Coal swamp environments predominated over much of the basin with the development of the Walloon Subgroup during the Early–Middle Jurassic. Towards the end of the Middle Jurassic, fluvial sediment deposition of the Orallo Formation predominated.

The coal measures of the Jurassic Walloon Subgroup are part of one of three upward fining megacycles. Megacycle one consists of the Precipice Sandstone and the Evergreen Formation. Megacycle two contains the Hutton Sandstone and Walloon Subgroup and megacycle three, the Springbok Sandstone and the Westbourne Formation.

The Orallo Formation comprises of variably-sorted labile to sub-labile in part calcareous and clayey sandstone, interbedded carbonaceous siltstone, mudstone, shale, minor coal, bentonite, conglomerate and fossil wood. Bentonite is mined in the Miles–Gurrulmundi area.

The Surat Basin, and the underlying Bowen Basin, host a large number of oil and gas fields in Queensland. Oil and natural gas were generated in the underlying Bowen Basin and some of it migrated and was trapped in the basal part of the Surat Basin. There is also potential for heavy mineral accumulations in some of the sandstone units of the Surat Basin.

The Surat Basin is being remapped to determine the distribution of coal seams in the Walloon Subgroup.

TERTIARY VOLCANIC ROCKS AND SEDIMENTS

The basalts at Brigooda consist of flows emanating from a conical hilly vent area. They comprise olivine-augite basalt, anorthoclase megacryst basalt, anorthoclase-augite megacryst basalt, under-saturated olivine basalt and ankaramite flows. Breccia consisting of pulverised granite is intruded by basaltic lava on the southern side of the vent. Fragments of Cr-diopside-spinel lherzolite are abundant in the breccias, with xenoliths of pyroxenite, garnet pyroxenite, garnetite and other rocks. Dating of anorthoclase from the breccia gave ages of around 400 000 years. Breccia was emplaced in the Garnet Gully area in the Late

Pleistocene as a result of a second phase of explosive maar-type volcanic activity (Russell, 1994).

Several diamonds were reported in the Brigooda area where volcaniclastic rocks similar to those in the Inverell and Glen Innes area have been found. Much of the area is covered by Cainozoic sediments, ranging from conglomerate to sandstone, which were deeply weathered in the Oligocene, and subsequently subjected to a deep weathering event in the Miocene resulting in the local formation of ferricrete. In the Miocene, basalts were extruded and flowed down valleys between remnant caps of the weathered sediments. Several periods of uplift and erosion have occurred since that time.

CAINOZOIC ALLUVIAL DEPOSITS

Tin-bearing alluvium of the Rocky Creek district is derived from a small intrusive granite stock. The granite at Rocky Creek is variable in its mineral composition and grain size, ranging from fine-grained pink aplitic granite with little ferromagnesian material to medium-grained green granite with xenoliths, and coarse-grained grey hornblende granite. Granophyre, quartz porphyry, and a wide variety of flow-banded rhyolite are common in the eastern part of the unit. The granite intrudes sediments of Early Carboniferous Maronghi Creek beds in the Brigooda area. Minor exposures of the Miocene Main Range Volcanics (olivine basalt, tuff, agglomerate, dolerite, minor shale, siltstone, and diatomite) form low hills in the area. Both granite and basalts have in places been subjected to lateritisation.

REGIONAL GRAVITY AND MAGNETIC DATA

During the late 2000s, the Queensland State Government initiated airborne radiometric, magnetic and gravity surveys to capture and update regional geophysical data over much of Queensland. These geophysical data are held by Geoscience Australia in their National Gravity Data Base that can be accessed at www.geoscience.gov.au/gadds. The magnetic and radiometric data can be downloaded from GADDS or acquired on DVD for ‘cost of provision’ from the Queensland Department of Mines and Energy at sales@dme.qld.gov.au.

Based on these surveys, geotiff images of regional 400m spacing airborne magnetic and radiometric and 4km station gravity data, for the Chinchilla 1:250 000 Sheet area are presented as Figures 5 to 10. These images contrast strongly with the previous geology map (edition 1965) and the projected solid geology, subject to interpretation, is quite different to the surface geology map.

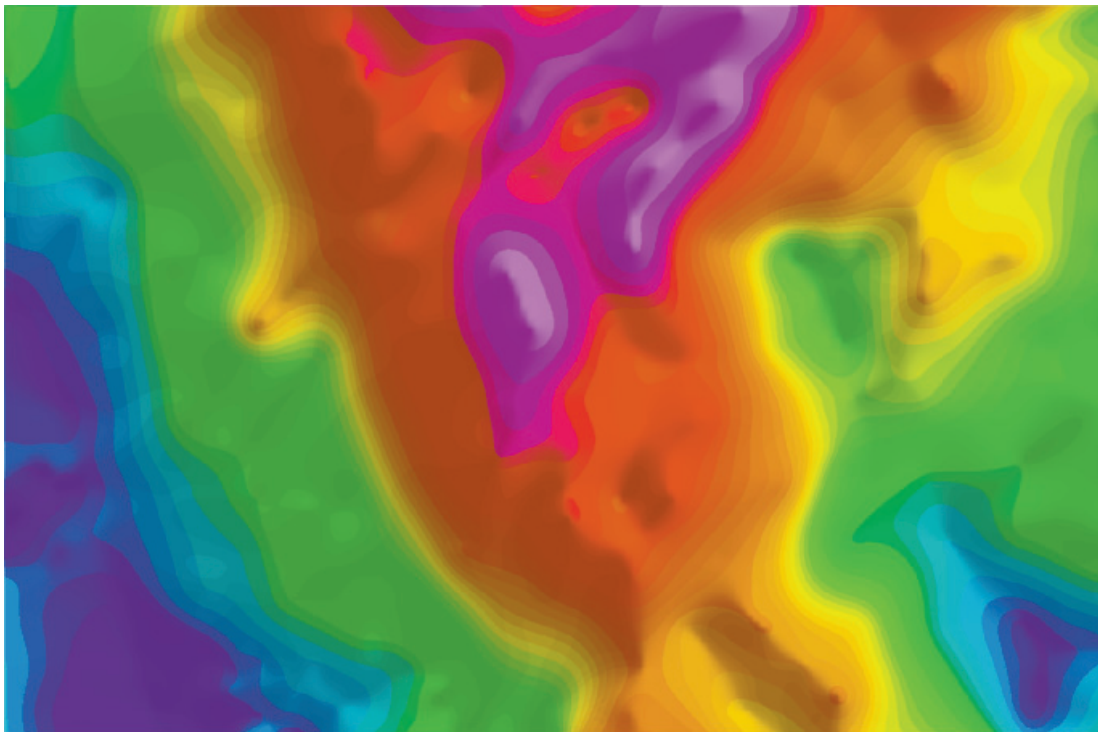

Figure 5: Bouguer Gravity tiff image at 4km x 4km station spacing (magenta-red high, green moderate, blue low gravity features)

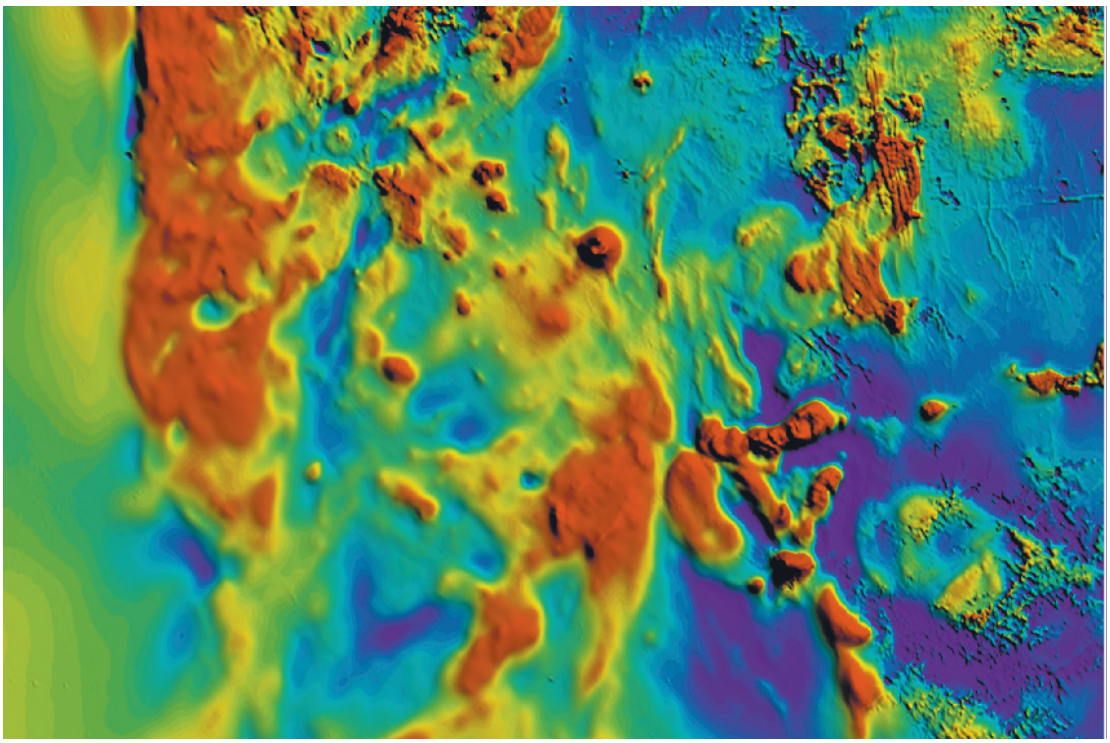

Figure 6: Pseudocolour total magnetic geotiff image (red high, blue low)

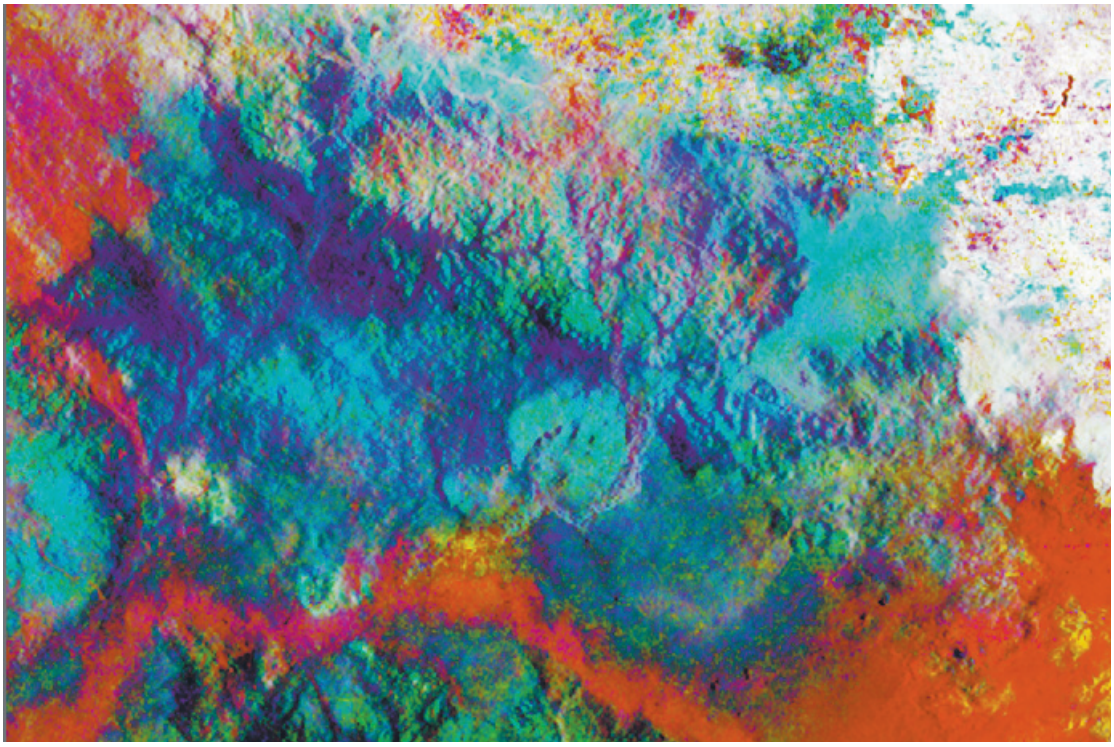

Figure 7: Radiometric Ternary K-Th-U (rbg) composite colour image

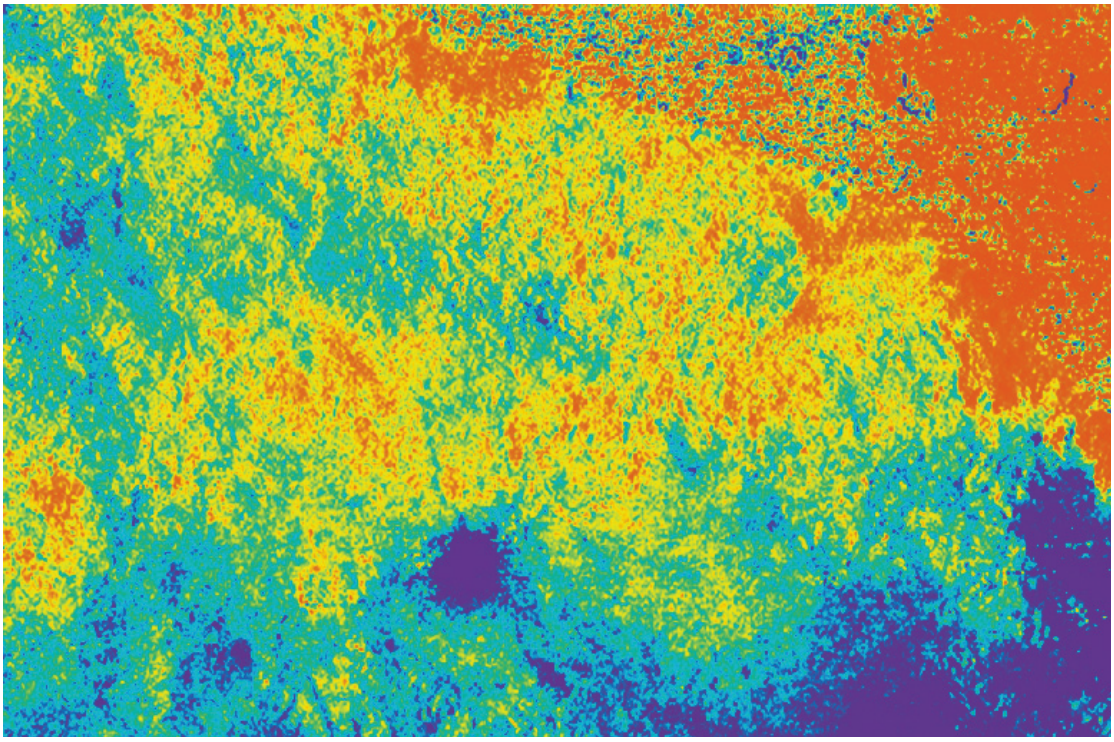

Figure 8: Pseudocolour radiometric geotiff image showing the U channel

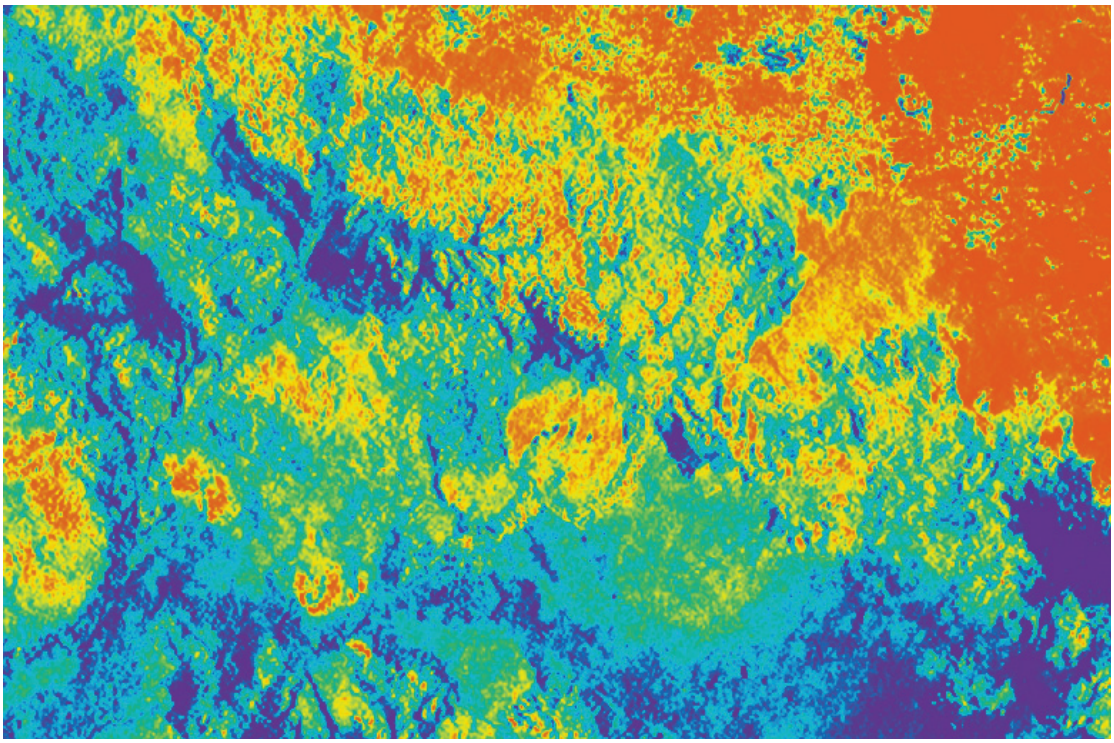

Figure 9: Pseudocolour radiometric geotiff image showing the Th channel

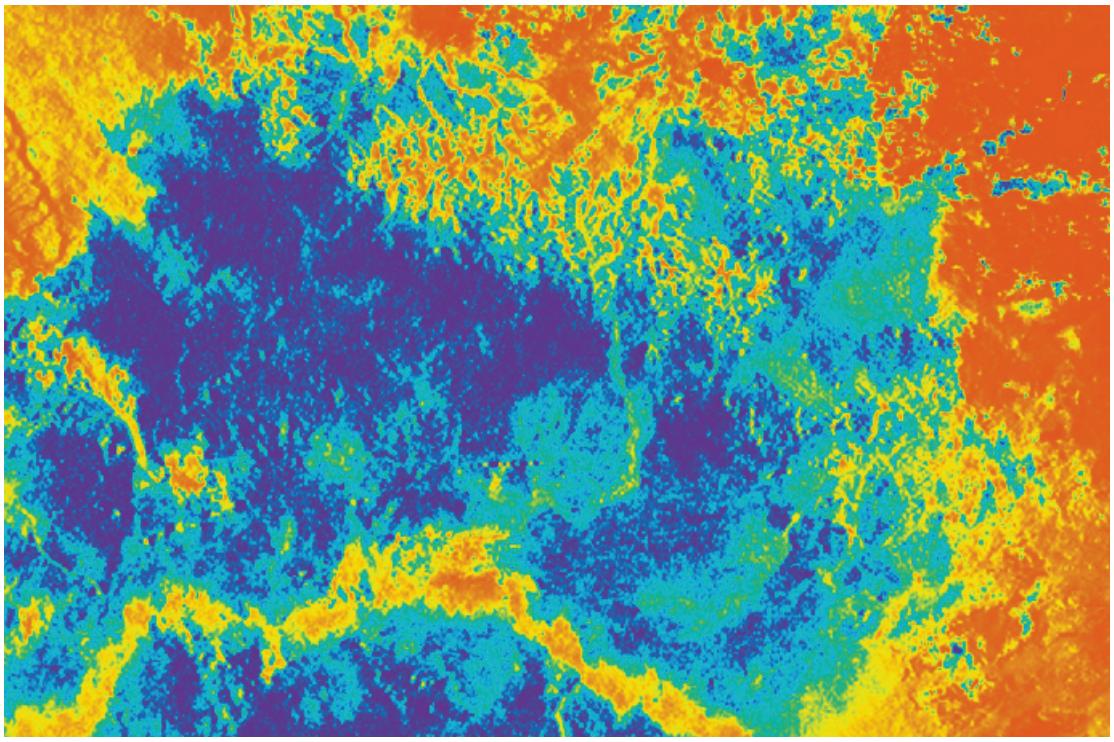

Figure 10: Pseudocolour radiometric geotiff image showing the K channel

COMPANY EXPLORATION RESULTS FOR MINERAL COMMODITIES (J Lam)

BENTONITE

Mineralisation

Bentonite is a rock composed mainly of montmorillonite and smectite minerals. The outstanding feature of bentonite is that water can enter between the clay unit layers causing the lattice to expand.

The sodium-rich or magnesium-rich bentonites at the Miles area are ash-fall deposits preserved in back-swamps at a distance from Jurassic stream channels. Bentonite beds up to 2m thick have been formed by weathering of a fine-grained tuff composed of andesitic glass shards. The shards devitrified to give montmorillonite and cristobalite. The deposits are older than, but most probably related to, the same episode of volcanism as the bentonite deposits at Yuleba further west.

Exploration

Sandy Creek area (MILES 8944, 35km west-south-west of Chinchilla)

F W Kiely Pty Ltd (EPM 3186, 1981) explored the Condamine River/Sandy Creek area for bentonite as it contains both Jurassic continental sedimentary rocks and Lower Cretaceous marine strata. Bentonite has been reported to occur in the Orallo Formation and also in the older Injune Creek Group. There are also substantial deposits of kaolinite occurring in the area. These two clay types appear to have close association. Geological mapping illustrated the occurrences of kaolinite clay beneath shallow overburden of sandy soils, sandstones and quartzite. A total of 9 vertical holes were drilled (~360m) and intersected thin coal seams of the Walloon Subgroup, but no oil shale or bentonite clay. There was no known workable coal nearby.

Cudgen RZ Ltd (EPM 5507, 1988; EPM 6843, 1990) conducted regional ‘grassroots’ exploration for bentonite. The tenements were applied for to cover a stratigraphic zone determined by air-photographic interpretation to be the contact between the Jurassic Orallo Formation and the overlying Cretaceous age Mooga Sandstone. This zone is known to host bentonite in other localities within the Surat Basin. The areas of ‘pale soil’ and ‘possible bentonite’ identified from photogeological interpretation were examined on the ground and proved to be minor expanses of aeolian sand. The contact between the Mooga Sandstone and the Orallo Formation was in part traversed. Of the seven holes (SC-1 to SC-7) drilled, four holes intersected bentonite, two did not and one hole was abandoned. A further nine holes (SC-10 to SC-18) were drilled. Drilling intersected 2–3m of isolated sandy bentonite lenses. A carbonaceous zone was intersected in all holes.

Rock-Ex Enterprises Pty Ltd and Bonaford Pty Ltd (EPM 9684, 1993) re-examined Cudgen RZ Ltd drill holes and collected bentonite clay chips at the

drill collars. Other bentonite samples were collected near an earth tank just east of Sandy Creek highway crossing. The outcrops in the creek banks near the earth tank showed the bentonite beds have thicknesses of only 0.3–0.5m occurring within clayey sandstone. Laboratory tests returned swelling indices ranging from 35 to 50, typical of the magnesium-rich bentonite of the Miles deposits, whereas the sodium-rich bentonite of the Miles deposits has swelling indices of 50 to 110. The company concluded these bentonite beds were thin and did not warrant further assessment.

International Exploration Services Pty Ltd and J Kenny (EPM 10633, 1995) inspected 4 potential bentonite occurrences and reported that only one deposit previously drilled by Cudgen R Z Ltd contains 2–3m of bentonite horizon and an immediate underlying horizon of similar thickness. The lower bentonite clay bed is contaminated by significant interstitial sand and also contains an irregular network of 'veinform' sand with individual 'veins' of sand up to 70mm wide. The upper horizon apparently has a limited lateral extent and was considered of little commercial potential.

L Tree Creek area (70km west-north-west of Chinchilla)

The L Tree Creek was explored by Mineral Deposits Ltd (EPM 555, 1969), and Cudgen RZ Ltd (EPM 1773, 1977; EPM 3484, 1983; EPM 5506, 1988). Mineral Deposits Ltd conducted drilling in the L Tree Creek area and outlined a resource of bentonite on Portion 67. A mining lease was applied for over the prospective area. No mining appears to have been carried out.

The L Tree Creek area was again explored by Cudgen RZ Ltd (EPM 1773, 1977). The main interest was to locate extensions of bentonite outside the company leases. Several bentonite clay outcrops were located along L Tree Creek. These bentonite occurrences appear to be confined to an old drainage channel. A total of 10 holes (209m) were drilled and intersected minor secondary accumulations of impure bentonite beds and showed that the main clay layer extends north-west and south-east from the company leases. The bentonite occurrences in this area were considered to be of low grade, and had no economic potential at the time of exploration.

On the basis of a study of mapping data collected by Geoscience Australia and the Geological Survey of Queensland (Wells & O'Brien, 1994), which suggested the presence of a 'bentonite belt' extending from Roma in the west, through Miles and south to Moonie, Cudgen RZ Ltd (EPM 3484, 1983) again conducted exploration for bentonite in the L Tree Creek area. Air-photo interpretation and geological field traverses were carried out, followed by open hole percussion drilling. This work outlined a prospective bentonite horizon having an eight kilometre strike length. The 'bentonite belt' strikes east-west to the west of the Gurulmundi bentonite pit, swings to north-west-south-east through the pit. Where the bentonite is developed, it occurs within a sequence of mudstone-siltstone containing minor carbonaceous partings and grey coarse-grained lithic sandstone towards the top of the Jurassic Orallo Formation. This sequence is overlain by Cretaceous Mooga Sandstone, fine- to medium-grained fawn sandstone that weathers yellow and brown. Forty holes drilled for a total of 856.7m outlined an

area of 1700m by 300m with an average thickness of 7m of bentonite. The company reported the ''bentonite belt' has the resource potential of 5.71Mt of good quality bentonite and one mining lease (ML 204302) was applied over the prospective area.

In 1988, Cudgen RZ Ltd again evaluated the 'bentonite belt' between the Gurulmundi pit located on ML 80 and the new Eisanhauer pit located on ML 107. Sixty-five holes totalling 1429m were drilled and bentonite was intersected in a continuous horizon between Gurulmundi and Eisanhauer. A calculation showed an indicated resource of 7 800 000t of bentonite at a weighted average CEC of 74.8 and Water Absorbency of 630. The average calculated stripping ratio based on volume of overburden to volume of bentonite was 3.5:1. A Mineral Development Licence application (MDL 101) covering 136.6 hectares was lodged on 14 December, 1990.

Paddy Creek area (67km north-west of Chinchilla)

FW Kiely Pty Ltd (EPM 2171, 1979) drilled 32 vertical holes totalling 557m. Drill cuttings were laboratory tested and the results showed that both kaolinitic and bentonitic clays were widespread and commonly associated with each other. The clays have montmorillonite-beidellite content with quartz as the most common impurity. The deposit lies beneath shallow over-burden and contains bentonite of prospective commercial quality. A mining lease was applied for over the prospective area.

J A Clift and W D Sinclair (EPM 3097, 1981) explored clay deposits in the Paddy Creek area by auger and rotary air-blast drilling. Samples from drilling were tested and found to have physical and chemical properties meeting the requirement of commercial grade bentonite. Two mining leases (ML 93 and ML 94) were applied over the prospective areas.

Wallan Creek area (60km west-north-west of Chinchilla)

J Gibbes, L T Newton, L V Newton, L J Richards, J J Clift, and A C Hansen (EPM 1568, 1975) conducted drilling in the Wallan Creek area and intersected 3m of red mottled clay and 2m of yellowish clay in holes 8 and 9 respectively in the far east of the tenement area. These two clay beds comprise very poor quality re-deposited kaolinite. In the central area of the tenement several thin bands of bentonitic clay were intersected. However, these are interbedded with kaolinitic clay, shale and sandstone. A hole drilled on the western boundary of the tenement area intersected 7m of kaolinitic clay at a depth of 10m. The drilling results indicated that very extensive clay deposits occur in the Orallo Formation but discrete bentonite beds are rare.

Ramyard Creek area (90km north-west of Chinchilla)

F W Kiely Pty Ltd (EPM 3366, 1982) conducted an investigation to determine whether additional prospective areas other than those being exploited by Cudgen RZ Ltd were available. Reconnaissance inspection of exposures (earth tanks, erosion gullies and road cuttings) and discussion with local landholders and water

borers delineated an area for further assessment. Samples of bentonite obtained from hand auger and open hole drilling, and selected samples taken from outcrops were tested with results indicating the bentonite could be beneficiated to a commercial specification. Although several small outcrops of workable and usable bentonite were found, it was decided that due to the low market demand and high internal costing, not to proceed with these areas and focus remained on prospective areas already held by the company under mining leases.

CLAY

Exploration

Condamine River (40km south-east of Chinchilla)

The Condamine River 40km south-east of Chinchilla cuts across an area of surface exposure of Pleistocene alluvium, which overlies part of the fluviatile Pliocene Chinchilla Sand. Previous drilling by Global Minerals Pty Ltd in the 1970s intersected white clay then discontinuous coal beds of the Middle to Upper Injune Creek Group at depths of 36m and 40m. The inferred location of drill holes D 7, D 14 and D 16A were selected by B Burban (EPM 10816, 1955) to obtain clay samples for laboratory testing. However, duplicate drilling failed to intersect the white clay at the reported depths, instead coloured clay was intersected at various depths. It was concluded the clay bands of the Injune Creek Group could have been reworked and have little lateral persistence. The reported white clay horizons could represent channel fill deposits and probably have been subjected to reworking by scour currents, redepositing as discontinuous lenses.

EPM 642 was granted to J M Huber Corporation. Exploration was mainly in the Kingaroy area (Gympie SG56-10, 1:250 000 Sheet) and consisted of core drilling and some grid drilling in the vicinity of the Goodger mine. A total of 223 holes with 4000m of non-core and 3000m of core was drilled.

DIAMOND

History

Gem quality red pyrope-almandine garnets have been reported from the Proston area. Fossicking of garnets has been carried on in the area since the 1940s, and at Garnet Gully garnets up to 100ct have been found. Other gemstones present with the garnet include peridot, rare zircon, sapphire, an orthoclase and diamond. In the Garnet Gully area, two diamonds of ~0.2–0.3ct weight were recovered. One stone was obtained from a xenolith of eclogite in an outcrop of brecciated granitic rock. The other was recovered from a trap in a minor watercourse (Robertson & Robertson, 1994).

Since the initial discovery, up to 20 diamonds have been reported by fossickers from trap sites downstream from the breccia pipes. Local fossickers reported diamonds near volcaniclastic rocks similar to those in the Inverell and Glen Innes

area have also been found around Brigooda. The surface morphology (*eg* resorption/corrosion features); physical properties and colour of some of the diamonds from Brigooda appear to be similar to those seen on diamonds from Copeton, NSW (Meyer & others, 1997).

Exploration

Brigooda area (100km north-east of Chinchilla)

Several diamonds were reported in the Brigooda area which contains similar volcaniclastic rocks to those in the Inverell and Glen Innes areas. In addition, breccia pipes near Proston also contain mantle xenoliths intruded under saturated alkali basalt lavas. Interpretation of gravity images suggest that the Brigooda occurrence lies at the intersection of two major lineaments — the north-east trending Darling River Lineament and a major continental scale west-north-west trending lineament. The geological setting attracted BHP Minerals Ltd to apply for EPM 10048 and EPM 10049 in 1994, covering the Brigooda and Ballogie target areas respectively. Australian Kimberley Diamonds NL subsequently surrounded the BHP Minerals Ltd tenements with a much larger exploration permit, EPM 10192 (1994). In the later years, David Royle was granted EPM 13506 in 2002 to reassess the Brigooda area for potential of diamond occurrence.

A study of Landsat images and aeromagnetic images by D Royle (EPM 13506, 2002) showed that the area is criss-crossed by numerous narrow E–W, N–S, NNE and NNW trending magnetic linear features interpreted as basalt dykes. At the southern end of the main basalt flow in the vicinity of Garnet Gully is a brecciated body. It contains abundant unsorted lithic and crystal fragments from upper mantle as well as crustal sources. An interpretative study of the Landsat image also showed a large circular feature ~1.8km in diameter 2km west of Garnet Gully. Other circular anomalies mapped by Australian Kimberley Diamonds NL (EPM 10192, 1994) are present along the main NNW trending fault zone particularly to the south of Garnet Gully. Breccia pipes were mapped in the Brigooda area. A ground magnetic survey by BHP Minerals Ltd carried out over the southern pipe at Brigooda showed that the magnetic responses of the basalts and granite mask the more subtle response of the pipe. In the Garnet Gully area, a ground magnetic survey conducted over the area by D Royle around the Garnet Gully diamond occurrence outlined several areas of mafic intrusive and extrusive rocks. However, the mafic/ultramafic diatreme breccia thought to represent the primary source of the diamonds did not have a unique magnetic response.

BHP Minerals Ltd (EPMs 10048 and 10049, 1994) collected 6 surface samples (DZ 6585-87; 6590-92), three each from the Brigooda and Ballogie areas. Laboratory test indicated that the Brigooda samples contained high percentages of Cr-diopside and other pyroxene, with lesser amounts of mica, spinel, picroilmenite, ilmenite, garnet, Fe-hydroxides and amphibole. The Ballogie samples were significantly different, containing a high percentage of Fe-hydroxides, spinel and pyroxene. No diamonds were recovered.

Selected amphibole in breccia from the Brigooda Prospect was dated at 19Ma (BHP Minerals Pty Ltd, 1996), which is in marked contrast to the previously

reported date of 0.4Ma, but comparable with a date of 18Ma from an adjacent basalt (Robertson & others, 1985). Amphibole in breccia from the Ballogie Prospect was dated at 43Ma, which is far older than a previously reported date of 16Ma (Hollis & others, 1983).

Australian Kimberley Diamonds NL (EPM 10192, 1994) undertook heavy mineral stream and loam sampling, focusing on structural and circular anomalies generated through an interpretation of Landsat images. Chromites and picroilmenites of possible kimberlitic affinity were detected in 6 out of 51 samples. A follow up sampling program of the anomalous sites returned negative results except for one stream sediment sample, which contained three possible kimberlitic chromites from downstream of Garnet Gully. Sobolev's plots of the chromite chemistry for samples indicate the grains were possible kimberlitic and plot in the associated diamond field.

In 2002, a representative heavy mineral concentrate sample from the Garnet Gully workings, l50m downstream of the western edge of the diatreme breccia was analysed by electron microprobe analysis. Results indicated the garnet compositions in the Brigooda diatreme breccia were sourced from diamond eclogite facies rocks at depth (Royle, 2002). Drilling of the breccia pipe by BHP Minerals Ltd (EPM 10048, 1994) intersected lapilli tuff, breccia with basaltic and ultramafic clasts in a sandy matrix of granitic composition. The drilling showed that the breccias are probably not actual pipes, but are probably deposits of volcanic ejectamenta with some mantle derived component.

FELDSPAR

History

Pegmatite dykes in the Iron Pot Creek – Burrandowan area west of Kingaroy were worked during the 1960s–-1970s for use in refractory bricks by Rylance Refractories (later Claypave Pty Ltd). Similar material was also worked at Brooklands, near Kingaroy, but total production from the two areas is reported to be <20t.

The material worked as a source of feldspar is a medium-grained leucogranite, and probably represents a late stage phase of the Boondooma Igneous Complex. Grains are mainly 1–2mm across, although the range is from 0.1–6mm. The microcline commonly occurs as larger grains but often contains smaller grains of quartz, plagioclase and mica.

Exploration

Bunya Resources Pty Ltd (EPM 11081, 1996) reviewed previous mining and geology and concluded that in the Iron Pot Creek – Burrandowan area the host rocks are dominantly fine- to medium-grained schist intruded by leucogranites. Both the country rock and the medium-grained leucogranite dykes contain feldspar. Petrological examination of two schist samples identified 35–40% plagioclase which is of the sodium (Na) variety. The dykes contain between

60–70% combined feldspar with ~30% quartz, and minor amounts of mica (both biotite and muscovite), garnet, sericite and apatite. Tests indicated crushing to 1mm would achieve a high degree of liberation, further crushing to 0.3–0.1mm would achieve almost complete liberation of feldspar from the schist and leucogranite. Beneficiation of the leucogranite would be required to produce feldspar material meeting commercial market specifications. Because of the low feldspar content the schist, the dykes can not be mined as a standalone source.

GOLD AND BASE METALS

Exploration

Allies Creek homestead area (95km north-east of Chinchilla)

The Allies Creek workings are centred on altered/sheared intermediate volcanic rocks within the predominantly sedimentary undifferentiated Carboniferous unit of the Rockhampton Group. Mineralisation comprises disseminated sulphide associated with a shear zone. Gold Fields Exploration Pty Ltd/Renison Ltd (EPM 4303, 1986; EPM 5771, 1989) conducted geological mapping east of Allies Creek Sawmill and outlined three zones of sheared, sericitised acid volcanic rocks with disseminated sulphides, underlain and overlain by fine- to medium-grained volcaniclastic sediments, tuffs and andesitic volcanic rocks. Much of the area has undergone albite/epidote alteration related to the emplacement of the Toondahra Granite 1.5km to the east, as well as minor local alteration due to micro-dioritic intrusions and quartz-feldspar porphyry dykes cross-cutting the area.

Stream sediment sampling returned several anomalous gold assay results around the old mine site. However, soil sampling over the shear zones returned very low gold assay results. Rock chip sampling of the old trenches yielded anomalous gold assay values ranging from 0.1–6.0g/t Au. Two diamond drill holes (AC 1 and 2) were drilled to test for lode extension below the Golden Whiptail workings, whereas AC-3 was completed to test the ground under Stumers Shaft. Hole AC-1 intersected 1.05g/t Au from 40.25–44.0m, with zinc values up to 6.7% and copper at 4800ppm in sericitic-altered, red-brown to purplish grey, sheared, fine-grained tuff containing 1–2% disseminated relic sulphide and secondary copper. Hole AC 2 intersected similar stratigraphy as in AC-1 between 55.2m and 59.16m. Hole AC 3 was designed to test the ground under Stumers Shaft, which contained a magnetite/hematite rich rock with up to 25g/t Au. Magnetite/hematite rich bands were intersected within tuffaceous sediment and tuff at 33m and 52m respectively, but no significant gold assay values were recorded at these intervals. The overall drilling results failed to induce the company to continue exploring the Golden Whiptail workings.

In 1989, Renison Ltd conducted ground geophysical survey over alluvium separating the outcropping northern and southern mineralized shear zones. Three IP anomaly targets were interpreted and were tested by 4 diamond drill holes (BC 1 to BC 4). Drill holes intersected various altered, andesitic volcanic rocks and volcaniclastic rocks, black shales, dioritic intrusive rocks and banded volcanic rocks. The andesites are pervasively and intensely altered with the

development of epidote/chlorite (propylitic alteration) and sericite. Patchy silicification occurs in all rock types. Hornfelsing is ubiquitous in the very fine-grained volcaniclastic rocks and shales. Disseminated pyrite occurs throughout in trace quantities, increasing to 2% in the black shales. Selected drill core samples returned gold assay values below detecting limits and low base metals assay values.

Probe Resources NL (EPM 9616, 1993) conducted percussion drilling (holes AC 4 to 7) of the Golden Whiptail line of workings. The best intercepts were in drill hole AC 4 (2–12m) at 2.9g/t Au, and in drill hole AC 7 (14–18m) at 0.8g/t Au.

Paradigm Queensland Pty Ltd (EPM 13877, 2003) examined a linear magnetic low surrounded by a circular feature. Mapping showed this area contains numerous outcrops of strongly weathered and lateritised basalt. The outcrop area broadly correlates with the north-south magnetic linear observed in the aeromagnetic data. Stream sediment sampling assayed up to 90ppm Cu, and 235ppm Zn. Gold anomalism (up to 0.8ppb) was considered very weak. The company concluded the copper and zinc anomalism reflecting the shallow basalt cover, and not related to any of Permo-Triassic intrusive rocks.

Rocky Creek area (105km north-east of Chinchilla)

Peko-Wallsend Operations Ltd (EPM 4821, 1987) collected rock chip and bulk leach extractable gold (BLEG) stream sediment samples in the Rocky Creek area where alluvial tin and lode tin were mined from aplitic granite at an igneous-sedimentary contact and in the quartz porphyry dykes. Three of the BLEG samples assayed >1.0ppb Au, with the highest value being 5.85ppb Au. However, repeat sampling of these sites returned a maximum gold value of 0.1ppb. The highest outcrop gold assay of 0.078ppm was obtained from monzonite porphyry with local stringer quartz venation and brecciation at the Geer Prospect. Sampling of the pegmatites and granites at the old Rocky Creek tin mining area resulted only slightly elevated gold and base metals geochemistry values than the expected background levels.

Garden Creek area (80km north-east of Chinchilla)

EPM 7069 comprising 2 sub-blocks 6km east of Durong South was granted on 23 May 1990 to WA Bennett and partners. Seven vertical diamond core holes and 6 airtrack holes were drilled at selected sites. Examination of the cuttings indicated that granite was penetrated in the majority of holes. Drill hole cuttings assayed <0.005ppm Au.

OIL SHALE

Exploration

Juandah Creek area (75km north-west of Chinchilla)

Brigalow Mines Pty Ltd (EPM 2769, 1981) explored the Juandah Creek area (GULUGUBA 8945) 75km north-west of Chinchilla, to assess the potential of oil shale in the Juandah Coal Measures within coal tenements EPC157, 182, and 138.

Nine open holes and thirteen 150mm diameter core holes were drilled to test the strata associated with the coal deposits, and fresh cuttings and core for torbanite. The dominant rock types were sandstone, siltstone, shale, mudstone, carbonaceous mudstone and coal. No torbanite intersections were recorded in any geological log.

Durong area (70km north-east of Chinchilla)

Dampier Mining Company Ltd (EPM 2790, 1981) explored around the Durong area (BOONDOOMA 9145) 70km north-east of Chinchilla. The area was selected as regional gravity data, indicating a 5–10 milligal low, was broadly coincident with the Durong Plain, which could have received Tertiary sedimentation. A ground gravity survey was conducted over the area and defined a 'low' target zone. Using previous drilling data generated by Phillips Petroleum Company and BP Australia Ltd within the 'low' target zone, two cross-sections of the area were constructed perpendicular to the trend of the gravity anomaly. From the sections, it appears that the gravity 'low' target zone is due to the presence of a blanket of unconsolidated Tertiary sediments, slightly thicker than in the surrounding areas, lying on granite basement. No oil shale intersection was reported from the drill hole data.

Condamine River area (40km west-south-west of Chinchilla)

Oil shale was reported by Jensen (1926) from the Orallo Formation in the Orallo area. Locally the Orallo Formation comprises of medium- to poorly-sorted, to well-sorted labile to sub-labile, in part, calcareous and clayey sandstone, interbedded carbonaceous siltstone, mudstone, shale, minor coal, bentonite, conglomerate and fossil wood. Swarbrick & others (1973) visited the reported site and were unable to confirm the occurrence of oil shale.

A shaft, as reported in a local newspaper, was sunk in 1944 and intersected oil shale near the Condamine River (MILES 8944). F W Kiely Pty Ltd (EPM 3186, 1981) selected the area at a distance 39km west-south-west of Chinchilla for further investigation. A total of 9 vertical holes were drilled (~360m) and intersected thin coal seams of the Walloon Subgroup, but no oil shale or bentonite clay was found.

South Pine Mines Pty Ltd (EPM 3200, 1982) conducted further exploration in the Wieambilla Creek area, 29km south-west of Chinchilla (MILES 8944). A series of 15 shallow rotary drill holes (up to 20m deep) were completed for a total of 260.6m and the bulk of this drilling intersected clayey, lithic sandstone containing numerous bands of mature pebbles. The only prospective lithology was inferior, coaly, carbonaceous shale encountered at 20m in RA 003. However, the adjoining holes contained no evidence of a similar rock type. A hand picked sample of the carbonaceous shale yielded 51 litres/tonne oil.

PLATINUM

Exploration

Johnson Creek area (75km north-east of Chinchilla)

EPM 13665 on Johnson Creek 75km north-east of Chinchilla was granted on 30 July 2001 to E.F. Pocock, W.A. Bennett and W.G. Battilana. Three RC holes totalling 150m were drilled in foliated grey, porphyritic alkali feldspar granodiorite of the Mistake Granodiorite. Selected rock chip samples were assayed for the platinum group of metals. Results were disappointing and no further work was conducted.

RUTILE AND ILMENITE

History

The presence of rutile at Jumma and Mannuem Creeks has been known since the late 19th century with references by Jack (1896) and Cribb (1943). Mapping by the Queensland Geological Survey in the 1990s located a new occurrence (Greenup) of rutile at a location along the South Burrandowan Road at 1km north of Cardown homestead. The area has been identified as having potential for rutile mineralisation within the amphibolite grade metamorphic rocks of the Chahpingah Meta-igneous Complex, which is part of the Lower to Middle Palaeozoic Yarraman Subprovince (Cranfield & others, 2001).

Exploration

Boyne River area (90km north-east of Chinchilla)

EPM 8692 was granted on January 1992 as a result of anomalous ilmenite/rutile mineralisation being brought to the attention of Consolidated Rutile Ltd by J Banks. The primary aim was to ascertain if economic quantities of rutile or ilmenite were present in accumulated sediments in the Boyne River valley.

The area consists of Early Palaeozoic undifferentiated rocks (schist gneiss, foliated granodiorite) intruded by acid to basic dykes of the Permian–Triassic Boondooma Igneous Complex. Jurassic sediments of the Marburg Formation (Clarence–Moreton Basin) and basalts of the Tertiary Main Range Volcanics unconformably overlie parts of the region.

Literature searches and site visits confirmed that the sediments of the Boyne River valley were generally finer (up to 70%) at the top of the profile, and graded into sands and then into gravels (particles up to 60mm) at the base, just above the weathered gneiss. The highest heavy mineral values (up to 15.7%) are all in the weathered zones of biotite gneiss. The ilmenite fraction of the heavy mineral is irregular in size, ranging from 0.3mm (50#) to 1mm. The remainder of the fraction consists mainly of large pink garnets, zircon and rutile. Rutile and ilmenite occur both as coarse-grained rosette-like aggregates in cross-cutting

aplitic and pegmatitic dykes within the gneiss, and as fine-grained minerals disseminated throughout the gneiss. Weathered out rutile/ilmenite 'crystals' (up to 60mm in length) were found downstream of the dykes.

XRD studies indicated the central section of the rutile crystals comprises pale yellow to red needles assayed 97–99% TiO_2. The outer sections of composite crystals, or entire crystals where they are only ilmenite, contain 52–54% TiO_2 and are massive, black, and have conchoidal fracture surfaces. The composite crystals comprise discrete rutile and ilmenite sections, and appear to have formed contemporaneously in a single igneous event.

Ten exploration holes, totalling 201.6m, were drilled with 9 of these holes (K 1 – K 7, K 9 – K 10) being drilled through Boyne River sediments into the underlying bedrock and one hole (K 8) entirely drilled through bedrock. The 9 holes drilled through the Boyne River valley sediments attained depths between 5.5m and 36m (average 21.0m), and intersected sediments from 4m to 27m (average 12.5m) and depths of weathered gneiss to 16m (average 9.6m).

The company concluded that no significant accumulations of rutile or ilmenite occur in the fluvial sediments of the Boyne River. The anomalous ilmenite and rutile occurrences associated with acid dykes in the gneisses offer little potential for economic exploitation.

In 2001, Rio Tinto Exploration Pty Ltd (EPM 13410) re-assessed potential of the area for an economic rutile deposit. A study of airborne magnetic data interpreted a linear magnetic anomaly, which appears to control the distribution of rutile mineralisation. Rutile mineralisation in the form of scattered slugs and crystal fragments up to 20mm in size were found at several localities in the southern part of the tenement area, more notably at the Greenup occurrence. Rutile is occasionally found as crystal fragments in vein quartz, but has not been found *in situ* in the biotite gneiss of the Chahpingah Meta-igneous Complex.

Three lines of ridge and spur hand auger sampling (43 soil samples) were undertaken over the area. The concentrate fractions were analysed for TiO_2. The results of this work correlated with the known presence of the fragmentary rutile on the surface but did not point to the presence of any significant concentration of rutile in the bedrock. The best results were found on the line over the Greenup occurrence with the highest count of 0.205% rutile. Background values were <0.02% TiO_2, with most values <0.01%.

TIN

History

In 1903, alluvial cassiterite was discovered in the Burnett district. The find caused a small rush to Rocky and Brovinia Creeks, 100km north-east of Chinchilla. By 1904, dredging claims from 1.5–3km long were pegged along Rocky Creek from its junction with Brovinia Creek. Other dredging claims were also taken up on Brovinia Creek, above and below the Rocky Creek junction and

on Busbnell's Flat between these two creeks. Further prospecting led to the discovery of lode tin hosted in aplitic granite on high ground north of Rocky Creek.

Many small mining syndicates worked the Rocky Creek alluvial deposits. However cassiterite production was low as the grades were concentrated in surface sandy wash and depleted in the underlying clayey sand. Intermittent mining operations carried on to 1910, then in the 1920s, and again in the 1950s. Records of total production for those years are not available.

Exploration

Rocky Creek area (104km north-east of Chinchilla)

Mines Administration Pty Ltd (EPM 326, 1966) and Goldfields Exploration Ltd (EPM 3489 & EPM 3490, 1983) explored the Rocky Creek area for alluvial, deep lead and lode cassiterite deposits. Ground investigations confirmed that the stanniferous alluvial deposits confined to that part of Rocky Creek which flows across and along the contact zone between the granite and metasediments extending for 17km downstream from the Gorge Waterhole. Deep leads at depth up to 5m occur on either side bordering this stretch of the creek.

The bed of Rocky Creek is crossed by numerous rocky bars of granite or metasediments, and locally minor occurrences of rich stanniferous wash occur in hollows among the bedrock. In the granitic rocks near the headwaters of Rocky Creek, and in other creeks similarly situated, only traces of cassiterite were found and the maximum thickness of alluvium was at the junction of Rocky Creek and McCananagy Creek, where alluvium up to 1m thick rested directly on weathered granite. The wash averaged 20–30mm thick. Near the Gorge Waterhole, the cassiterite-bearing wash or 'deep lead' contains very poorly-sorted, bouldery conglomerate with rounded and angular pebbles of weathered granite, rhyolite, quartzite and other metasediment, in a brown sandy matrix.

On the southern bank of Tailors Creek (BOODOOMA 9145) five small shafts were sunk 10–20m deep in highly kaolinised granite. The shafts trend northerly and lie within an area of 20m by 35m. Although cassiterite could be panned from dump material, rock chip samples taken from the dumps and surrounding outcrop returned a maximum tin assay value of 270ppm. There was no evidence of quartz or tourmaline on the dumps.

The companies concluded that the main cassiterite deposits were confined to the original prospecting area on Rocky Creek discovered in 1903 and there was little potential for company scale mining.

URANIUM

Exploration

Goggs Creek area (80km north-east of Chinchilla)

Pechiney (Qld) Pty Ltd (EPM 666, 1969) conducted a regional aerial survey searching for radiometric anomalies as indicators of uranium mineralisation in the Monto area. The search extended onto the Chinchilla area and no significant uranium targets were detected.

The Goggs Creek area (BOONDOOMA 9145) was singled out as a potential uranium target as a result of an assessment of airborne magnetic and radiometric datasets by Superior Resources Ltd (EPM 15120, 2005). Of particular interest to the company was the anomalous background uranium response of the Boondooma Igneous Complex which potentially makes it a possible source of uranium for roll front or sandstone uranium deposits. A ground radiometric survey was conducted to inspect and sample in the vicinity of an identified airborne radiometric anomaly at the headwaters of a west branch of Goggs Creek.

Moderately anomalous counts up to 500cps against a background of ~50cps away from the area were obtained over a Tertiary fluvial deposit of sandstone and conglomerate overlying Permo-Triassic granite of the Boondooma Igneous Complex. Adjacent to the Tertiary stream channel the granite showed low levels of radioactivity. Two samples of oxidized sandstone collected from the centre of the uranium anomaly gave background readings.

CURRENT OUTCOMES OF MINERAL EXPLORATION

The Chinchilla 1:250 000 Sheet area has been explored for residual bentonite deposits probably derived from weathered of particular tuffs with andesitic glass shards of the Jurassic Orallo Formation. The bentonite-bearing horizons occur as flat-lying beds below or on an unconformity separating the Orallo Formation from the overlying Cretaceous Mooga Sandstone. Sub-economic deposits also occur in the Jurassic Injune Creek Group, a lower stratigraphic unit to the Orallo Formation.

There is continuing exploration in both units for further bentonite resources around the Miles and Gurulmundi areas. Shallow drilling in the **Sandy Creek** area intersected narrow beds of low-grade, magnesium-rich bentonite with restricted lateral continuity. Exploration in the **L Tree Creek** area outlined an eight kilometre strike length of bentonite horizon. The ‘bentonite belt’ strikes east-west to the west of the Gurulmundi bentonite pit and exploration of this belt has an indicated resource of 7.8Mt of bentonite. In the **Paddy Creek** and **Ramyard Creek** areas, both kaolinitic and bentonitic clays are widespread and commonly associated. Laboratory tests indicated these deposits have the potential of meeting the standard for a commercial grade product.

The Orallo Formation was also explored for its oil shale potential based on several previous reported occurrences in the Orallo area. Shallow drilling at **Condamine River** intersected thin coal seams of the Walloon Subgroup, but no oil shale was found. However, shallow drilling in the **Wieambilla Creek** area intersected clayey lithic sandstone and a narrow restricted zone of inferior coaly carbonaceous shale which yielded 51 litres/tonne. The Juandah Coal Measures in the **Juandah Creek** area and the gravity low over the **Durong Plain** were also targetted for oil shales but no finds were made.

The potential of deep lead alluvial tin deposits was evaluated along **Rocky Creek**. The stanniferous alluvial deposits were found to be limited to that part of Rocky Creek crossing and along the contact zone between the granite and metasediments.

Near the **Gorge Waterhole**, the cassiterite-bearing wash is coarse, very poorly-sorted, bouldery conglomerate comprising rounded and angular pebbles of weathered granite, rhyolite, quartzite and other metasediment, in a brown sandy matrix. No commercial grade of alluvial deposits was found. The source rock for the alluvial tin has not been determined as most of the kaolinised granite of the Boondooma Igneous Complex in the area show little quartz and tourmaline alteration.

The Golden Whiptail workings in the **Allies Creek** area were singled out as the most prospective target for gold. Stream sediment sampling and rock chip sampling of the old trenches returned several anomalous gold assay results around the old mine site, however, soil sampling over the shear zones returned low gold assay results. The best diamond drill hole returned assay values of 1.05g/t Au and 6.7% Zn. Gold mineralisation appears to be confined to narrow north-north-west trending shear zones in metasediments of the Maronghi Creek beds intruded by Triassic granitoids of the Toondahra Granite. The granites in the **Rocky Creek** and **Garden Creek** areas were also explored for gold mineralisation associated with igneous intrusions. No significant find was made. The granites at Rocky Creek had low radioactive values.

Rutile associated with gneiss of the Chahpingah Meta-igneous Complex is known in the **Jumma Creek** area. Surface mapping has led to the discovery of many small occurrences of rutile crystal fragments in the **Mannuen Creek** area. Rutile was found in cross-cutting aplitic and pegmatitic dykes within the gneiss, and as fine-grained minerals disseminated throughout the gneiss. Drilling for fluvial rutile deposits failed to outline an economic deposit at Boyne River near Chahpingah homestead.

The potential of feldspar in schist and leucogranite of the Chahpingah Meta-igneous Complex was also assessed. Tests indicated that beneficiation of the leucogranite would be required to produce feldspar material meeting commercial market specifications.

Several diamonds were reported to have been found in the Brigooda area. Drilling of breccia pipe near **Garnet Gully** intersected diamond indicator minerals possibly sourced from diamond eclogite facies rocks. However, the breccias are

probably not actual pipes, but are probably deposits of volcanic ejectamenta with some mantle derived component.

COMPANY EXPLORATION FOR COAL
(J Hodgkinson)

COAL RESOURCES

The principle targets for exploration are the Taroom and Juandah Coal Measures of the Jurassic Walloon Subgroup, although exploration of potential for underground mining of the Permian Baralaba Coal Measures has been undertaken. The outcrop/subcrop limit of the Walloon Subgroup coals follows an approximately linear trend from north-west to south-east through the Chinchilla sheet area. Established open cut resources lie to the south-west of this boundary following the regional south-west dip of the coal measures to the point of maximum economic viability. Typical values for raw coal quality parameters in the Walloon Subgroup coals are given below:

Relative density	Inherent moisture %	Ash %	Volatile content %	Fixed carbon %	Specific energy MJ/kg	Total sulphur %
1.36	6.80	18.40	41.20	33.60	25.04	0.33
1.29	8.00	7.30	45.00	39.70	28.46	0.24
1.30	7.60	7.90	43.70	40.80	28.56	0.28
2.39	6.00	35.80	30.10	28.10	18.76	0.31
1.71	6.10	24.50	35.30	34.10	20.94	0.54
na	8.50	26.70	20.41	31.00	20.41	0.36
1.31	8.20	6.90	34.90	31.30	19.38	0.31
1.49	11.50	23.80	43.50	40.50	27.59	0.53

Coal seams containing abundant dirt and stone bands generally contribute to the high ash content. An economical thermal coal product can be derived from the Walloon Subgroup coals despite their high ash content, due to their perhydrous nature and high volatile bituminous rank. The Kogan Creek power plant has been specifically designed to take raw, high ash Walloon Subgroup coals as feedstock. The Juandah and Taroom Coal Measures have primarily been developed for the domestic market (Kogan Creek — CS Energy, Glen Wilga and Haystack Road — Tarong Energy) but Xstrata Coal Queensland Pty Ltd plan to develop the vast Wandoan resource in the neighbouring Roma sheet area to produce washed, export-quality product.

Chinchilla was the first area in Queensland used to demonstrate the viability of underground coal gasification (Chinchilla resource — Linc Energy Ltd with an initial test burn of 35 000t of Walloon coal). Total thermal coal resources in the Chinchilla 1:250 000 Sheet area (not including the Wandoan resource) are estimated at 2.56 billion tonnes, consisting of 1.58 billion tonnes in the measured and indicated category and 980Mt inferred.

COAL EXPLORATION

Delineation of the currently established coal resource areas was largely due to extensive exploration activities carried out by a series of joint ventures involving: Exoil N.L., Transoil N.L., Brigalow Mines Pty Ltd., Lone Star Exploration N.L., Global Minerals Pty Ltd, Rio Grande Group, Petromin N.L., Shell Company of Australia Pty Ltd. (SDA) and Oilmin N.L. Subsequent to this early phase of exploration Mobil Energy Minerals Australia Inc., BP Australia Ltd., Pacific Coal Pty Ltd., Griffin Coal, Marathon Petroleum Australia Ltd. (MPAL), BHP Minerals, Allied Queensland Coalfields, Linc Energy, Tarong Energy, Ribfield Pty Ltd., Syntech Resources, New Hope Corporation Pty Ltd., Xstrata Coal, Bowen Central Coal, Carbon Energy (Metex Resources) and Ecarlate Pty Ltd. all carried out further exploration, mainly on a sole operator basis with fewer joint venture projects.

In 1967 EPC39 was granted to the Exoil N.L.–Transoil N.L. joint venture and 136 holes were drilled. Results were disappointing with no coal intersected in most of the holes and seams ~3m thick encountered only at some sites. The poor results led to most of the tenement being relinquished. EPC77 was granted to the same joint venture in 1970 for exploration based on prior drilling carried out by Brigalow Mines in the area, but results were again unsatisfactory. Global Minerals drilled 41 holes to a maximum depth of 46m but encountered only thin seams of high ash coal at 8 sites (ash content 39.8–61 %).

Greater success was experienced in EPC105 covering the eastern Wandoan coal resource area, initially granted to Global Minerals Pty Ltd in 1971. Eight chip holes were drilled in 1972 prior to the establishment of a joint venture farm-in with Rio Grande Group, Lone Star Exporation N.L., Syncline Pty Ltd and Wiltul Ltd. Rio Grande Group drilled a further 10 chip holes including 3m of core and Brigalow Mines drilled another 28 holes including 5.7m of core. This exploration effort produced an initial resource estimate of 67.5Mt of high ash raw coal in the Wandoan area.

EPC125 was granted to the Exoil N.L., Petromin N.L. and Transoil N.L. joint venture in 1972. The main drilling program consisted of an aggregate total of 1,992m spread across 26 holes with an additional 18 close spaced holes around drill site No. 6. Four holes were drilled in the north of the tenement but encountered no coal of economic value. The exploration program formulated an early estimate of coal resources for the Cameby Downs deposits of 30Mt.

Mines Administration Pty Ltd. were granted EPC133 straddling the southern boundary between the Chinchilla and Dalby sheet areas. Seventeen chip holes were drilled and shallow coal was intersected at ~38m with seams ~2m thick but of poor quality. Many drill holes encountered extensive subsurface basalts and thick alluvium sheets. A moderate to low ash (11.7–12.6%) resource of 15Mt was estimated but not of economic value.

Drilling in 1982/3 by Brigalow Mines Pty Ltd. and Rio Grande Group in EPC138 intersected major deep coals in the Juandah Coal Measures at 160m and 240m depth respectively. The EPC covers the established Guluguba, Glen Laurel,

Stanley Park and Burunga resources but no shallow coals were considered commercially exploitable during the life of the tenement. Brigalow Mines also conducted exploration in EPC150 near the Sefton Park and Lallilindi resources but intersected 80–100m of Kumbarilla beds overlying the Juandah Coal Measures. Thirteen chip holes were drilled but no economically viable coal was located. The Surat Coal joint venture drilled 162 holes including 9 part-cored holes in EPC431 covering a similar area between 1985 and 1988. Coal seams in the Juandah Coal Measures were lenticular and contained rapid short range changes in thickness. Some seams were 4–8m thick and contained clean coal but were laterally restricted. Coals were mainly high ash, high volatile and perhydrous with average total sulphur of 0.5% and ~7% moisture (raw coal air dried basis).

The Oilmin N.L., Exoil N.L., and Transoil N.L. joint venture were granted EPC155 to explore the west and south-west extension of the Kogan Creek resource (then known as the Brigalow deposit). A total of 24 holes were drilled with an aggregate thickness of 3205 m and all encountered coal seams. Seven holes intersected seams less than 1.52m thick and one hole contained a seam 6m thick at 116–122m depth. Further drilling established that the thicker seam decreased to 2–3m over a short distance. Additional seams of 7.6m and 12.2m thickness were discontinuous with seam splits apparent in some holes.

A second joint venture also included Shell Development (Australia) Pty Ltd. in EPC156 over the Cameby Downs resource. Thirteen chip holes were drilled to an average depth of 140m with an aggregate total of 1832.5m. The Cameby Downs Resource was re-evaluated at a stripping ratio of 10:1 to a maximum depth of 60m giving an estimated 120Mt of coal. Mineral Deposits Ltd. carried out a desktop study of the area north-west of Cameby Downs in EPC161 but concluded that potentially economic deposits were unlikely. Oimin N.L and Transoil N.L. returned to Kogan Creek with the grant of EPC401 in 1986 but only intersected a durain rich seam ~1m thick in a part-cored hole. Cameby Downs is now held under EPC732 granted to Syntech Resources Pty Ltd. in 2000.

Early exploration of the Horse Creek resource was conducted by another joint venture between Shell Development (Australia) Pty Ltd., Oilmin N.L., Petromin N.L. and Transoil N.L. in EPC162. Drilling started with 45 holes in 1973, followed by a further 38 holes in 1974 and 10 in 1976. A 6m interbanded coal seam was intersected and was correlated along strike for 20 km using petrophysical logs. At least one fault with ~50m displacement was identified as offsetting the deposit. The same joint venture was granted EPC181 covering the Jimbour area and extending south into the Dalby sheet area.

A second class indicated reserve (prior to publication of the Galligan and Mengel 1986 guidelines) of 198Mt was established for the Ownaview resource but no economic coals were identified in the Chinchilla portion of the EPC. The Dutch group revisited the Horse Creek resource for further exploration, this time without Shell Development in EPC210. Drilling included 14 chip holes and 18 cored holes but coals intersected were not considered economic in the face of prevailing market conditions. Marathon Petroleum Australia Ltd. (MPAL) was granted EPC255 also over the Horse Creek resource and drilled 19 chip holes to an

average depth of 135.4m and an aggregate thickness of 2580m. MPAL also considered the resource to be uneconomic. Griffin Coal Mining Company drilled 7 holes to the north-east and south-east of the Horse Creek resource in EPC356 but only encountered thin (maximum 0.20m) insignificant coals. MPAL returned to the Horse Creek area under EPC411 and drilled 95 chip holes and 2 part-cored holes. Coal seams were thin and discontinuous, and described as seams of the intermediate and lower Walloon Coal Measures.

The Horse Creek resource along with Wilkie Creek was acquired from MPAL by Allied Queensland Coalfields (AQC) under EPC465 in 1993. The Horse Creek resource is now held under MDL173 granted to Peabody (Wilkie Creek) Pty Ltd. in 1996. MDL173 is surrounded by EPC796, granted to Bowen Central Coal Pty Ltd. in 2003. Aquila Coal Pty Ltd. farmed-in to a joint venture with Bowen Central Coal Pty Ltd in 2004 and the 8 test holes drilled in 2005 revealed deep Tertiary cover greatly reducing the prospectivity of the coal resource.

The Shell-Oilmin-Petromin-Transoil joint venture drilled 4 chip holes to an average depth of 113m in EPC223 over the Collingwood resource but found no economic seams. Griffin Coal Mining Company Ltd. was granted EPC309 over a similar area and carried out a more extensive exploration program including 46 open holes. A similar conclusion was reached that the resource was not economically viable. The Dutch joint venture revisited exploration of the Collingwood resource with the grant of EPC312 in 1980. Fifty-eight holes were drilled with an aggregate thickness of 4720m including 8 part-cored holes. Revision of the existing geological model with augmented petrophysical data resulted in an indicated resource estimate of 140Mt. Raw coal ash content was 15–20% with a Hardgrove Grindability index of 42 and high specific energy values, indicating the product was suitable for domestic use or a washed export product. Estimates of washability suggested a maximum yield of 83% at a relative density of ~1.65.

All significant coal resources are located in the Taroom Coal Measures and seams are lenticular with rapid changes in mineable thickness. Mobil Energy Minerals Australia Inc. assessed resource potential in the area between Collingwood and Wandoan in EPC422. Extensive coal analyses were carried out, but no resources were considered economic in the Chinchilla section of the EPC. Ribfield Pty Ltd. was granted EPC640 over the Collingwood resource in 1997. No further drilling was carried out and the original Shell-Oilmin-Petromin-Transoil data was used for resource assessment. Anglo Coal (Taroom) Pty Ltd. currently hold the Collingwood resource under EPC640 granted in 1998.

Mobil Energy Minerals Australia Inc. was granted EPC262 covering the Glen Wilga and Chinchilla resources in 1974 and EPC270 over the Haystack Road resource in 1980. Ten rotary holes totalling an aggregate thickness of 893.39m were drilled in EPC262. A maximum seam thickness of 1.5m in the program was intersected at between 77.5-79.0m depth. Exploration in EPC270 was more extensive with 45 open holes and 1 cased hole drilled between 1980 and 1982 intersecting banded coal seams up to 4.1m thick. Resources in both tenements were not considered economic. A joint venture between BHP Minerals and Mobil Energy Minerals Australia (M.E.M.A.) was granted EPC428 in 1984 over a

similar area and resource estimates for the Glen Wilga and Haystack Road resources were formalised. The drilling program consisted of 343 holes including 60 part-cored and 5 fully-cored holes. Thirteen seems in the Juandah Coal Measures were identified as part of the Glen Wilga resource and an initial measured resource was calculated as 203Mt. This was subsequently downgraded to 132Mt measured and 30Mt indicated by Tarong Energy in conformity with the JORC code. The deeper Haystack Road resource in the Taroom Coal Measures was calculated as a indicated resource of 142Mt, based on a 10:1 stripping ratio to 100m depth.

The Chinchilla resource is currently held by Linc Energy Ltd under EPC635 and MDL309. Linc Energy pioneered underground coal gasification in Queensland at the Chinchilla site and plan to develop a production syngas facility. Linc Energy Ltd also hold EPC897 and 898 to the south-west and north-east of the Kogan Creek and Glen Wilga resources. Tarong Energy were granted EPC468 in 1987 over the Haystack Road and Glen Wilga resources and also hold the adjacent tenements EPC585 and 637.

New Hope Collieries Pty Ltd conducted a shallow drilling program in EPC254 which covered a region over the eastern boundary between the the Surat and Clarence-Moreton Basins and the Yarraman Block. Some thin and highly banded coals were intersected in the Boyne River and Ironpot Creek areas but no resources of economic significance were found. In 1980 BP Australia Ltd carried out exploration in the adjacent EPC310 and drilled 16 chip holes and 1 part-cored hole over a depth range of 60-213m. BP were also granted EPC322 which covered a similar area to EPC254 and drilled 18 chip holes and 1 part-cored hole. It was hoped that an extensional basin fill sequence analogous to the Tarong Basin would be present but no economic coal resources were found and seams intersected were <1m thick.

The only investigation into the viability of the Baralaba Coal Measures at depth was carried out by Pacific Coal Pty Ltd. in EPC326. Twelve holes were drilled totalling an aggregate of 4768m. Intersected coal measures were 500–600m thick dipping 15–20° west under the Surat Basin. Thirteen seams with working sections ~2m and one at 5–6m thick were identified. The resource was considered uneconomic at this time because of depth, seam thickness, remoteness of location and groundwater stored in the Precipice Sandstone.

Marathon Petroleum looked into underground potential in EPC328, a large linear area near the town of Miles, trending north-west-south-east and south-west of established open cut resources. The top Walloon Subgroup coals were intersected at depths of 120–300m from a drilling program consisting of 35 chip holes and 4 part-cored holes. The same company investigated resource potential in the Wilkie Creek area with EPC383 and EPC413. Drilling of 121 chip holes in the two tenements found no significant coal above 60m depth and seams were thin and banded. Some potential for underground mining may exist but this was not pursued further.

The area held under EPC760 by New Hope Exploration Pty Ltd has been named the Jimbour Creek resource. Historical data from previous exploration has been

used to construct a geological model but no resource statement has been issued to date. New Hope intend to develop EPCs 758, 759, 760, 761, 762 and 763 as a single project. EPC918, also granted to New Hope, abuts the eastern boundary of EPC760 and has been named Jimbour East. Conceptual modelling of the Surat–Clarence Moreton Basins has been carried out but no resource statements have been issued at the current time. Sections of EPC918 were explored by previous companies under: EPC133 (Mines Administration Pty Ltd (Minad)), EPC270 (SDA) and EPC376 (BHP).

EPC787 in the north-west of the Chinchilla sheet area was granted to MIM Holdings in 2003. Xstrata acquired MIM in the same year and currently hold the area jointly with ICRA RPW Pty Ltd and Sumisho Coal Australia Pty Ltd EPC787 trends north-west-south-east and abuts the north-east margin of the previously delineated Wandoan resource group, also held by the same joint venture. The joint venture group also hold EPC792 to the south-west of the Wandoan resource and EPC838 to the south-east and north-west of the Collingwood resource. Three chip holes drilled in EPC838 to a depth of 120m penetrated only coal barren sections of the Taroom Coal Measures and the Eurombah Formation.

Carbon Energy Pty Ltd was granted EPC869 in 2004 with a view to exploration for underground coal gasification resources. The area is located to the south-west of the Kogan Creek, Glen Wilga and Wilkie Creek resources. Forty percent of the EPC was relinquished after two years subsequent to a desktop study. No field exploration was carried out.

The inferred Baking Board and Lallilindi resources are currently held under EPC873 granted to AMH (Chinchilla Coal) Pty Ltd (Ecarlate Pty Ltd). The resource potential was originally assessed by Brigalow Mines Pty Ltd from a 93 hole drilling program. The Juandah Coal Measures are the exploration target and outcrop near the adjacent Sefton Park resource area. Individual seams have a potential working thickness of 3m and cumulative thicknesses of up to 10m.

SUMMARY OF COAL RESOURCES

The principal coal resource in the Chinchilla sheet area is derived from the Jurassic Walloon Subgroup, with only minor exploration interest in the deeper Permian Baralaba Coal Measures in the underlying Bowen Basin. The high ash, heterogeneous seams of the Taroom and Juandah Coal Measures were explored extensively in the 1970s and 80s but prevailing market conditions precluded exploitation. The shallow Jurassic coals form a linear corridor trending north-west-south-east along the eastern limb of the Mimosa Syncline. To the north-east of the Horse Creek deposit, coal seams are truncated by erosion, oxidation and the presence of igneous and metamorphic rocks along the eastern margins of the Surat and Clarence–Morton Basins. The coal measures have a shallow dip to the south-west towards the axis of the Mimosa Syncline.

Recent exploration results still rely heavily on the early resource estimates which in many cases are poorly constrained. Most of the 2.56 billion tonne resource was

calculated prior to formalisation of both the Galligan & Mengel (1986) scheme for reporting and the JORC (1999, 2004) guidelines. Some resource estimates have been recalculated using modern modelling techniques and conform to the 1999 JORC guidelines. Despite this inadequacy the Kogan Creek resource has been successfully re-evaluated and exploited, as has the Wilkie Creek resource immediately south of the Chinchilla sheet area. Xstrata Coal also have a high level of confidence in developing the Wandoan resource to the north-west of Chinchilla.

The dramatic increase in global demand for thermal coal has significantly increased exploration interest in the Walloon Subgroup coal measures. Resource estimates will become more tightly constrained, as exploration proceeds to mine development and commercial exploitation. It is anticipated that improved infrastructure access to the Surat Basin will lead to extensive development of open cut coal resources along the eastern margins of the Surat Basin in the Chinchilla area. New technologies, such as underground coal gasification, also offer greater incentives for the exploitation of the high-ash, heterogeneous Walloon coals.

COMPANY EXPLORATION FOR COAL SEAM GAS
(J Hodgkinson)

COAL SEAM GAS RESOURCES

Successful coal seam gas (CSG) exploitation in the Chinchilla sheet area comes from both the underlying Bowen Basin coals and the Surat Basin Walloon Subgroup. The Peat field, operated by Origin Energy, sources gas from the Baralaba Coal Measures in the Permian Bowen Basin. Coal seam permeabilty has been enhanced by fracturing in the hangingwall anticline of the Burunga fault producing high gas flow rates. The Berwyndale and Argyle-Kenya fields in the south-west are operated by Queensland Gas Company and source gas from the perhydrous Jurassic Walloon Subgroup coals.

The total CSG reserves potential for the Chinchilla area is currently unrealised and probably understated, partly due to the differences in policies adopted by the different operators reporting the reserves. Origin currently reports reserves only in the immediate vicinity of a developed field and thus report 91PJ of 2P reserves for the Peat field. Queensland Gas Company use a broader scope and currently report 2P reserves for Berwyndale and Argyle-Kenya of 1371PJ. Origin consider the Walloon coals to potentially host resources of more than 15 000PJ which suggests that currently reported reserves for the Chinchilla sheet area are conservative.

COAL SEAM GAS EXPLORATION

Early exploration for coal seam gas (CSG) in the Chinchilla sheet area targeted the Permian Baralaba Coal Measures of the Bowen Basin underlying the Jurassic

Surat Basin. The first well spudded in the Chinchilla sheet area was Peat-1 in the Peat CSG field located in the north-west. Exploration of CSG potential in the Jurassic Walloon Subgroup coals in the Chinchilla area started with the spudding of Argyle-1 in 2000, by Queensland Gas Company in ATP620. Argyle-1 was followed by a series of appraisal wells and development of the Argyle-Kenya CSG field in the south of the Chinchilla sheet area. The first Berwyndale exploration well was spudded in 2001 with establishment of the field in 2004 in the south-west.

Moonie Oil Pty Ltd and Vamgas Pty Ltd were granted ATP378 in 1986 to explore the CSG potential of the Burunga anticline. The Scotia exploration and appraisal wells were drilled to the north of the Peat field in the adjacent Mundubbera sheet area. Scotia-3 was fracture stimulated and tested in 1997 and Scotia-4 in 1999, along with a 37km seismic survey and associated interpretation. The Scotia gas field now forms the northern extension of the Peat field in the north-west of the Chinchilla sheet area.

ATP519 in the north-west of the Chinchilla sheet area was granted to Anzoil N.L. in 1992. The primary target was for conventional gas potentially trapped in a fractured rock play in the Camboon Andesite. CSG was a secondary target in the Baralaba Coal Measures and the Back Creek Group subcrop. The exploration effort consisted of a detailed airphoto interpretation to assess the structural complexity in the western area of the tenement.

The general conclusion was that ‘late’ uplift and extension would enhance prospectivity for both conventional gas and CSG plays. Anulka N.L. was granted ATP628 covering a similar area to ATP519 in 1996 to explore the potential of the southern Burunga Anticline. Peat wells drilled to the north-west of the tenement had given good CSG flow rates (Peat #2 — 2.5 mmcfd, Peat #3 — 1.27 mmcfd) with CH_4 content of 78.35–98%. Despite promising results the CSG prospects were not considered economical under the prevailing gas market conditions.

ATP525, also in the north-western area, was granted to a joint venture between Pacific Oil and Gas Pty Ltd, Qgas Pty Ltd and GFK Investments Pty Ltd in 1992. Oil Company of Australia (Moura) Ltd. (Origin Energy) acquired the permit in two tranches in 1996 and 2000. The principle CSG exploitation targets for Origin were the Baralaba Coal Measures and the Walloon Subgroup. A possible fractured rock play in the Camboon Andesite was also considered. Origin commissioned an additional seismic survey to bring the total number of lines up to twelve. Relinquished sub-blocks were considered to have low CSG prospectivity due to high overburden stress at depths >1000m or in areas outside the outcrop edge of the coal measures.

A joint venture between TMOC Exploration Pty Ltd. and GFE Resources Ltd. was granted ATP579 in 1994. GFE withdrew from the joint venture in 1995 and TMOC completed an interpretation of the available seismic data. Conclusions drawn from the interpretation indicated a lack of resource potential and TMOC relinquished the ATP in 1996. No drilling was carried out during the period of tenure.

The Walloon Subgroup was a primary target for CSG explorers Starzap Pty Ltd. granted ATP647 in 2001. Queensland Gas Company acquired the tenure in the same year and drilled the Andrew-1 and 2 exploration wells which indicated CSG potential. Fifty percent of the tenement in the west was relinquished as per the conditions of tenure renewal. Although relinquished, the area was considered likely to have good CSG prospectivity.

ATP676 covering almost 50% of the Chinchilla sheet area was granted to Australian CBM Pty Ltd (ACBM). The permit covered several established open cut coal resources in the Walloon Subgroup and extended south into the Dalby sheet area covering the Wilkie Creek resource. ACBM later became a wholly owned subsidiary of Arrow Energy N.L. Exploration drilling was focused in the south and south-west of the ATP with several sub-blocks relinquished along the north-east boundary. This part of the area was considered to lack potential due to its location along the outcrop/subcrop limit of the coal measures. The producing Daandine and Kogan fields were subsequently established immediately south of the Chinchilla sheet area boundary, close to the Wilkie Creek resource.

SUMMARY OF COAL SEAM GAS RESOURCES

Coal seam gas exploration and commercialisation from both the Permian Baralaba Coal Measures and the Jurassic Walloon Subgroup, exploded in the early 21st Century. A weak gas market in the 1980s and early 90s precluded exploitation despite promising exploration results.

The Peat field established in the Baralaba Coal Measures north-west of Chinchilla relies heavily on enhanced permeability due to fracturing in the hanging wall anticline of the Burunga fault. The Walloon coals of the Berwyndale and Argyle-Kenya fields are much ‘tighter’ but the perhydrous nature of the Jurassic coal measures produces commercial quantities of gas.

An accurate estimate of the total coal seam gas resource for the Chinchilla sheet area is as yet unrealised. Queensland Gas Company currently quote 1371 PJ of 2P reserves for the Berwyndale and Argyle-Kenya fields in the Walloon Subgroup (as at February 2008) and intend to ramp up to 7000 PJ. Origin Energy report reserves immediately adjacent to the production well and, therefore, publish low reserve estimates for the Peat field in the Baralaba Coal Measures.

SUMMARY OF EXPLORATION METHODS

Table 1: EPC, ATP, EPM company exploration report summary

TENURE	LOCALITY	TENURE HOLDER	EXPLORATION TECHNIQUE	COMMODITY	REPORT NO
EPC39	NE of Chinchilla	EXOIL NL TRANSOIL NL	drilling log correlation mapping	coal	2333
EPC77	SE of Chinchilla	EXOIL NL TRANSOIL NL	drilling	coal	3700
EPC102	Central Chinchilla	BRIGALOW MINES PTY LTD LONE STAR EXPLORATION NL	drilling	coal	5025
EPC103	SE of Chinchilla	GLOBAL MINERALS PTY LTD	drilling logging laboratory analysis	coal	4203 3923
EPC105	NW of Chinchilla	GLOBAL MINERALS PTY LTD	drilling logging proximate analysis	coal	4205 4542 5038
EPC125	NW of Chinchilla	EXOIL NL TRANSOIL NL PETROMIN NL	drilling logging	coal	4525 4879
EPC133	SE of Chinchilla	MINES ADMINISTRATION PTY LTD	drilling logging laboratory analysis	coal	4942
EPC138	NW of Chinchilla	BRIGALOW MINES PTY LTD	photogrammetric mapping drilling	coal	13639
EPC150	S and W of Chinchilla	BRIGALOW MINES PTY LTD	drilling geophysical logging log correlation	coal	13641
EPC155	SE of Chinchilla	OILMIN NL TRANSOIL NL	drilling logging	coal	5841
EPC156	NW of Chinchilla	SHELL DEVELOPMENT (AUSTRALIA) PTY LTD OILMIN NL TRANSOIL NL PETROMIN NL	drilling logging geophysical logging log correlation	coal	7998
EPC161	NW of Chinchilla	MINERAL DEPOSITS LTD	desktop study	coal	4951
EPC162	N of Chinchilla	SHELL DEVELOPMENT (AUSTRALIA) PTY LTD OILMIN NL TRANSOIL NL PETROMIN NL	drilling logging geophysical logging laboratory analyses	coal	5804
EPC181	SE of Chinchilla	SHELL DEVELOPMENT (AUSTRALIA) PTY LTD OILMIN NL TRANSOIL NL PETROMIN NL	drilling logging geophysical logging laboratory analyses	coal	5937

Table 1 (continued)

TENURE	LOCALITY	TENURE HOLDER	EXPLORATION TECHNIQUE	COMMODITY	REPORT NO
EPC210	N of Chinchilla	OILMIN NL TRANSOIL NL PETROMIN NL	drilling logging	coal	6521
EPC223	NW of Chinchilla	SHELL COMPANY OF AUSTRALIA LTD OILMIN NL TRANSOIL NL PETROMIN NL	drilling logging geophysical logging log correlation	coal	8411
EPC254	NE of Chinchilla	NEW HOPE COLLIERIES PTY LTD	mapping drilling logging geophysical logging	coal	7819
EPC255	N of Chinchilla	MARATHON PETROLEUM AUSTRALIA LTD	drilling logging geophysical logging log correlation	coal	12202
EPC262	SE of Chinchilla	MOBIL ENERGY MINERALS AUSTRALIA	drilling logging	coal	9753 11142
EPC270	SE of Chinchilla	AGIP AUSTRALIA PTY LTD MOBIL ENERGY MINERALS AUSTRALIA	drilling logging geophysical logging laboratory analyses	coal	12822
EPC309	NW of Chinchilla	GRIFFIN COAL MINING COMPANY LTD	drilling logging geophysical logging laboratory analyses	coal	12405
EPC310	NE of Chinchilla	BP AUSTRALIA LTD	drilling logging geophysical logging	coal	9499
EPC312	NW of Chinchilla	SHELL COMPANY OF AUSTRALIA LTD OILMIN NL TRANSOIL NL PETROMIN NL	drilling logging geophysical logging laboratory analyses petrophysical modelling	coal	13155 16578
EPC322	E of Chinchilla	BP AUSTRALIA LTD	drilling logging geophysical logging	coal	9754
EPC326	NW of Chinchilla	PACIFIC COAL PTY LTD	mapping drilling logging geophysical logging laboratory analyses	coal	11557
EPC328	SW of Chinchilla	MARATHON PETROLEUM AUSTRALIA LTD	drilling logging geophysical logging laboratory analyses geotechnical	coal	12272
EPC356	NE of Chinchilla	GRIFFIN COAL MINING COMPANY LTD	drilling logging geophysical logging	coal	10355
EPC383	SE of Chinchilla	MARATHON PETROLEUM AUSTRALIA LTD	drilling logging geophysical logging	coal	11987

Table 1 (continued)

TENURE	LOCALITY	TENURE HOLDER	EXPLORATION TECHNIQUE	COMMODITY	REPORT NO
EPC401	SE of Chinchilla	OILMIN NL TRANSOIL NL	drilling logging	coal	15955
EPC411	NE and SW of Chinchilla	MARATHON PETROLEUM AUSTRALIA LTD	drilling logging geophysical logging laboratory analyses	coal	15796
EPC413	SE of Chinchilla	MARATHON PETROLEUM AUSTRALIA LTD	drilling logging geophysical logging	coal	15797 14923
EPC422	NW of Chinchilla	MOBIL ENERGY MINERALS AUSTRALIA	drilling logging geophysical logging	coal	16035
EPC428	SE of Chinchilla	BHP MINERALS MOBIL ENERGY MINERALS AUSTRALIA	drilling logging geophysical logging resource modelling	coal	16642
EPC431	SW of Chinchilla	SURAT COAL JOINT VENTURE	mapping airphoto interpretation drilling logging	coal	19226
EPC465	SE of Chinchilla	ALLIED QUEENSLAND COALFIELDS PTY LTD	drilling logging geophysical logging resource modelling	coal	33200
EPC635	S of Chinchilla	LINC ENERGY LTD	drilling logging geophysical logging laboratory analyses	coal	38471
EPC637	SE of Chinchilla	TARONG ENERGY CORPORATION LTD	desktop study	coal	37542
EPC640	NW of Chinchilla	RIBFIELD PTY LTD	desktop study	coal	32038
EPC732	NW of Chinchilla	SYNTECH RESOURCES PTY LTD	drilling logging resource evaluation	coal	38909
EPC760	SE of Chinchilla	NEW HOPE EXPLORATION PTY LTD	desktop study project database resource modelling	coal	39151
EPC787	NW of Chinchilla	XSTRATA COAL QUEENSLAND PTY LTD	desktop study drilling logging mini-sosie trial regional correlation acquisition of satellite data	coal	42772
EPC792	NW of Chinchilla	XSTRATA COAL QUEENSLAND PTY LTD	desktop study drilling logging mini-sosie trial regional correlation acquisition of satellite data	coal	42777
EPC796	N of Chinchilla	AQUILA COAL PTY LTD BOWEN CENTRAL COAL PTY LTD	desktop study	coal	39872

Table 1 (continued)

TENURE	LOCALITY	TENURE HOLDER	EXPLORATION TECHNIQUE	COMMODITY	REPORT NO
EPC838	NW of Chinchilla	XSTRATA COAL QUEENSLAND PTY LTD	desktop study drilling logging photogeological study regional correlation acquisition of satellite data	coal	47691
EPC869	S of Chinchilla	CARBON ENERGY PTY LTD	desktop study	coal	45416
EPC873	SW of Chinchilla	ECARLATE PTY LTD	desktop study	coal	44649
EPC897	SE of Chinchilla	LINC ENERGY	desktop study	coal	49476
EPC898	SE of Chinchilla	LINC ENERGY	desktop study	coal	49477
EPC918	SE of Chinchilla	NEW HOPE EXPLORATION PTY LTD	desktop study conceptual modelling	coal	49430
ATP519P	NW of Chinchilla	MOONIE OIL PTY LTD VAMGAS PTY LTD	mapping drilling logging seismic survey reservoir modelling	coal seam gas	33460
ATP519P	NW of Chinchilla	ANZOIL NL	photogeological study fracture density mapping	coal seam gas	24509
ATP525P	NW of Chinchilla	OIL COMPANY OF AUSTRALIA LTD	mapping drilling logging seismic survey	coal seam gas	33736
ATP579P	W of Chinchilla	TMOC EXPLORATION PTY LTD GFE RESOURCES LTD	seismic interpretation subcrop mapping	coal seam gas	29718
ATP628P	NW of Chinchilla	ANULKA NL	desktop study gas testing	coal seam gas	29852
ATP647P	SW of Chinchilla	QUEENSLAND GAS COMPANY LTD	desktop study	coal seam gas	45440
ATP676P	surrounding Chinchilla	AUSTRALIAN CBM PTY LTD (ARROW ENERGY NL)	desktop study	coal seam gas	49134
EPM 77	WNW of Chinchilla	QLD MINERALS PTY LTD	na	gypsum	na
EPM 326	N of Chinchilla	MINES ADMINISTRATION PTY LTD	mapping geochemical exploration mineral exploration placer deposits assay value ore reserves bulk sampling	tin	1997 2024

Table 1 (continued)

TENURE	LOCALITY	TENURE HOLDER	EXPLORATION TECHNIQUE	COMMODITY	REPORT NO
EPM 555	NW of Chinchilla	MINERAL DEPOSITS LTD	mineral exploration geological logs drilling	bentonite clay	2848 3024 3383 3458 4148 4212 4284 4552
EPM 665	Monto	PECHINEY (AUST) EXPLORATION PTY LTD	geophysical anomalies auger drilling mineral exploration geophysical surveys aerial photography aerial radioactivity surveys petrology geology	uranium	2977
EPM 1568	NW of Miles	GIBBES, J. NEWTON, L. T. NEWTON, L. V. RICHARDS, L. J. CLIFT, J.J. HANSEN, A.C.	structural geology surficial geology drilling stratigraphy mineral exploration	bentonite	6333
EPM 1773	N of Drillham	CUDGEN RUTILE (NOS 1 & 2) PTY LTD	rotary drilling mineral exploration core sampling sedimentary ores laboratory tests drill cuttings	bentonite	6349 7158
EPM 2080	na	CUDGEN R.Z. LTD	na	na	na
EPM 2171	Miles	FW KELLY PTY LTD	geological mapping mineral exploration laboratory tests rotary drilling	bentonite kaolin	9525
EPM 2767 EPM 2768 EPM 2769 EPM 2770	Wandoan	BRIGALOW MINES PTY LTD RIO GRANDE LTD	mineral exploration geophysical logs photogeology geological logs drilling	coal oil shale	10726
EPM 2790	N of Dalby	DAMPIER MINING CO LTD	gravity surveys mineral exploration literature reviews	oil shale	9981
EPM 3097	S of Wandoan	CLIFT, J.J. SINCLAIR, W.D.	mineral exploration auger drilling diamond drilling percussion drilling	bentonite ilmenite monazite rutile zircon	10056
EPM 3186	S of Miles	F.W. KIELY PTY LTD	mineral exploration geological mapping rotary drilling	bentonite oil shale	10901
EPM 3200	NW of Chinchilla	SOUTH PINE MINES PTY LTD	geological logs drilling analysis literature reviews mineral exploration	oil shale	10740

Table 1 (continued)

TENURE	LOCALITY	TENURE HOLDER	EXPLORATION TECHNIQUE	COMMODITY	REPORT NO
EPM 3366	Wandoan	SINCLAIR W.D.	mineral exploration sediments auger drilling drill cuttings sampling	bentonite	13137, 14151
EPM 3484	NNW of Miles	CUDGEN RUTILE (NOS 1 & 2) PTY LTD	literature reviews geological logs photo-interpretation mineral exploration percussion drilling reconnaissance assaying	bentonite	13748 14913 20879
EPM 3489 EPM 3490	NW of Proston SW of Eidsvold	RENISON LTD	reconnaissance panning geochemical exploration rock chip sampling mineral exploration	molybdenum tin tantalum tungsten	12748 13057 13672
EPM 4303	SSW of Mundubbera	RENISON LTD	stream sediment sampling mineral exploration trenching magnetic surveys geophysical surveys assay value diamond drilling geological mapping rock chip sampling geochemical exploration soil sampling	gold	17277, 17553, 21913
EPM 4576	SW of Eidsvold	DOMINION GOLD OPERATIONS PTY LIMITED	geochemical exploration mineral exploration literature reviews assay value gold exploration base metal exploration rock chip sampling	silver gold calcite copper quartz	18570 18755 18757 19717
EPM 4821	S of Mundubbera	PEKO-WALLSEND OPERATIONS LTD	leaching stream sediment sampling mineral exploration landsat bulk sampling assay value photogeology geological mapping grab sampling rock chip sampling geochemical exploration reconnaissance	silver gold copper lead zinc	17556
EPM 5506	NW of Miles	CUDGEN RZ LIMITED	mineral exploration laboratory tests drilling geochemical exploration photogeological maps mapping reconnaissance	bentonite	19756 20980 23035 23637

Table 1 (continued)

TENURE	LOCALITY	TENURE HOLDER	EXPLORATION TECHNIQUE	COMMODITY	REPORT NO
EPM 5507	SSE of Miles	CUDGEN RZ LIMITED	reconnaissance mineral exploration photogeology photo-interpretation	bentonite	19570
EPM 5771	SSW of Mundubbera	RENISON LTD	assay value core logs geochemical exploration stream sediment sampling mineral exploration IP surveys reconnaissance rock chip sampling resistivity surveys bulk sampling geophysical surveys diamond drilling leaching	silver gold copper lead zinc	21573
EPM 6843	SE of Miles	CUDGEN RZ LTD	rotary drilling mineral exploration geochemical exploration	bentonite	21527 22386
EPM 7069	WNW of Kingaroy	BENNETT, WILLIAM ARTHUR BATTILANA, WILLIAM GEORGE TURNER, MAXWELL & TURNER, CHRISTOPHER MAXWELL	assay value mineral exploration assaying geochemical exploration core drilling drill cuttings analysis diamond drilling	gold copper lead zinc	23668 23774
EPM 8222	NW of Miles	WALTON, JOHN COLIN & WALTON, MICHAEL JOHN	mineral exploration geological mapping reconnaissance	bentonite	24174
EPM 8613 EPM 8614 EPM 8615	NE of Wandoan	BHP MINERALS LTD	leaching stream sampling mineral exploration tenement maps rock chip sampling geochemical exploration chemical analysis literature reviews bulk sampling sample location maps assaying	gold copper lead zinc	23491
EPM 8692	W of Kingaroy	CONSOLIDATED RUTILE LTD	core logs RC drilling geochemical exploration assaying mineral exploration assay value literature reviews	ilmenite rutile zircon	24179

Table 1 (continued)

TENURE	LOCALITY	TENURE HOLDER	EXPLORATION TECHNIQUE	COMMODITY	REPORT NO
EPM 9616	SSW of Mundubbera	TORBANLEA PROSPECTORS PTY LTD	geological mapping rock chip sampling assay value geochemical exploration percussion drilling mineral exploration assaying base maps literature reviews	gold	26592 27415
EPM 9684	SE of Miles	BONAFORD PTY LTD ROCK-EX ENTERPRISES PTY LTD	rock chip sampling drilling stratigraphy laboratory tests reconnaissance X-ray diffraction geochemical exploration mineral exploration base maps geological mapping literature reviews photogeology photo-interpretation	bentonite	26165
EPM 10048 EPM 10049	S of Mundubbera	BHP MINERALS PTY LTD	drilling rock chip sampling sample location maps sampling geochemical exploration percussion drilling bulk sampling geological maps pits chemical analysis petrology	diamond	26981 27887
EPM 10192	N of Dalby	AUSTRALIAN KIMBERLEY DIAMONDS NL	indicator minerals mineralogy auger drilling photo-interpretation heavy mineral sampling geological mapping aerial photography mineral exploration geomorphology geochemical exploration stream sediment sampling literature reviews landsat	diamond	27009 28169 29615

Table 1 (continued)

TENURE	LOCALITY	TENURE HOLDER	EXPLORATION TECHNIQUE	COMMODITY	REPORT NO
EPM 10633	SE of Miles	INTERNATIONAL EXPLORATION SERVICES PTY LTD JOHN KENNY	geological mapping literature reviews mineral exploration laboratory tests sampling geochemical exploration stream sampling reconnaissance	bentonite	27840
EPM 10816	SE of Chinchilla	BOHDAN BURBAN	drilling mineral exploration geochemical exploration drill cuttings analysis rotary drilling base maps	clay	27677
EPM 11081	W of Kingaroy	BUNYA RESOURCES PTY LTD	sampling mineral processing market research geological mapping geochemical exploration mineralogy rock chip sampling reconnaissance sample location maps petrology mineral exploration literature reviews	feldspar	29378
EPM 13365	NW of Kingaroy	POCOCK, ELAINE FRANCES, BENNETT, WILLIAM ARTHUR, BATTILANA, WILLIAM GEORGE	mineral exploration base maps drilling assaying laboratory tests assay value	platinum	37349
EPM 13410	WSW of Kingaroy	RIO TINTO EXPLORATION PTY LIMITED	mineral exploration reconnaissance tenement maps geological maps aerial geophysical surveys aerial magnetic surveys data processing geophysical interpretation geochemical exploration rock chip sampling soil sampling assaying assay value auger drilling petrology sample location maps	ilmenite rutile	33796 33797

Table 1 (continued)

TENURE	LOCALITY	TENURE HOLDER	EXPLORATION TECHNIQUE	COMMODITY	REPORT NO
EPM 13506	NW of Kingaroy	SOUTH EAST DIAMONDS NL	ground magnetic surveys data processing geophysical interpretation geophysical surveys geochemical exploration soil sampling indicator minerals petrology literature reviews assaying assay value mineralogy mineral exploration geological mapping remote sensing landsat regional geology	diamond	34091 34357 36614
EPM 13877	NNE of Chinchilla	PARADIGM QUEENSLAND PTY LTD	mineral exploration stream sediment sampling literature reviews reconnaissance assaying assay value regional geology imagery geological mapping sample location maps geochemical anomalies	COPPER ZINC	37244 38813
EPM 15120	N of Dalby	SUPERIOR RESOURCES LTD	mineral exploration data processing aerial magnetic surveys aerial radioactivity surveys soil sampling rock chip sampling regional geology assay value assaying geological mapping	uranium	43676

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APPENDIX

Location of EPMs, EPCs and ATPs

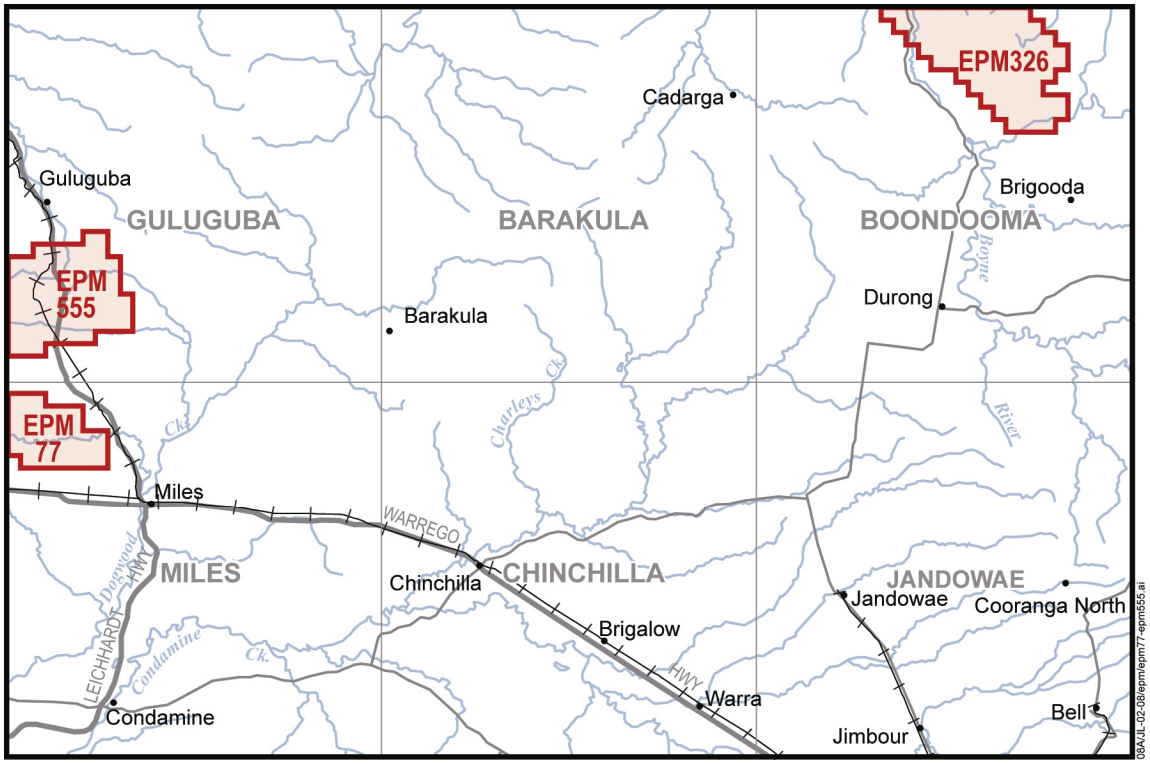

Figure 11: EPM 77 – EPM 555

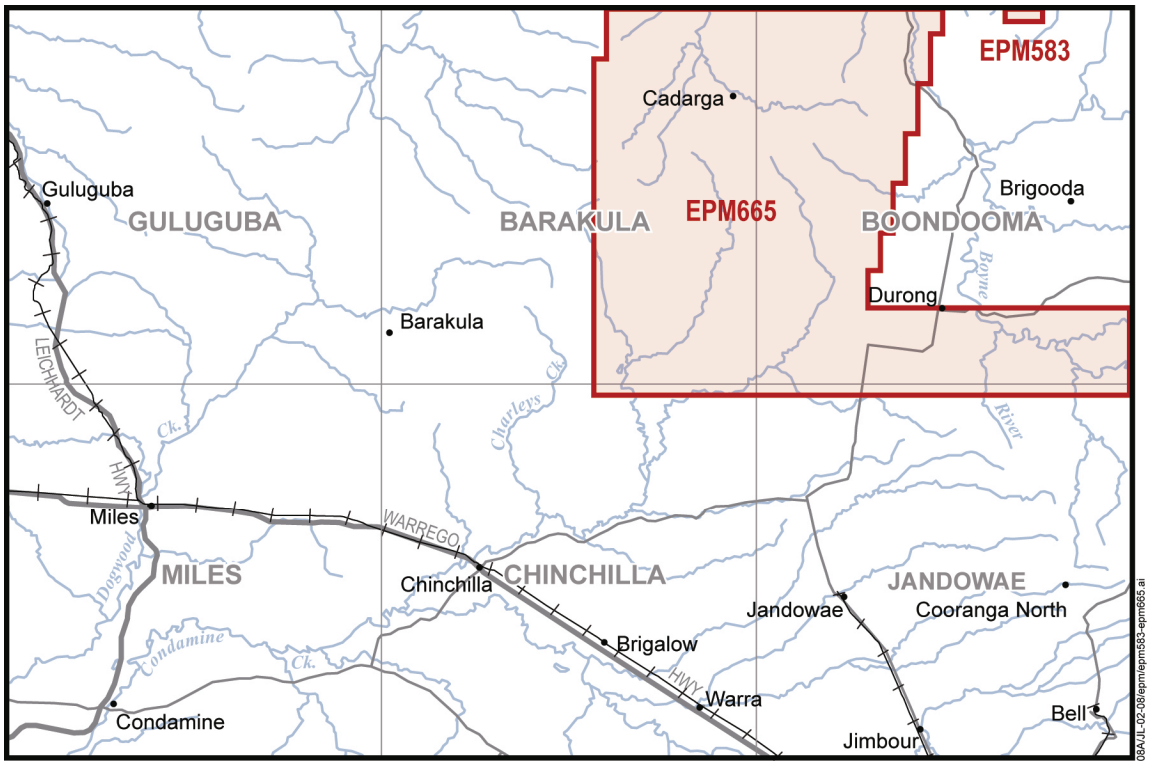

Figure 12: EPM 583 – EPM 665

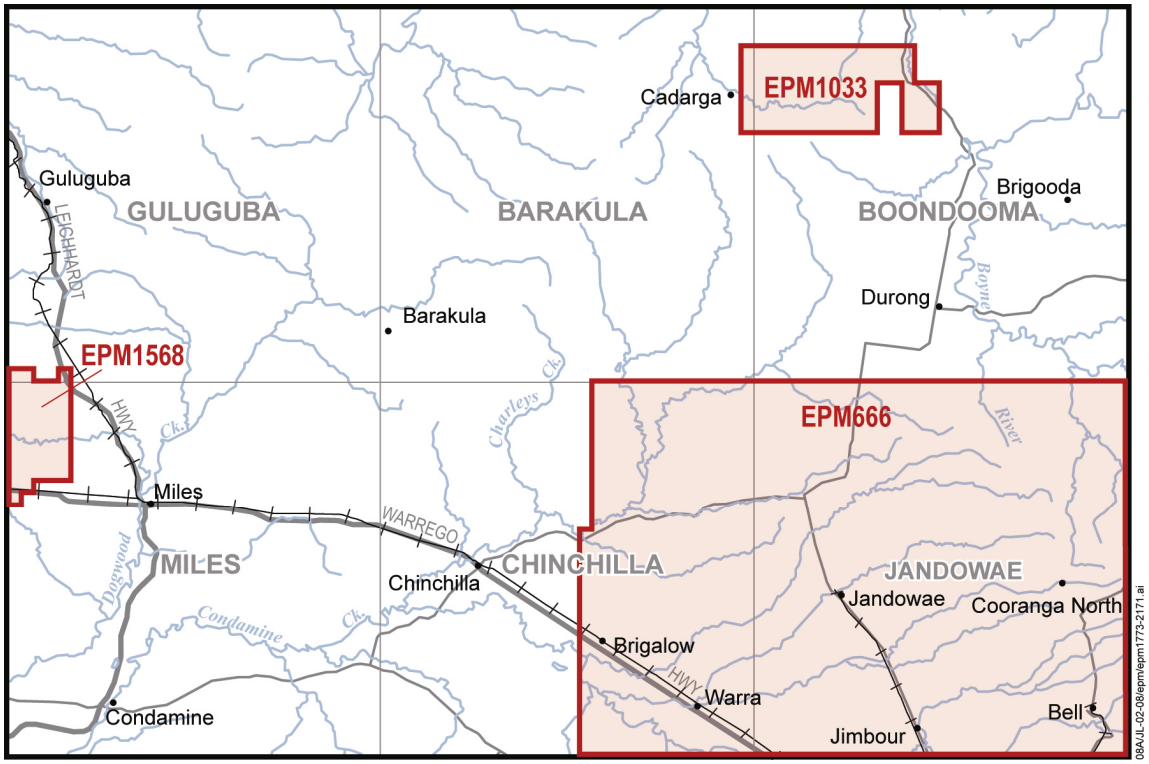

Figure 13: EPM 666 – EPM 1568

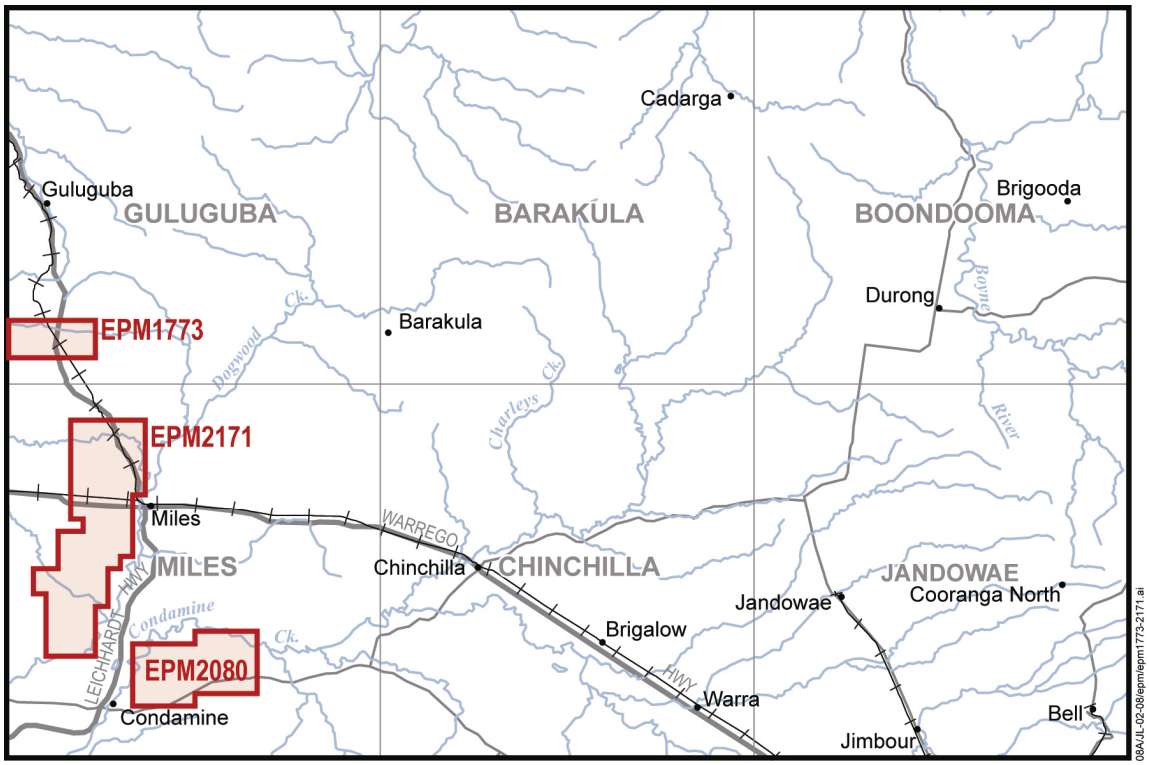

Figure 14: EPM 1773 – EPM 2171

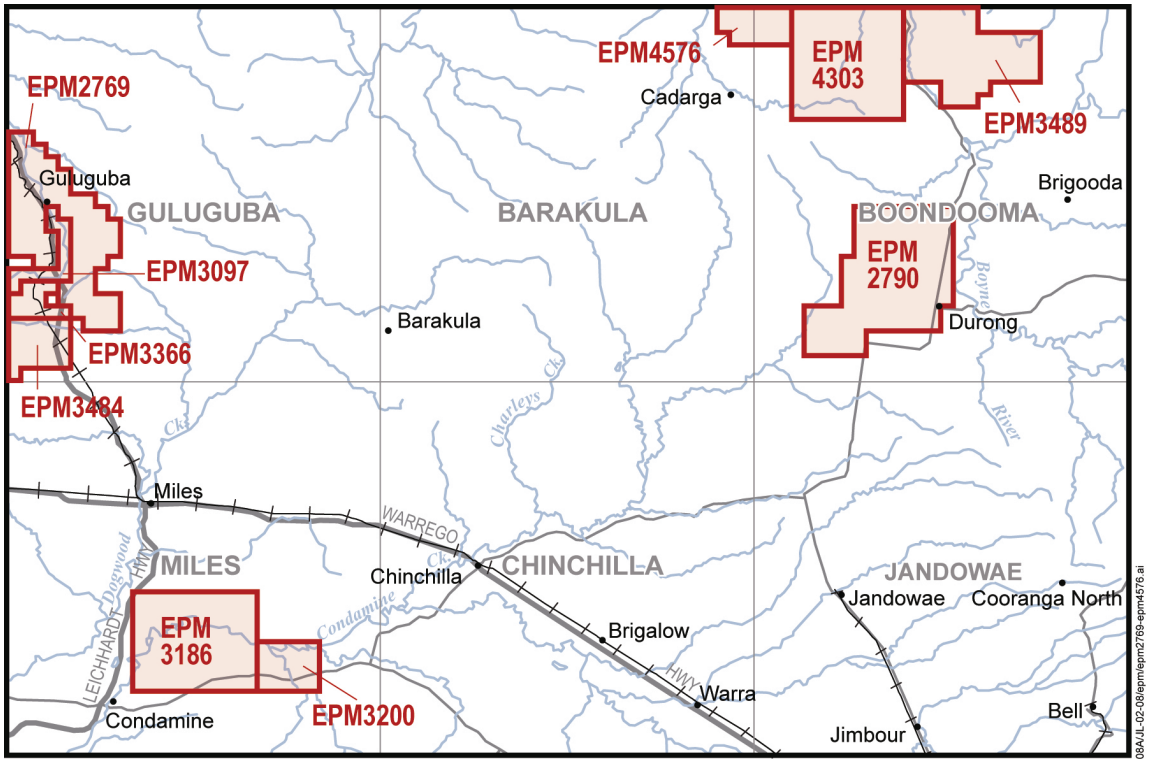

Figure 15: EPM 2769 – EPM 4576

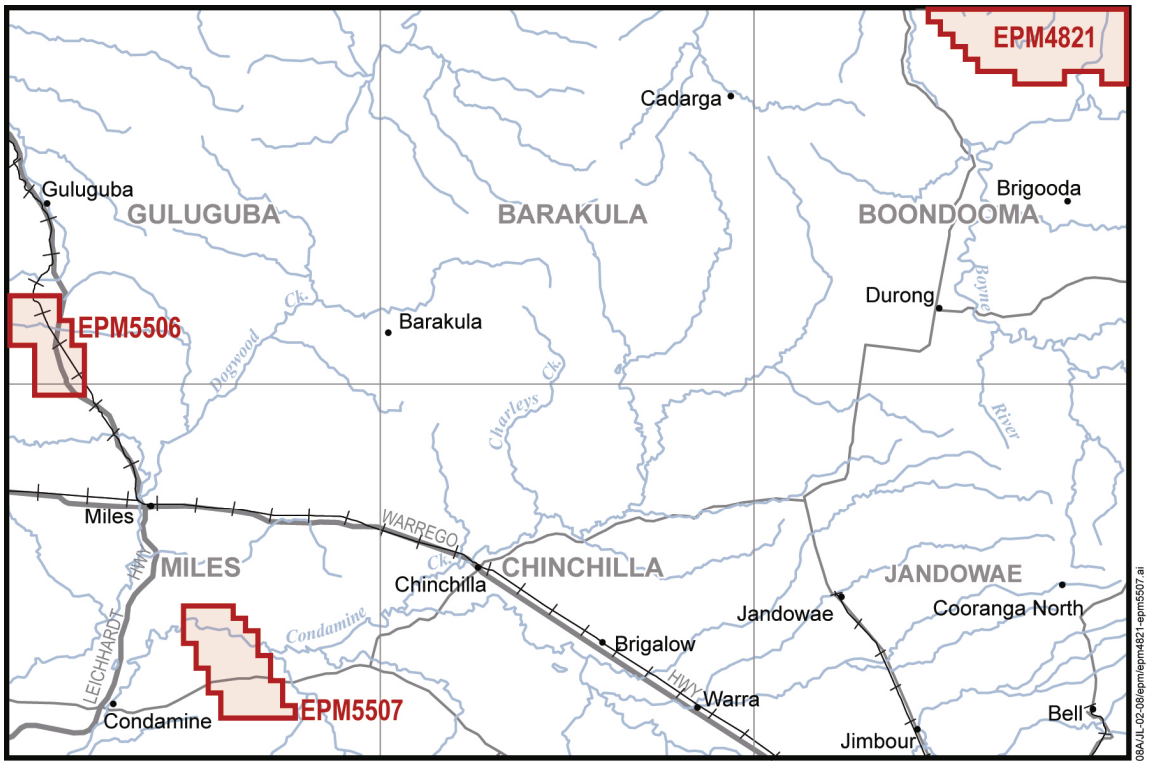

Figure 16: EPM 4821 – EPM 5507

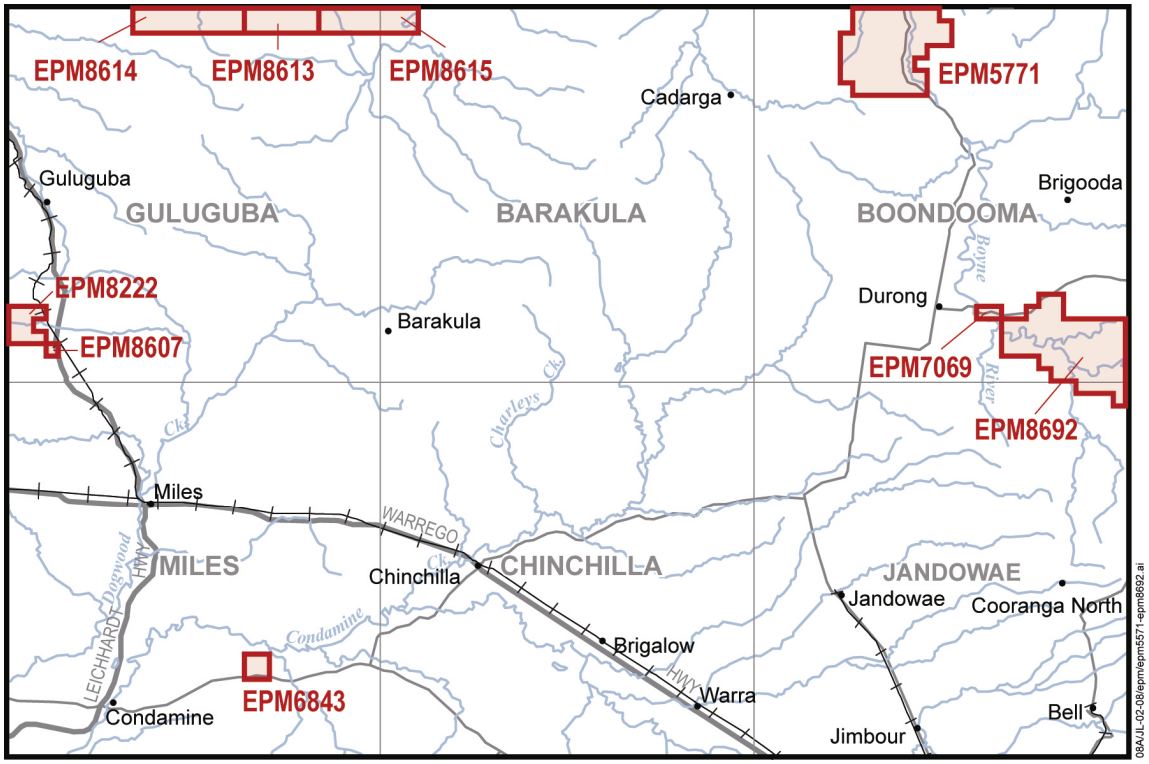

Figure 17: EPM 5771 – EPM 8692

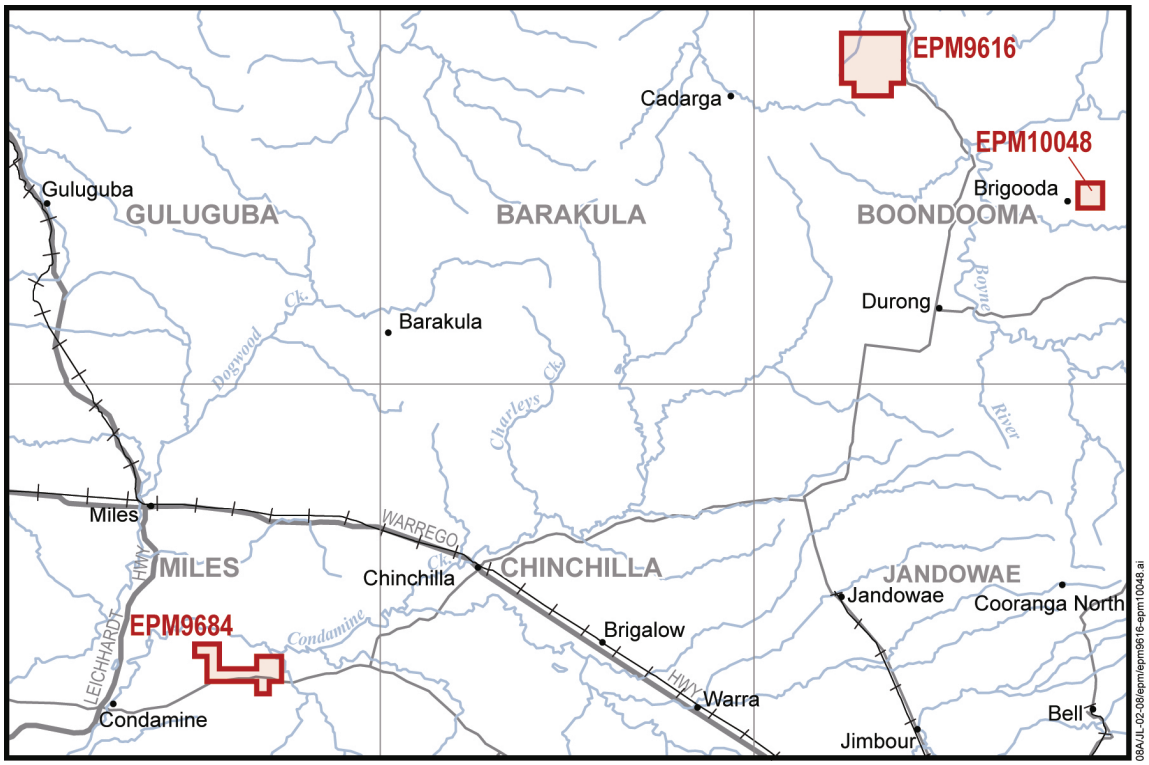

Figure 18: EPM 9616 – EPM 10048

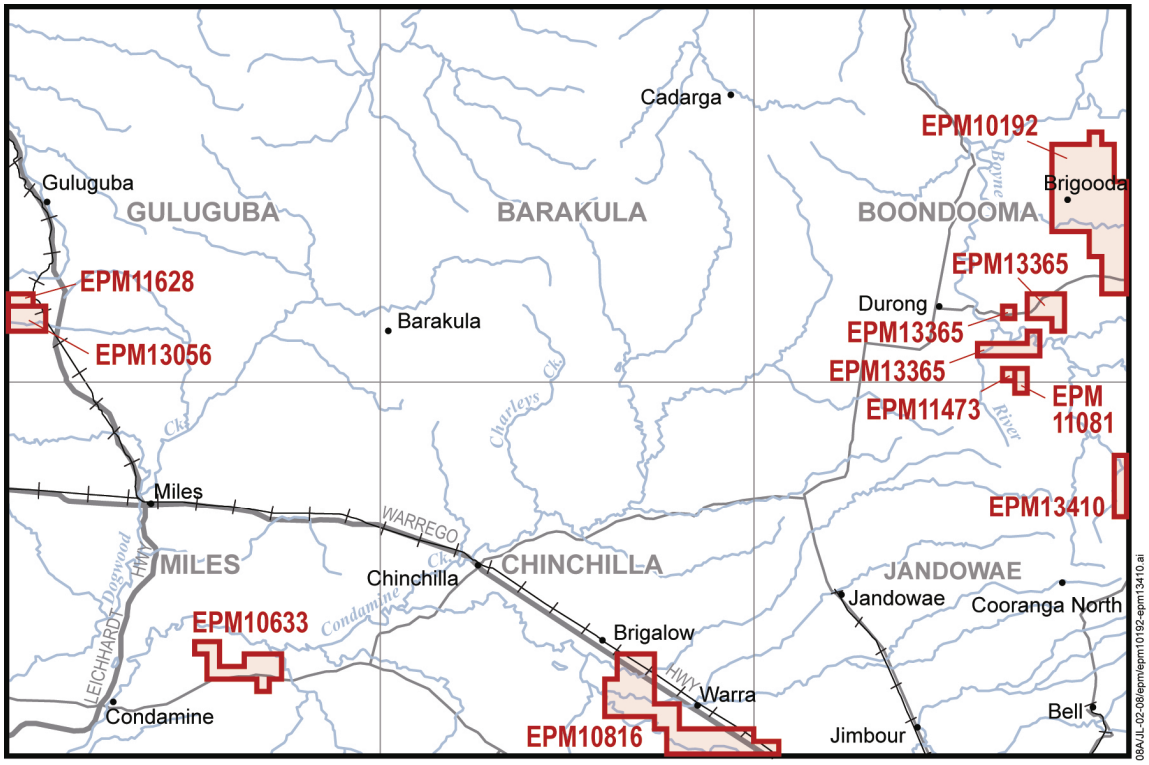

Figure 19: EPM 10192 – EPM 13410

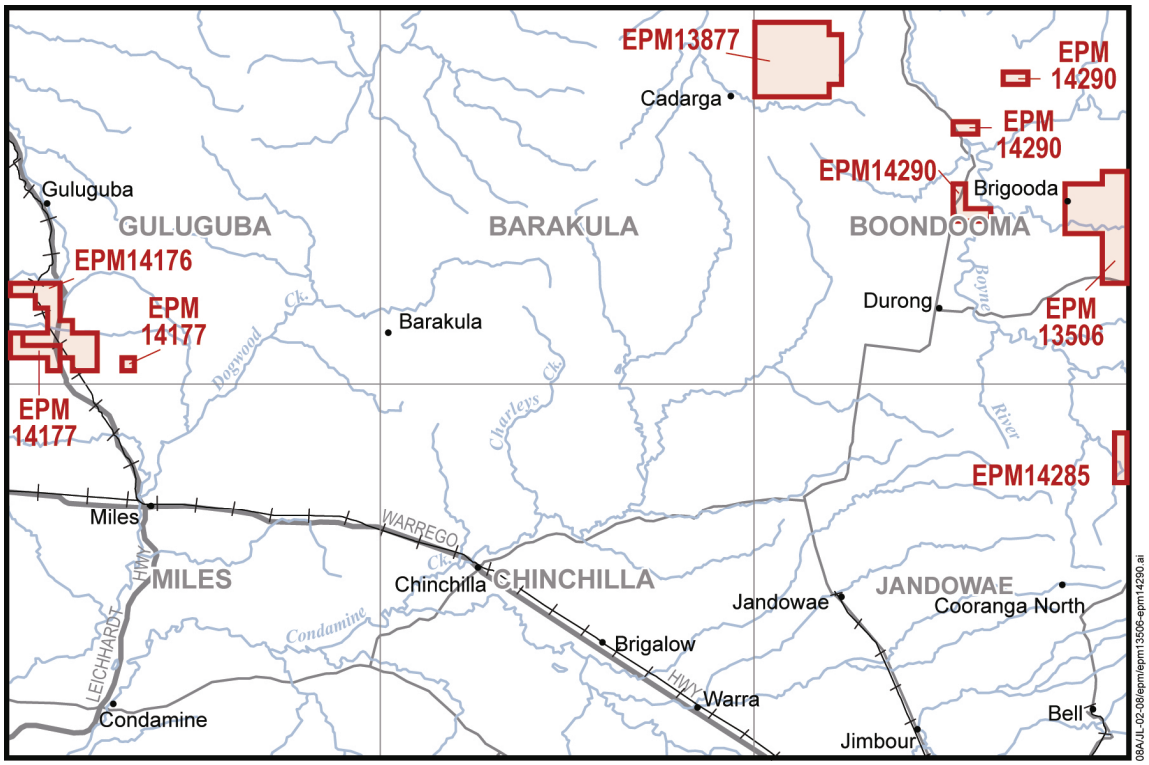

Figure 20: EPM 13506 – EPM 14290

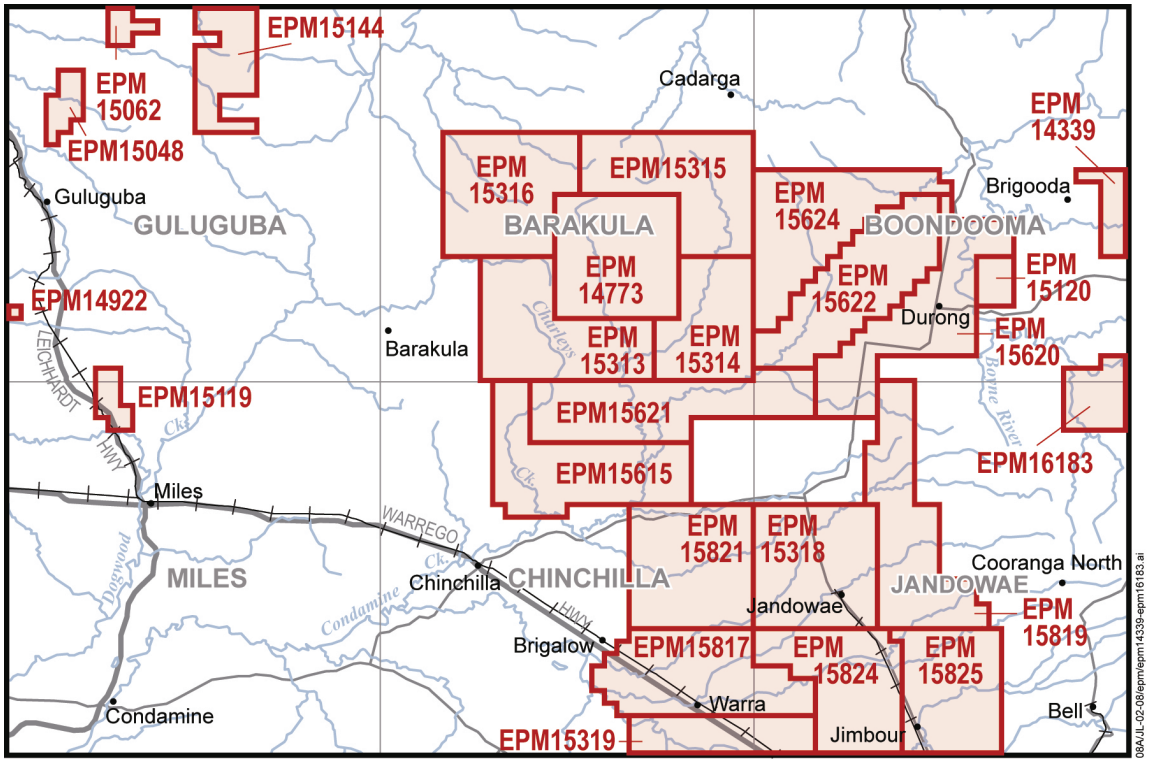

Figure 21: EPM 14339 – EPM 16183

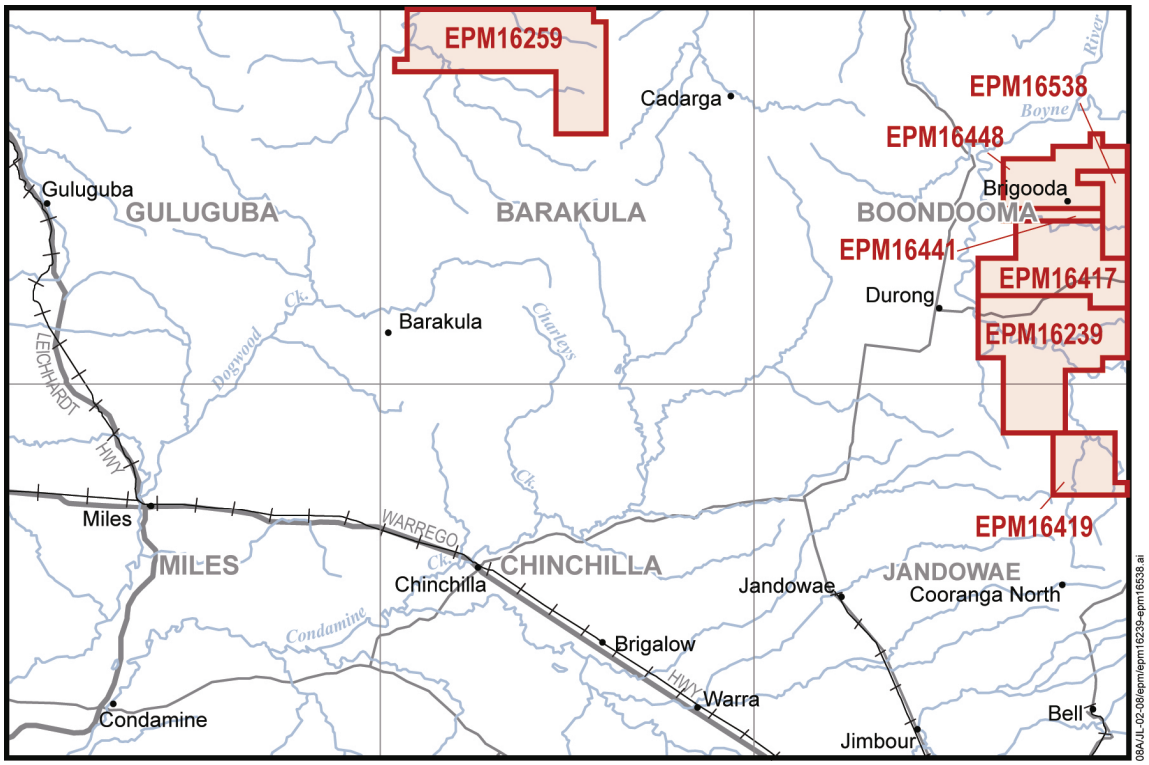

Figure 22: EPM 16239 – EPM 16538

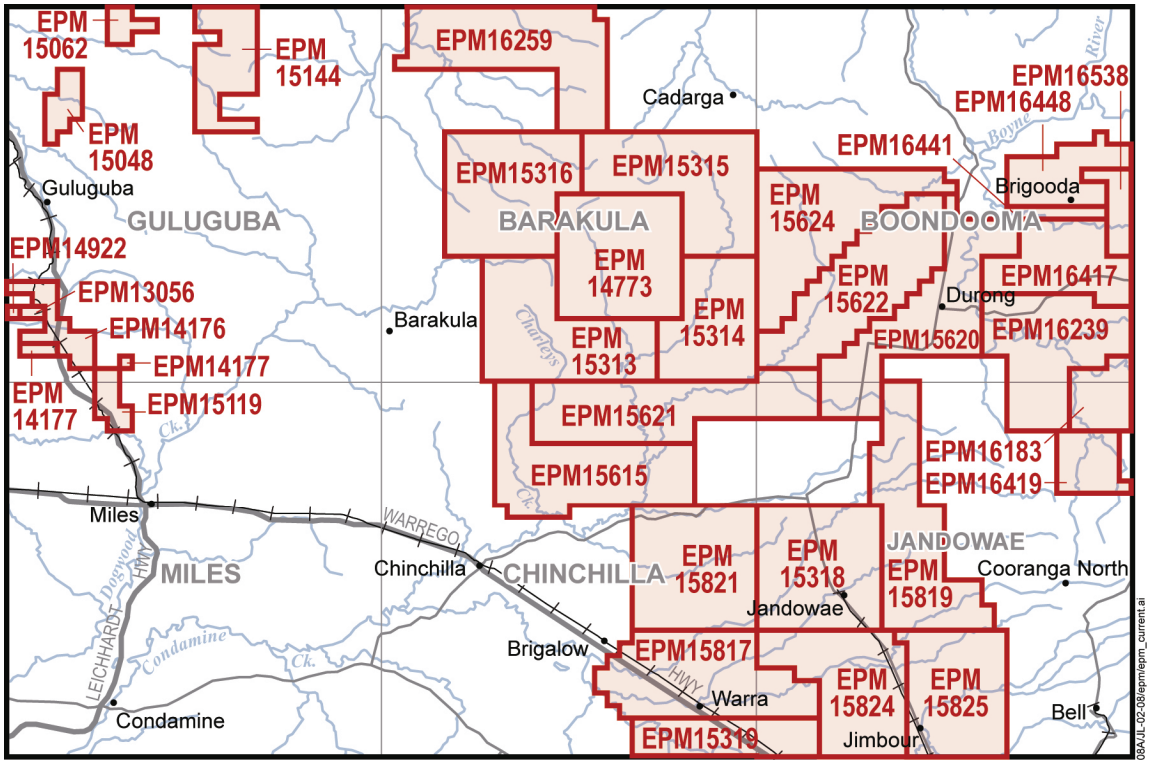

Figure 23: Current EPM 13056 – EPM 16538

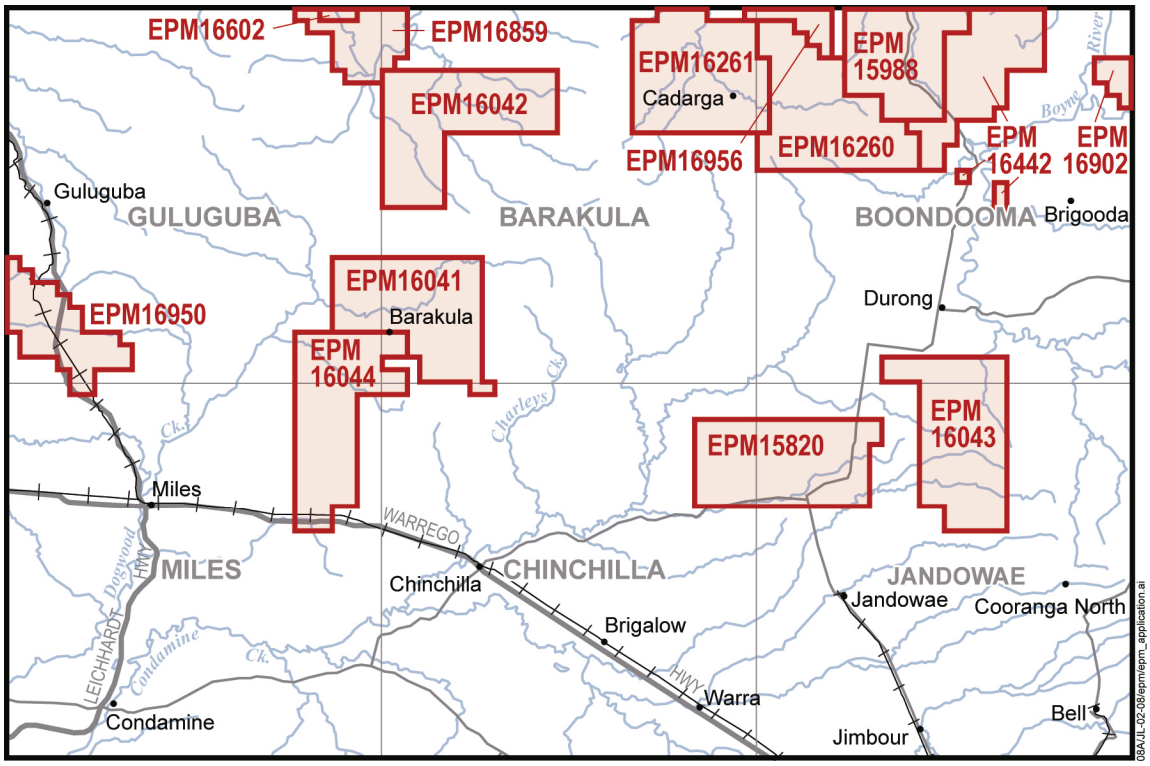

Figure 24: Application EPM 15820 – EPM 16950

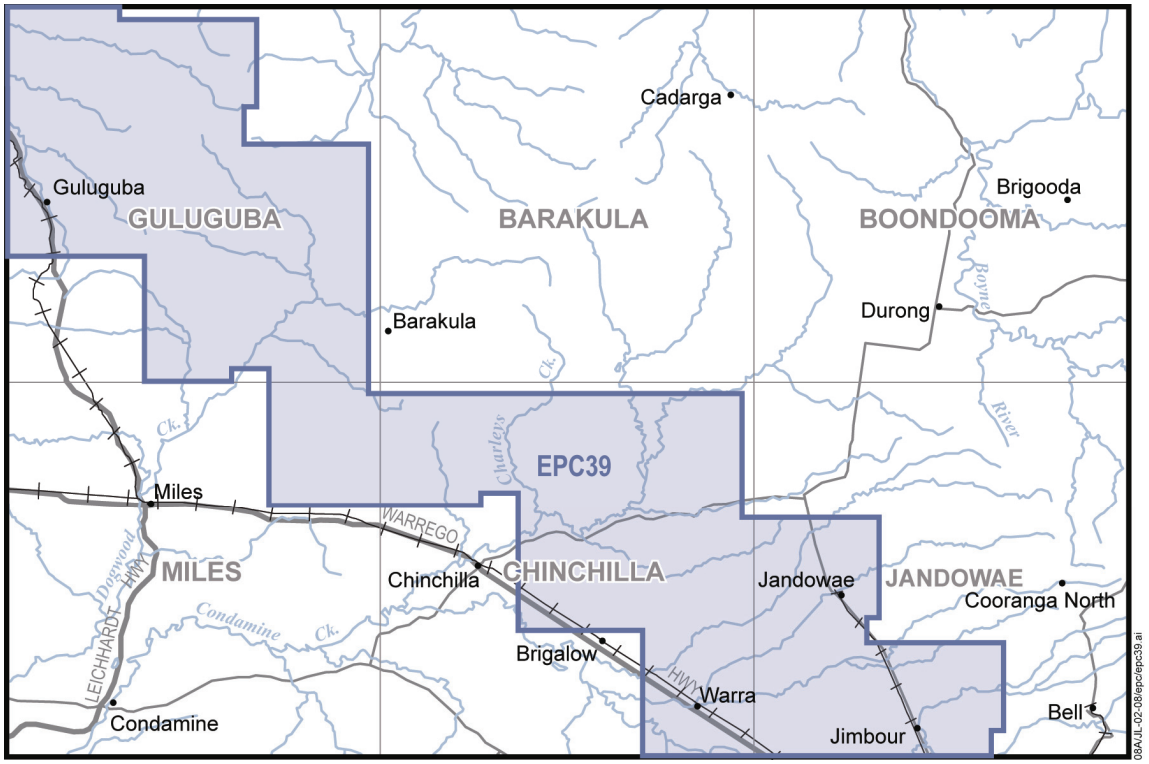

Figure 25: EPC 39

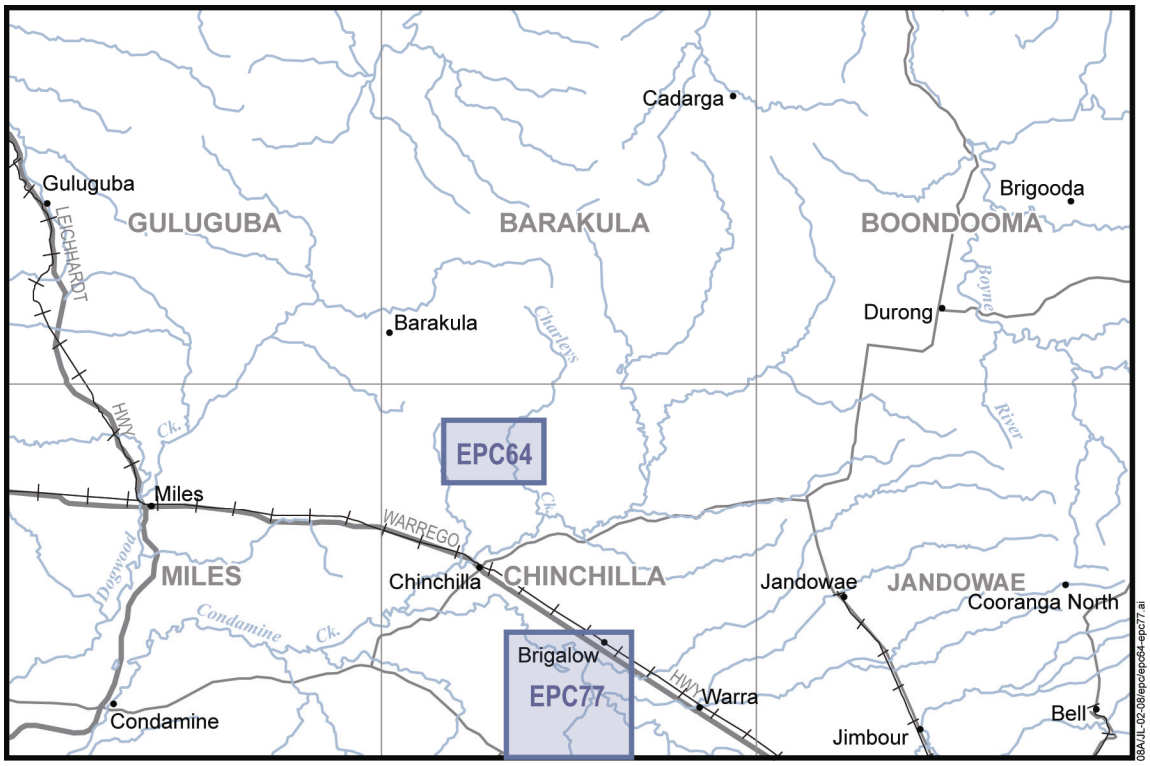

Figure 26: EPC 64 – EPC 77

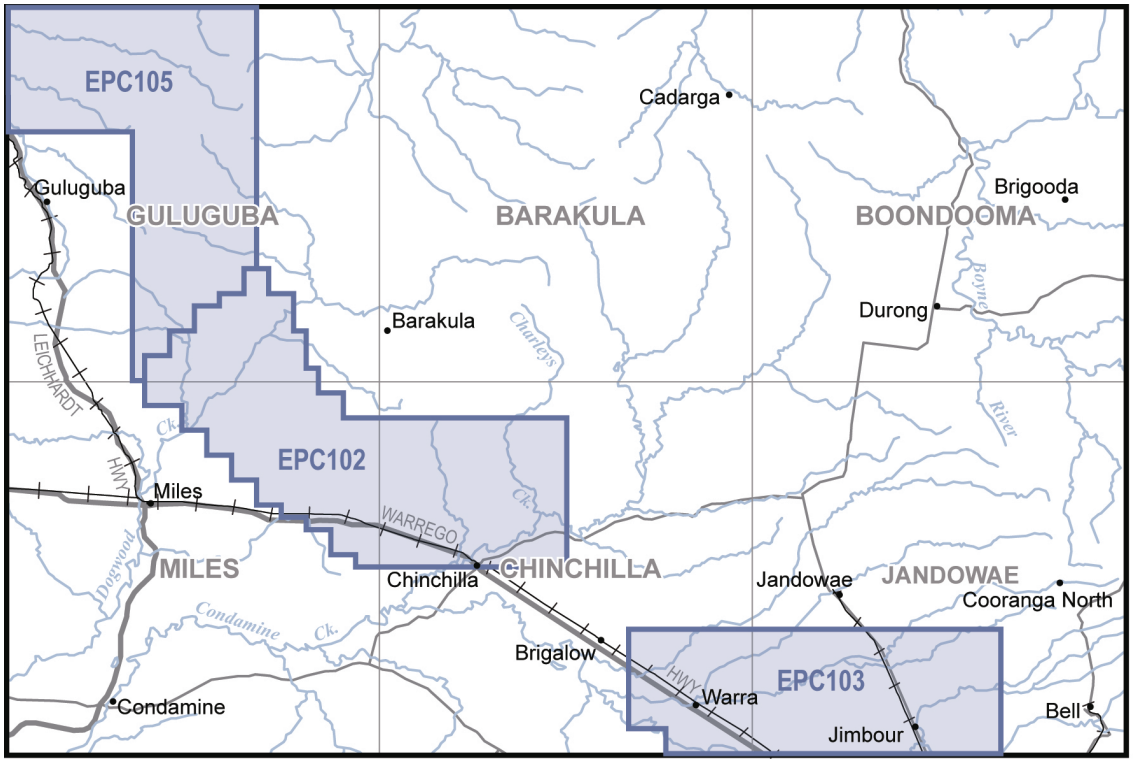

Figure 27: EPC 102 – EPC 105

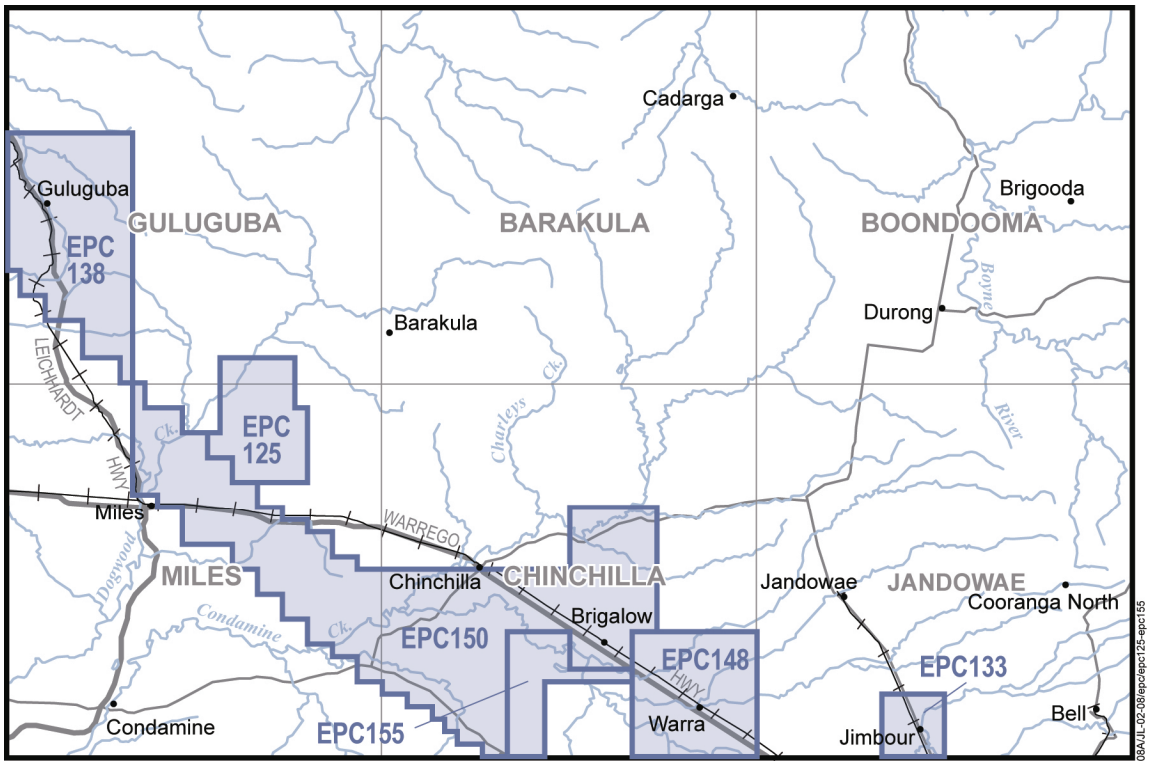

Figure 28: EPC 125 – EPC 155

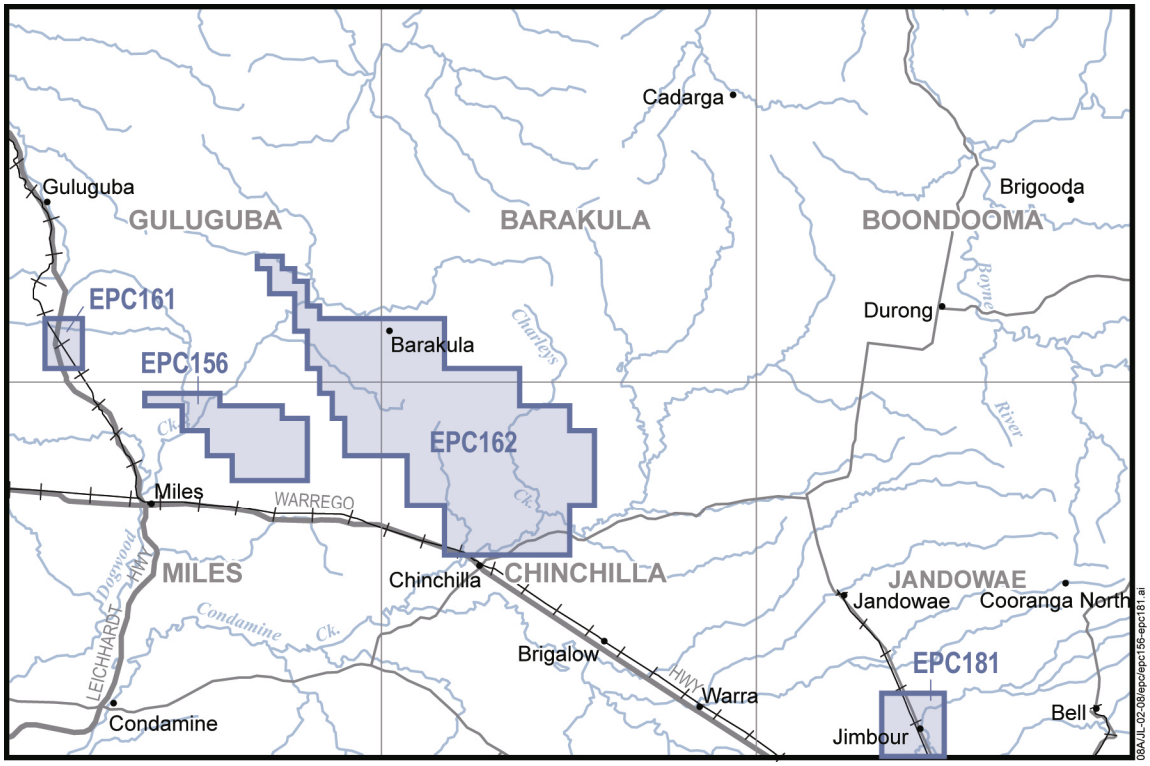

Figure 29: EPC 156 – EPC 181

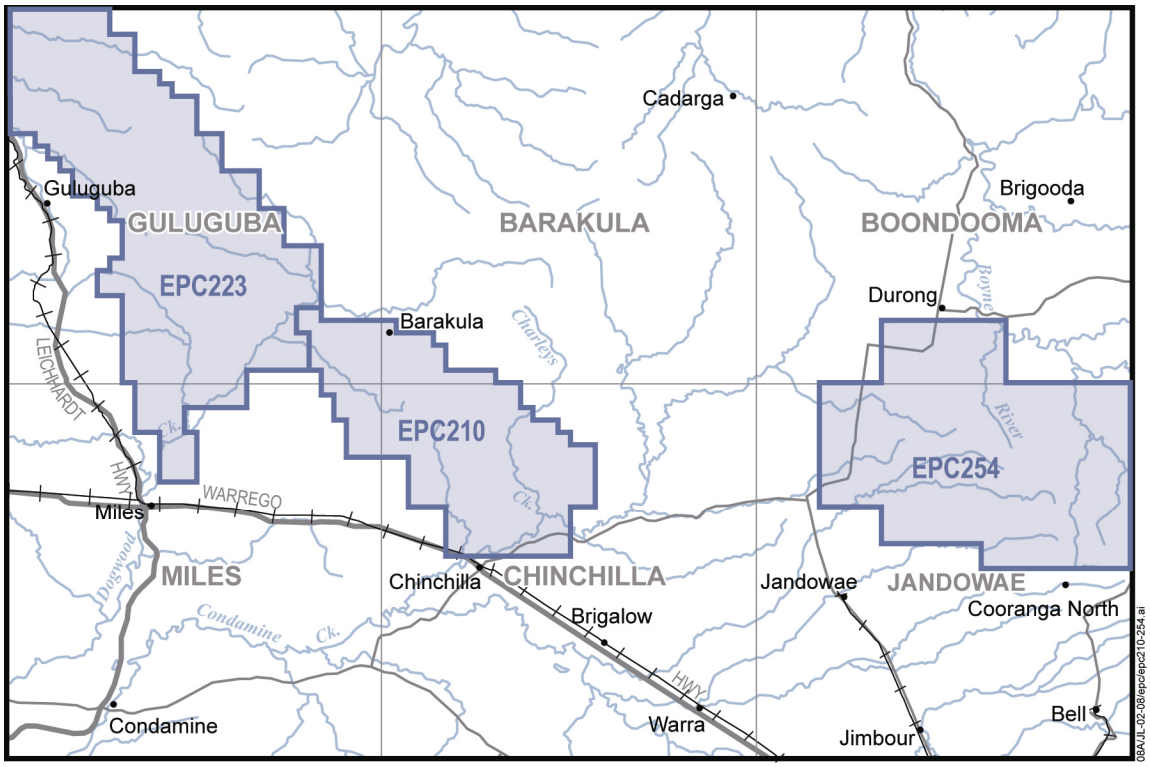

Figure 30: EPC 210 – EPC 254

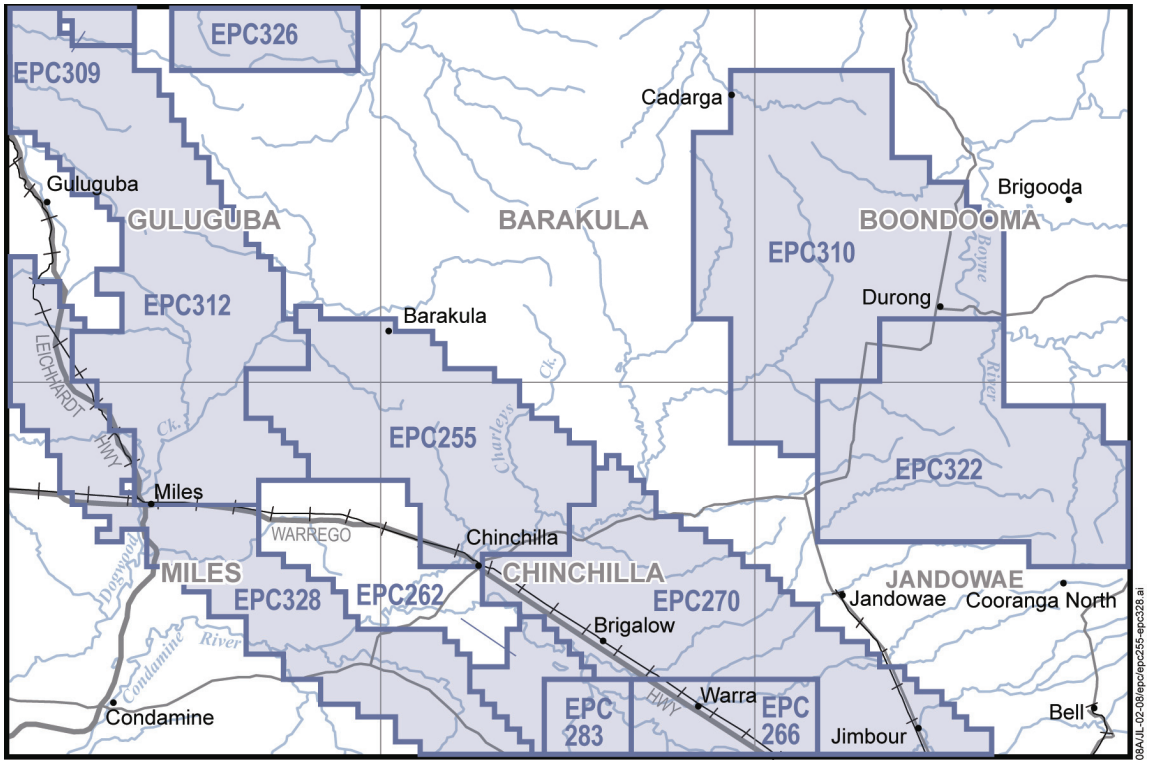

Figure 31: EPC 255 – EPC 328

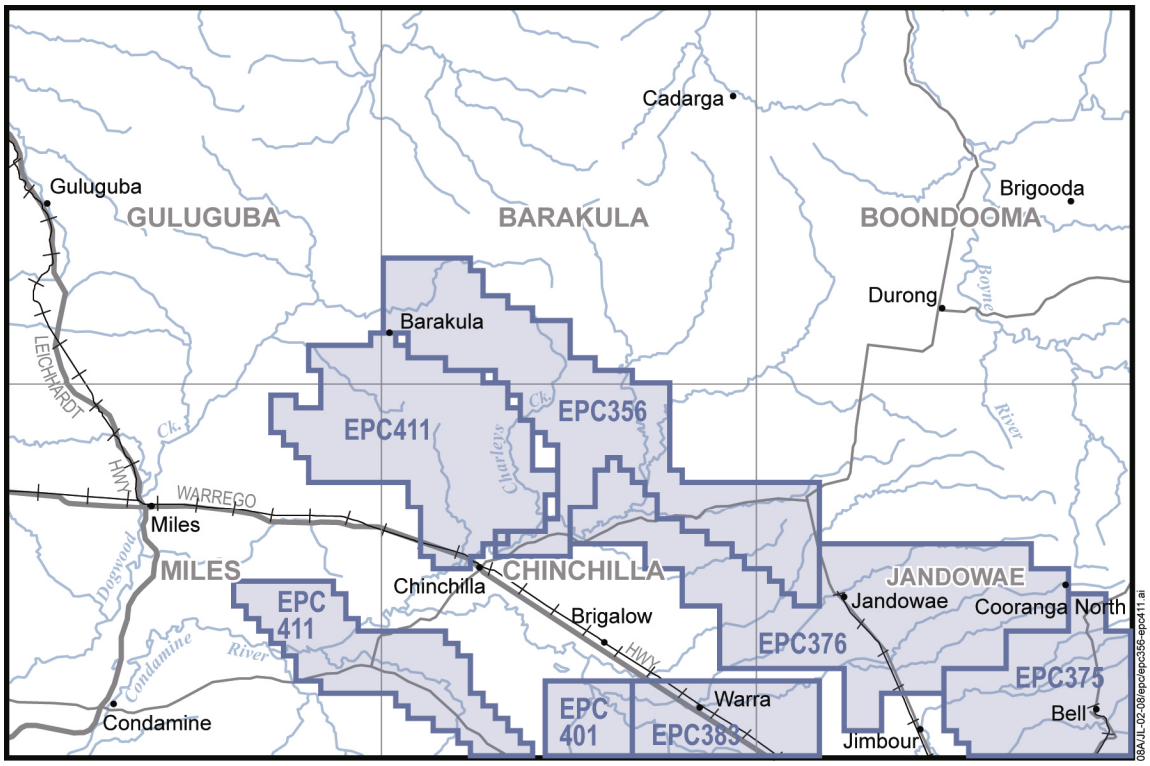

Figure 32: EPC 356 – EPC 411

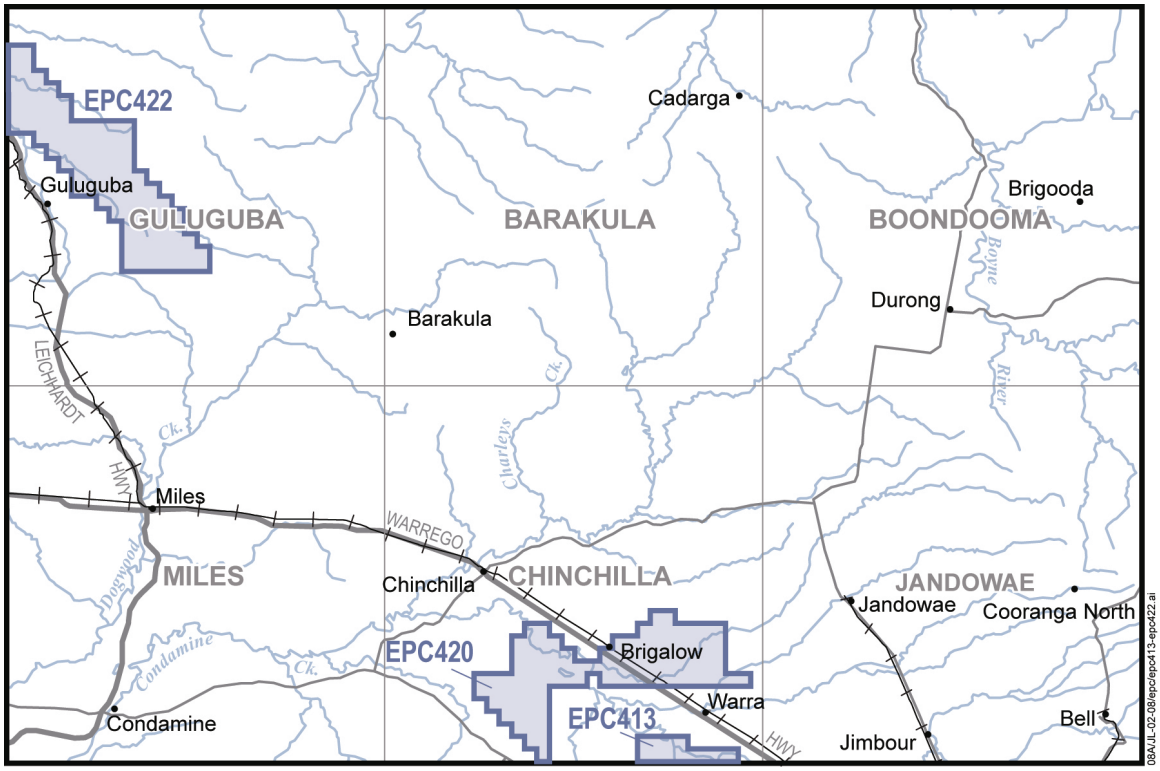

Figure 33: EPC 413 – EPC 422

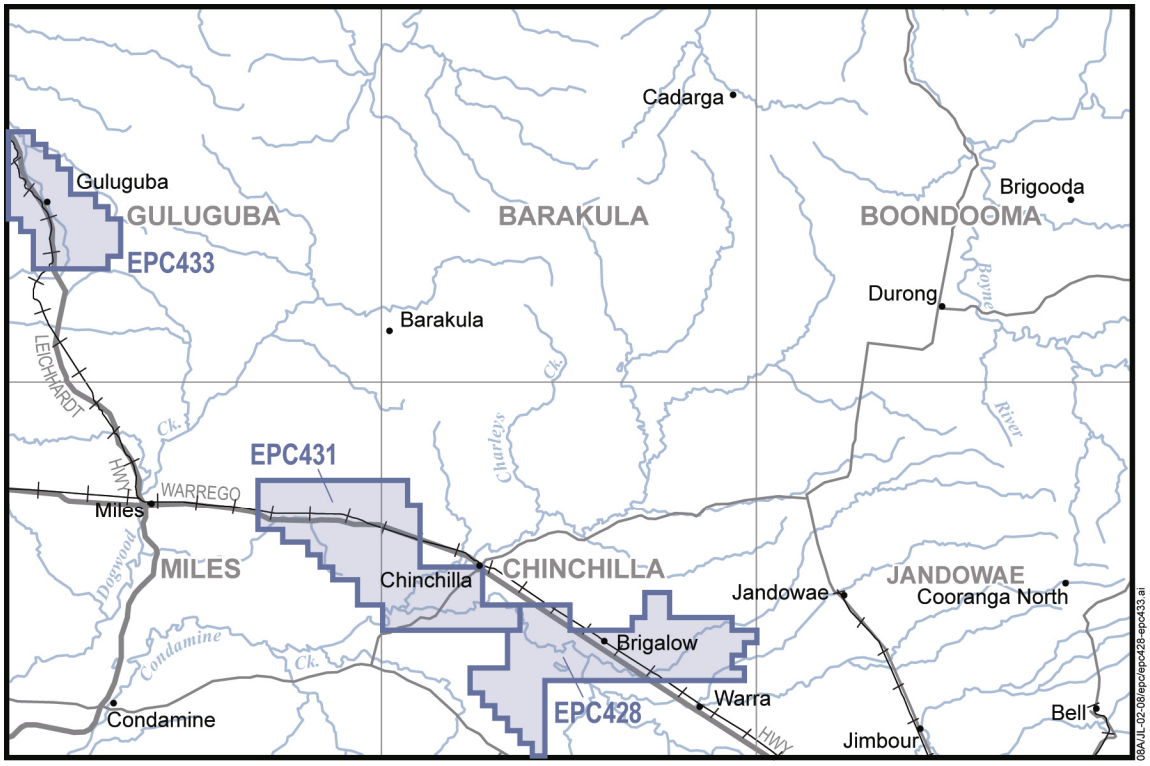

Figure 34: EPC 428 – EPC 433

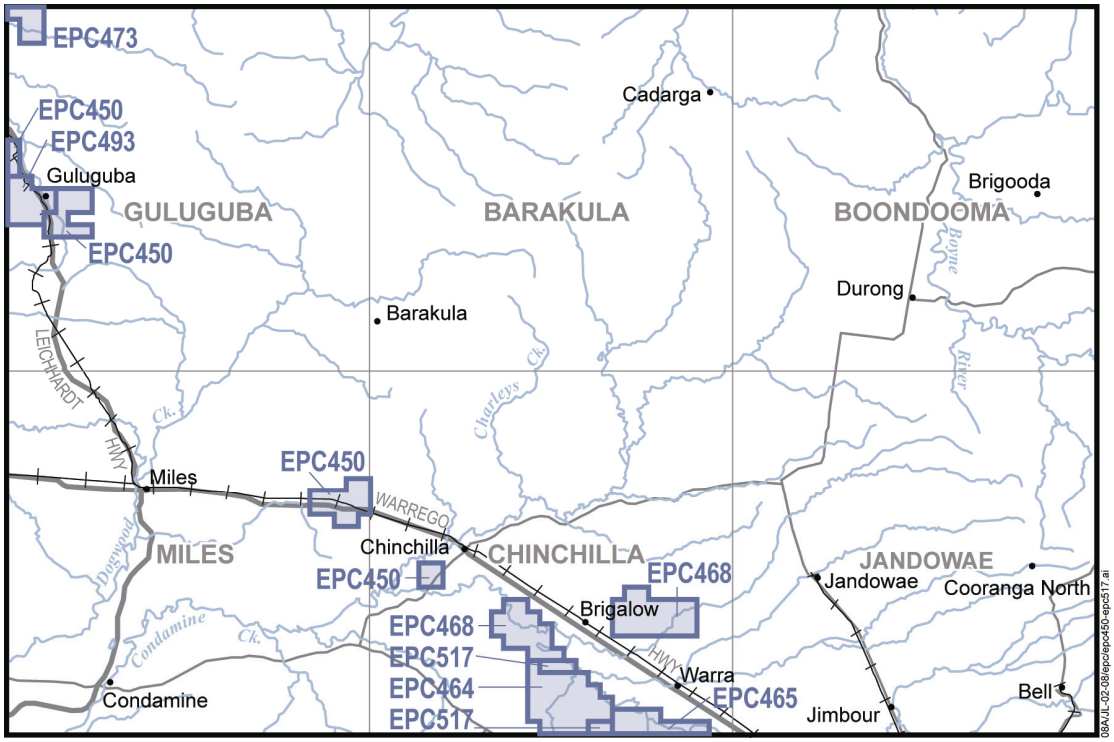

Figure 35: EPC 450 – EPC 517

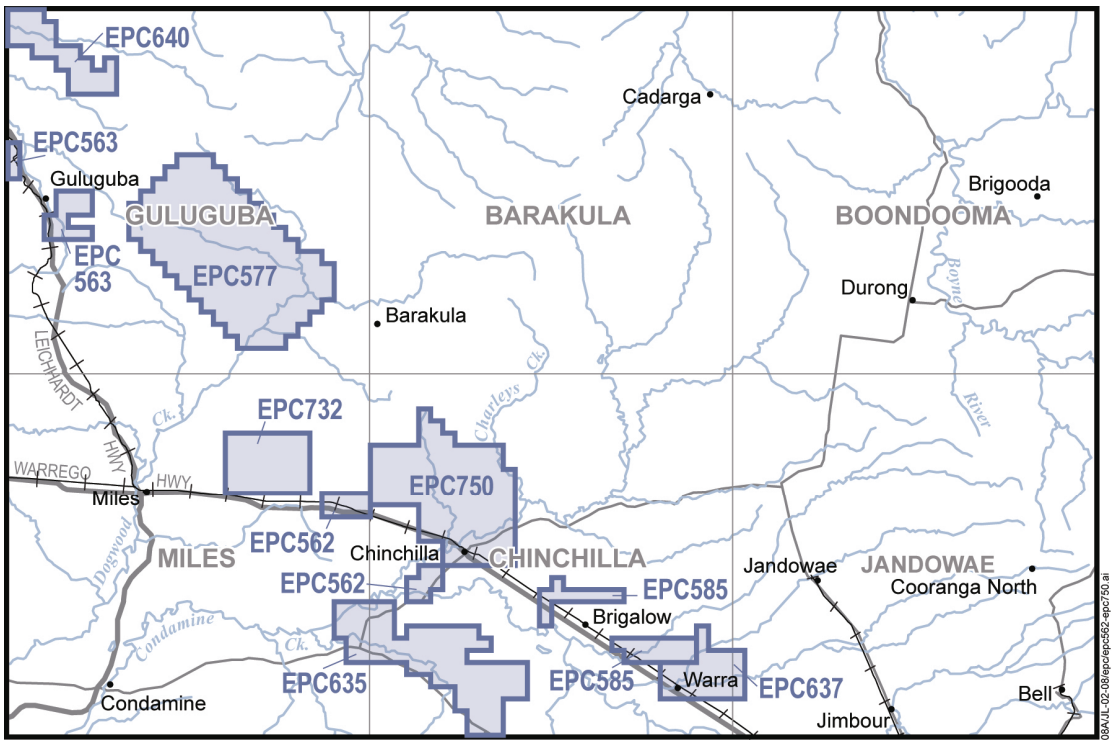

Figure 36: EPC 562 – EPC 750

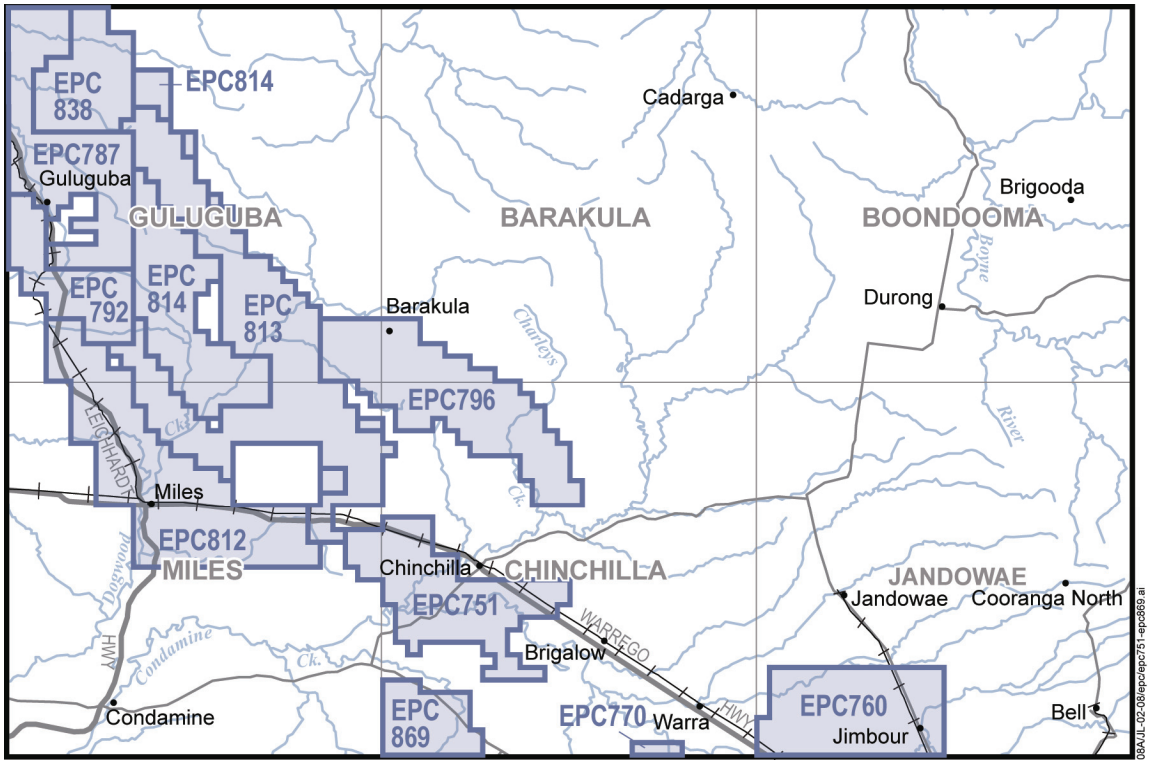

Figure 37: EPC 751 – EPC 869

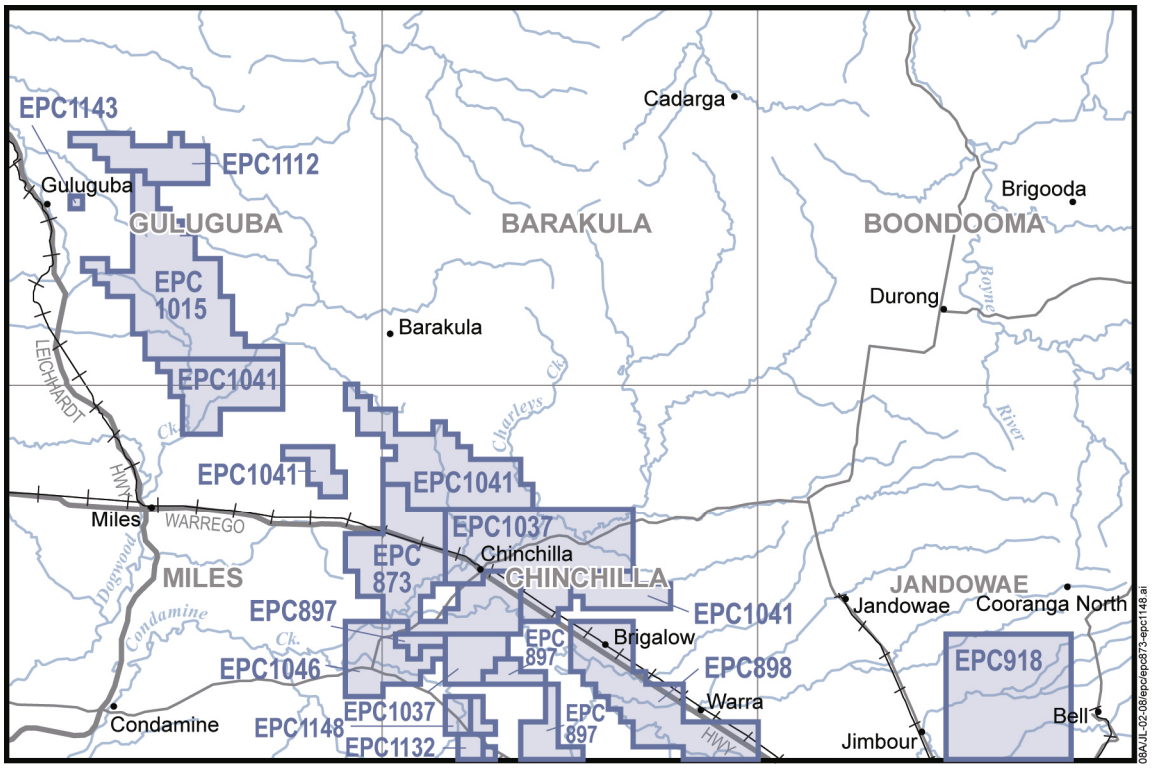

Figure 38: EPC 873 – EPC 1148

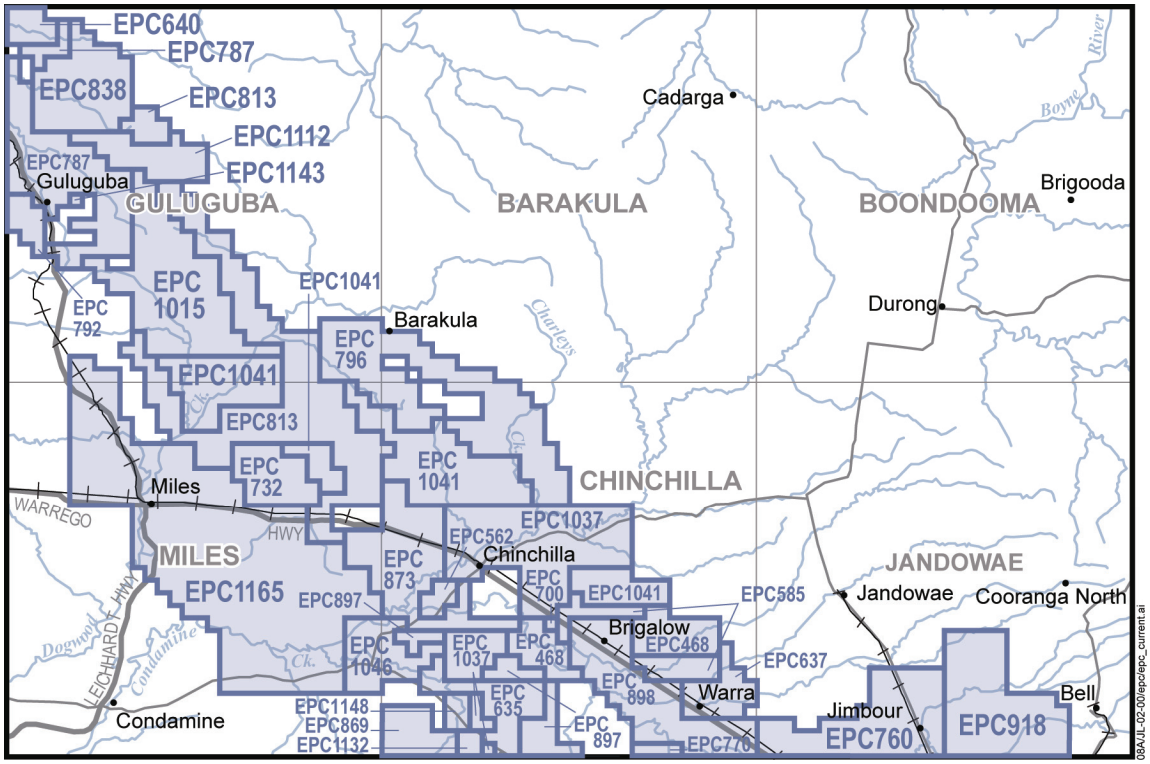

Figure 39: Current EPC 562 – EPC 1165

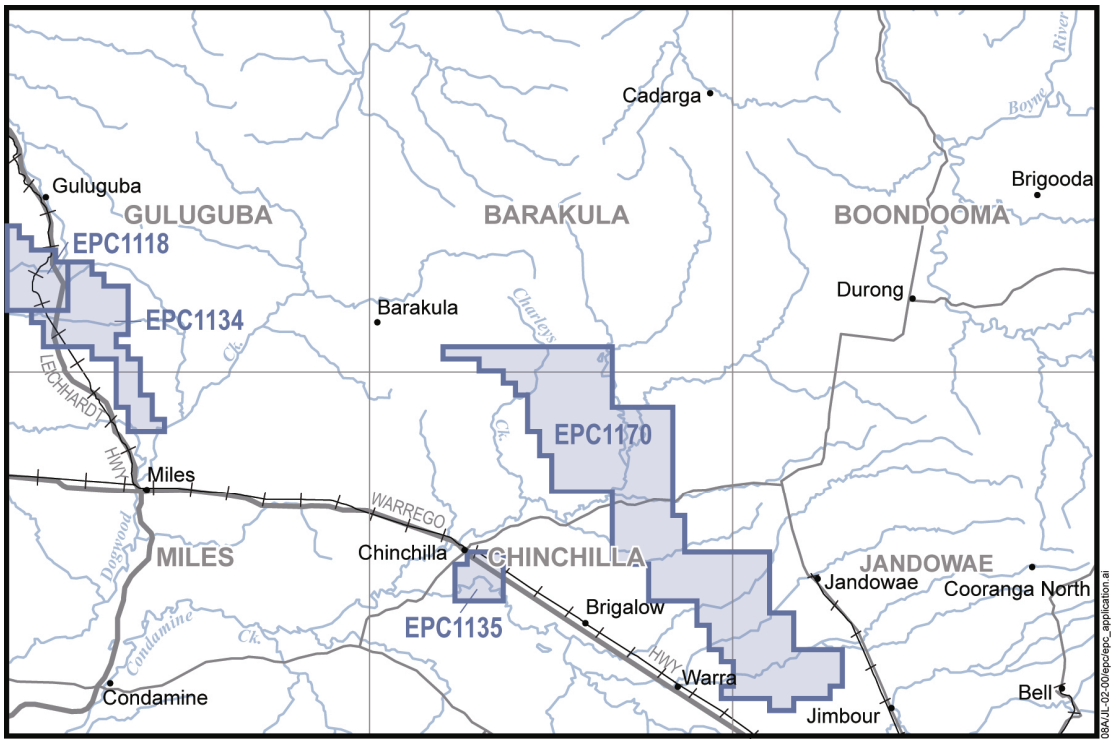

Figure 40: Application EPC 1118 – EPC 1170

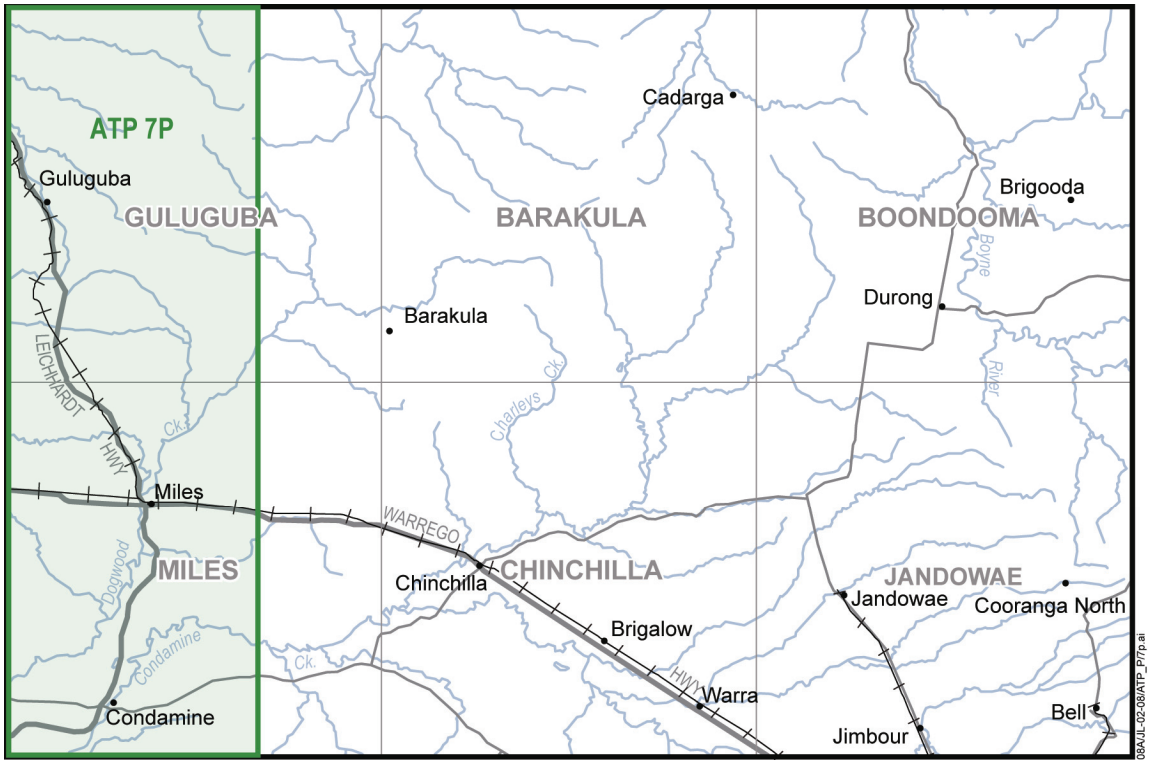

Figure 41: ATP 7P

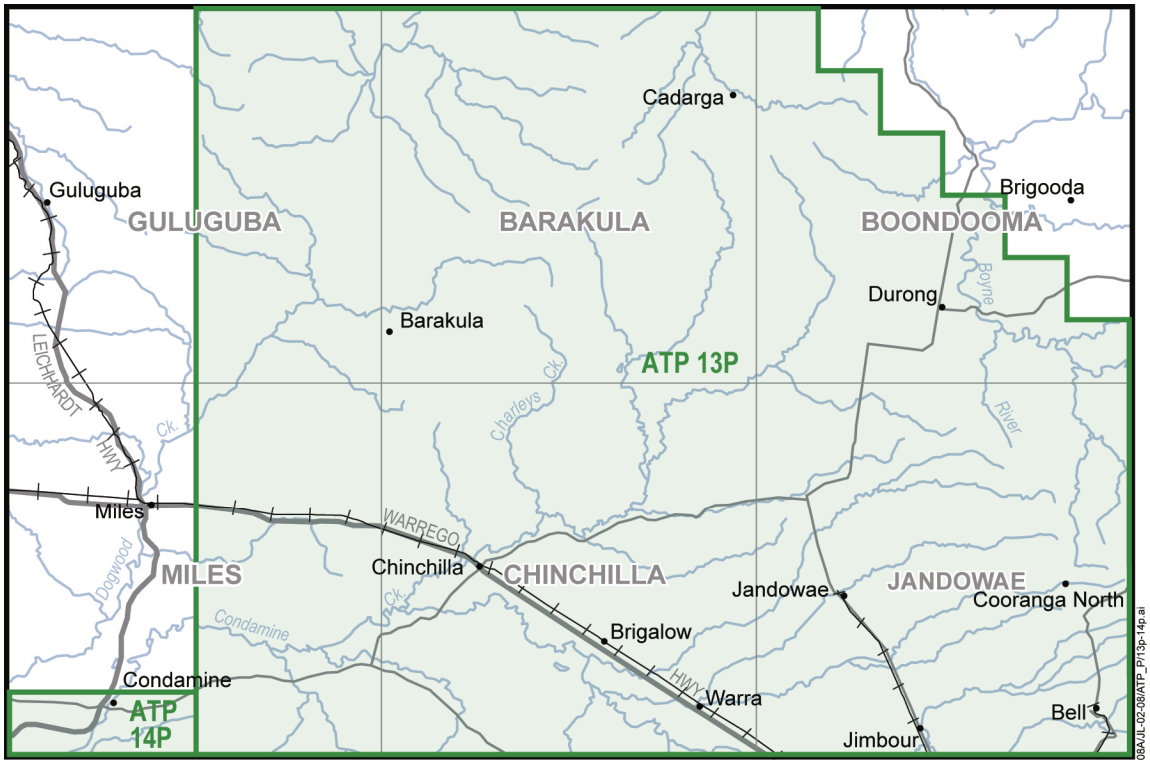

Figure 42: ATP 13P - ATP 14P

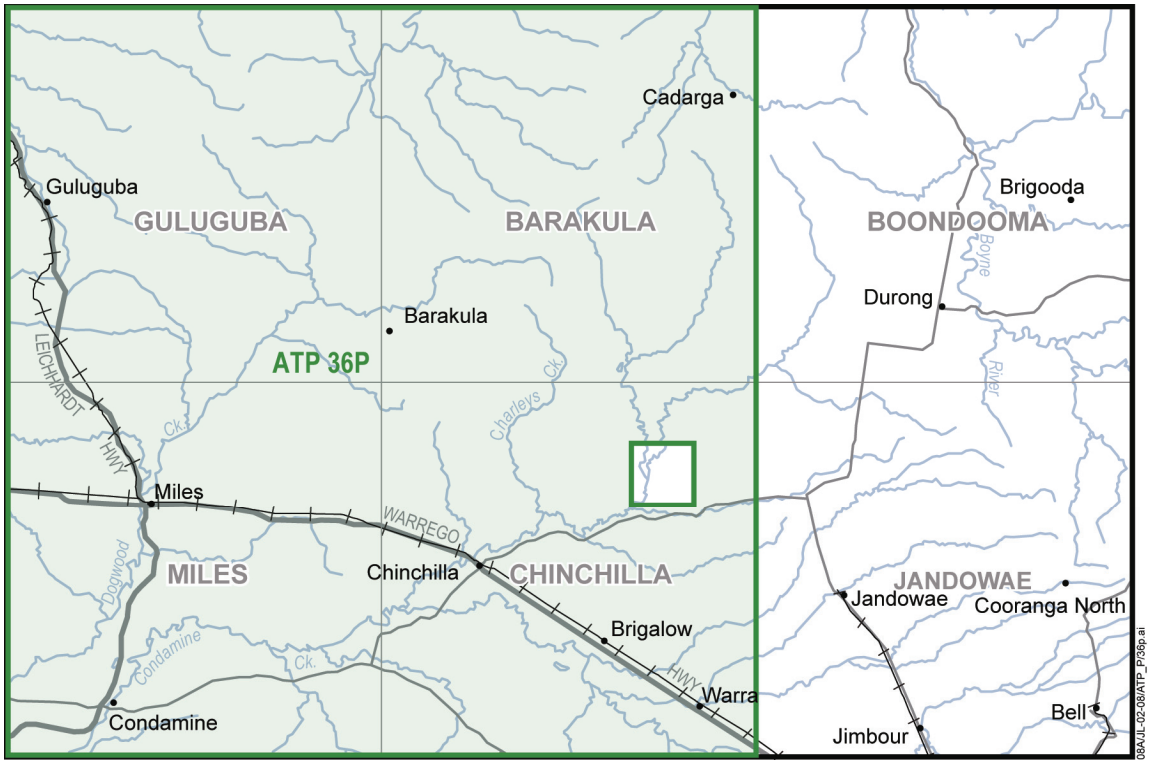

Figure 43: ATP 36P

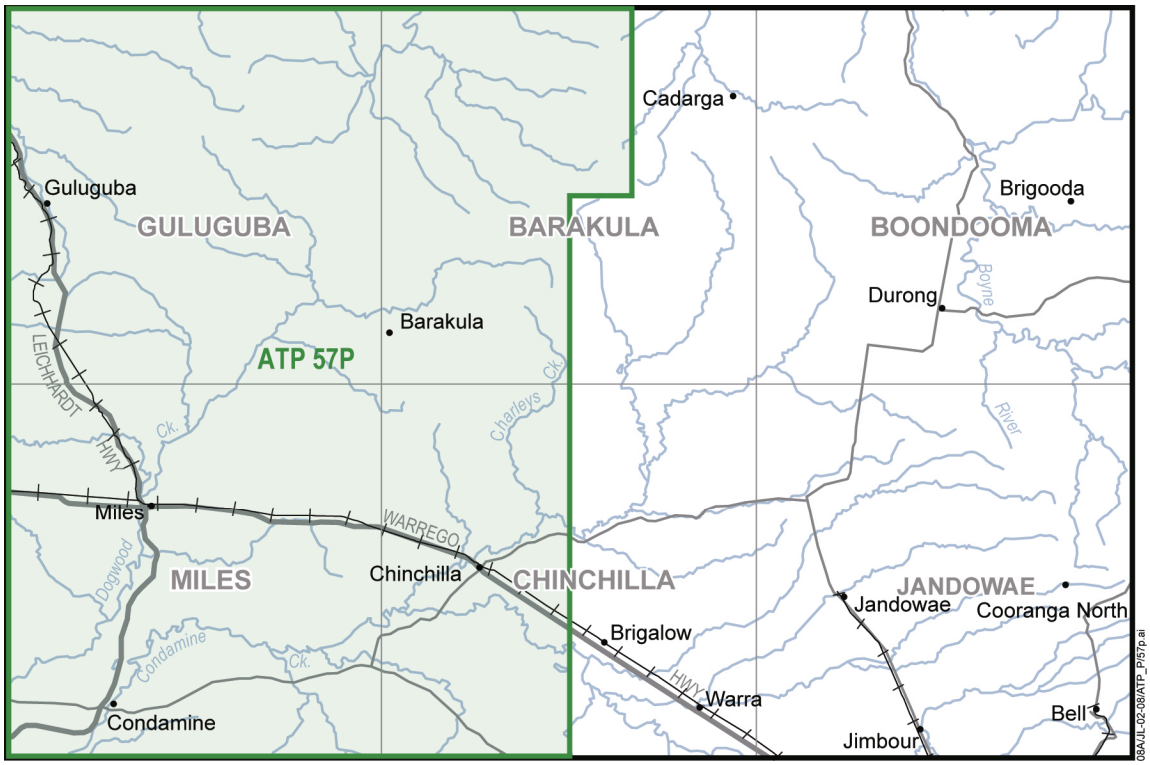

Figure 44: ATP 57P

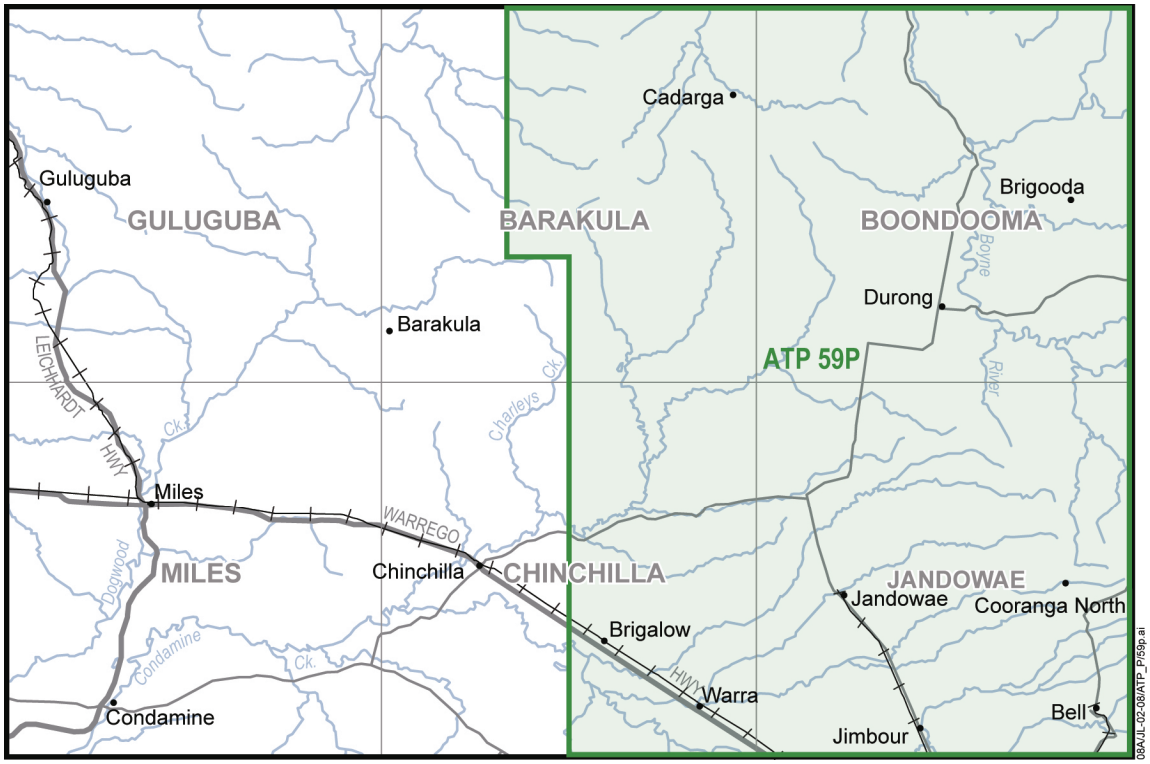

Figure 45: ATP 59P

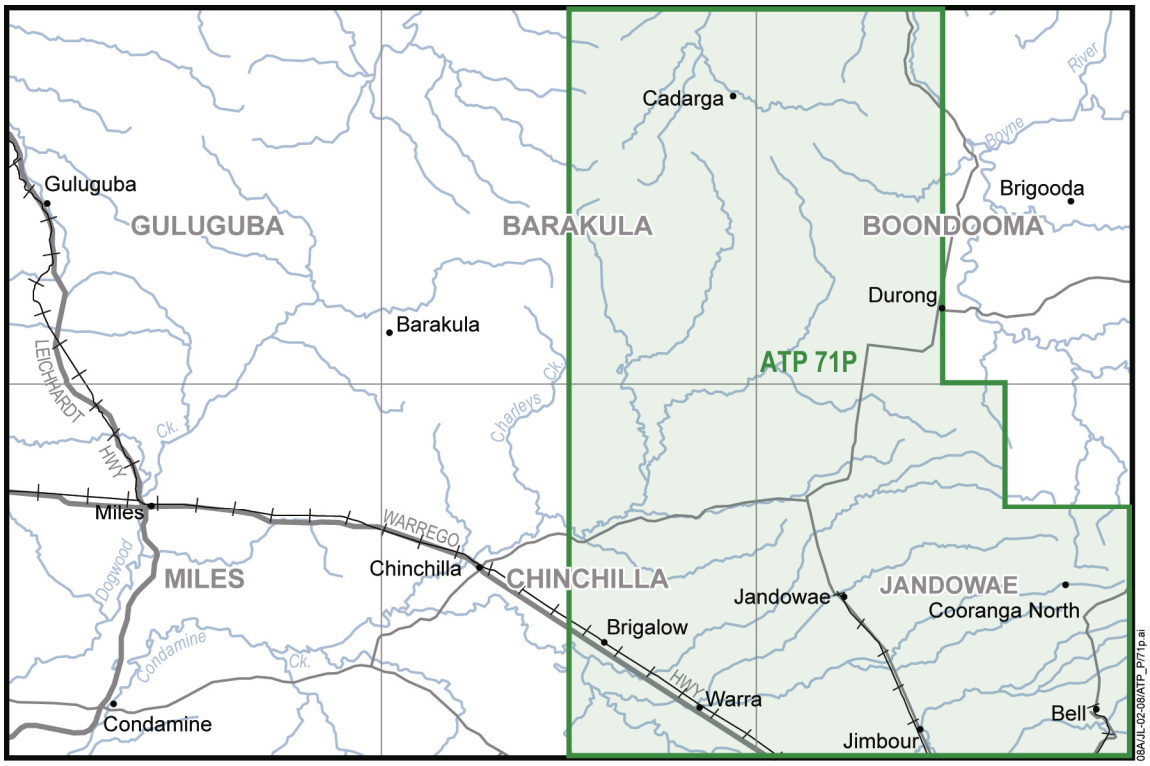

Figure 45: ATP 71P

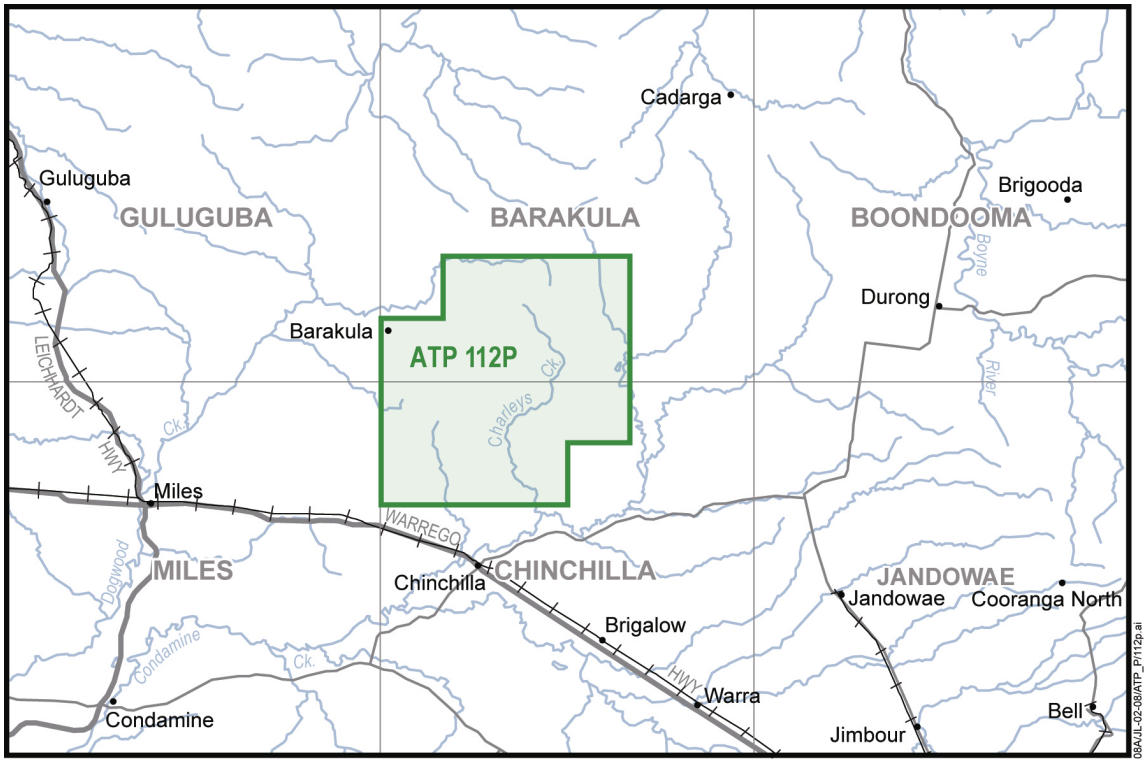

Figure 46: ATP 112P

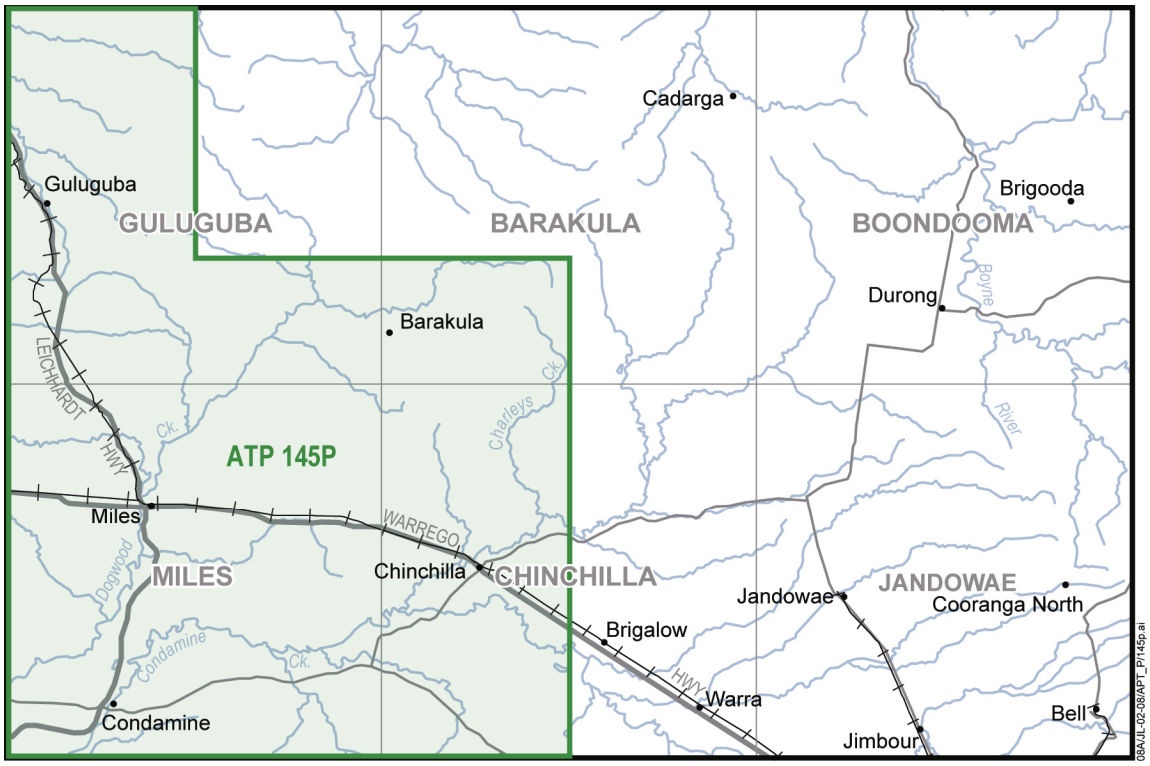

Figure 47: ATP 145P

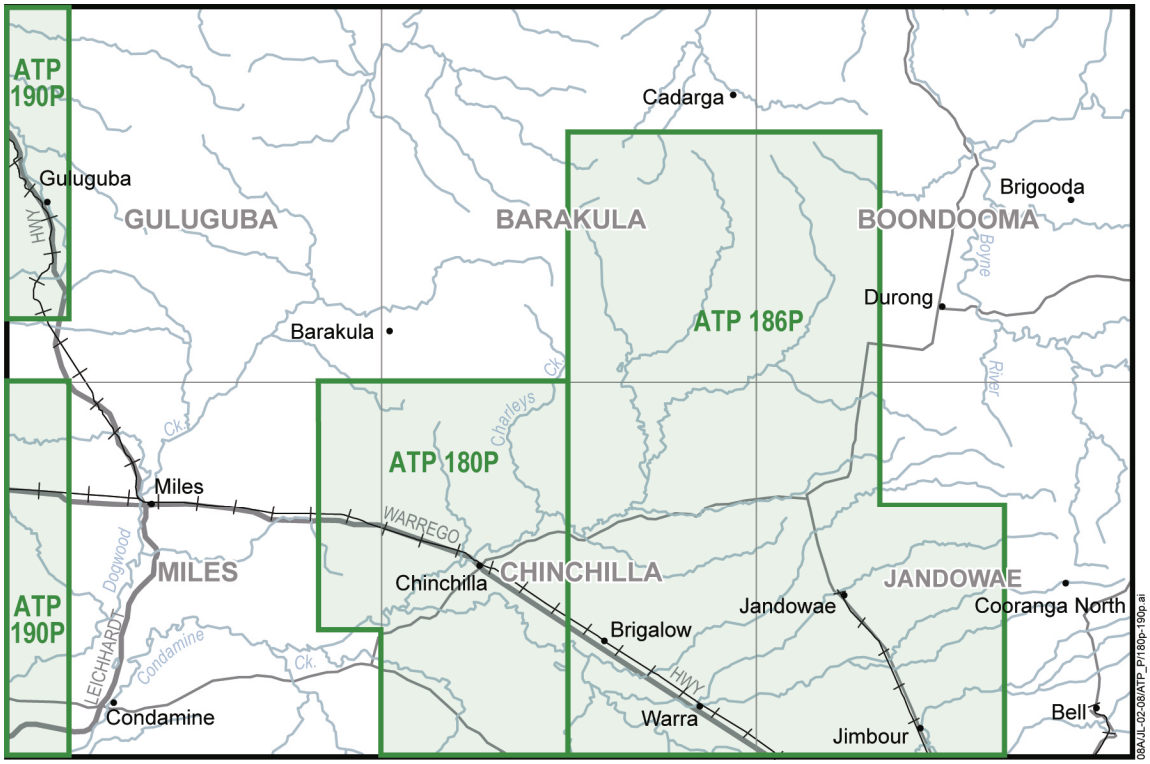

Figure 48: ATP 180P – ATP 190P

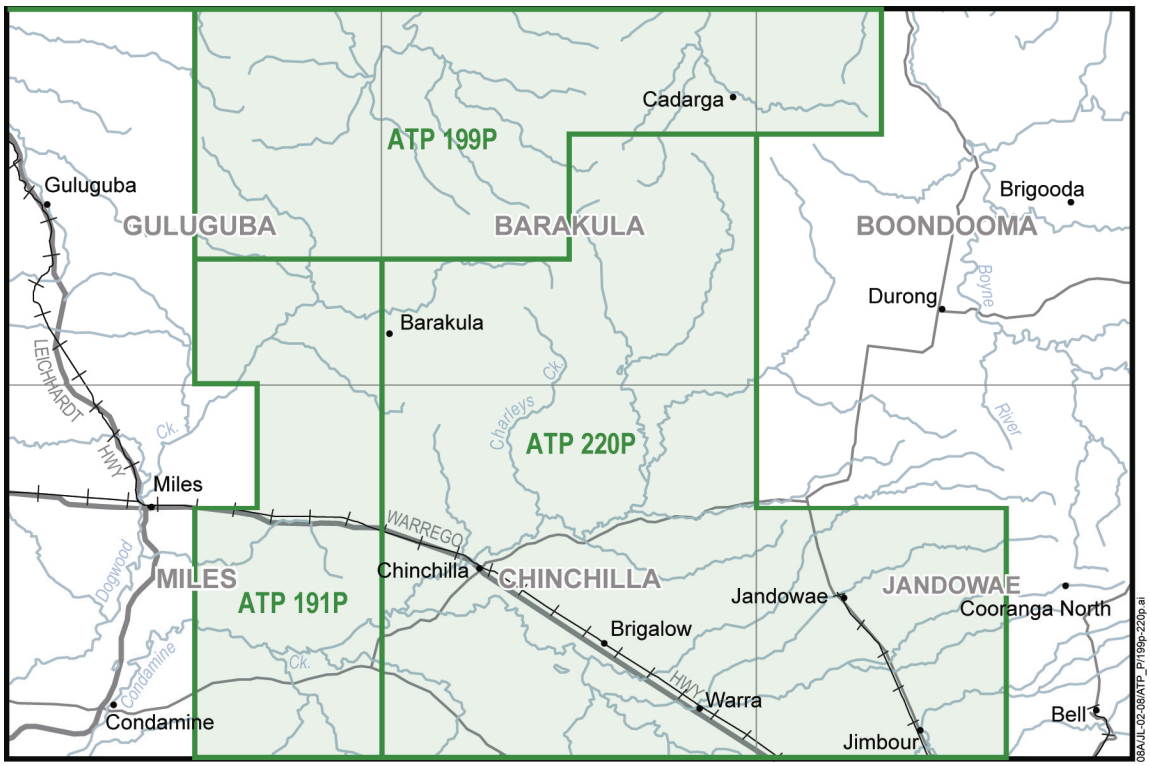

Figure 49: ATP 199P – ATP 220P

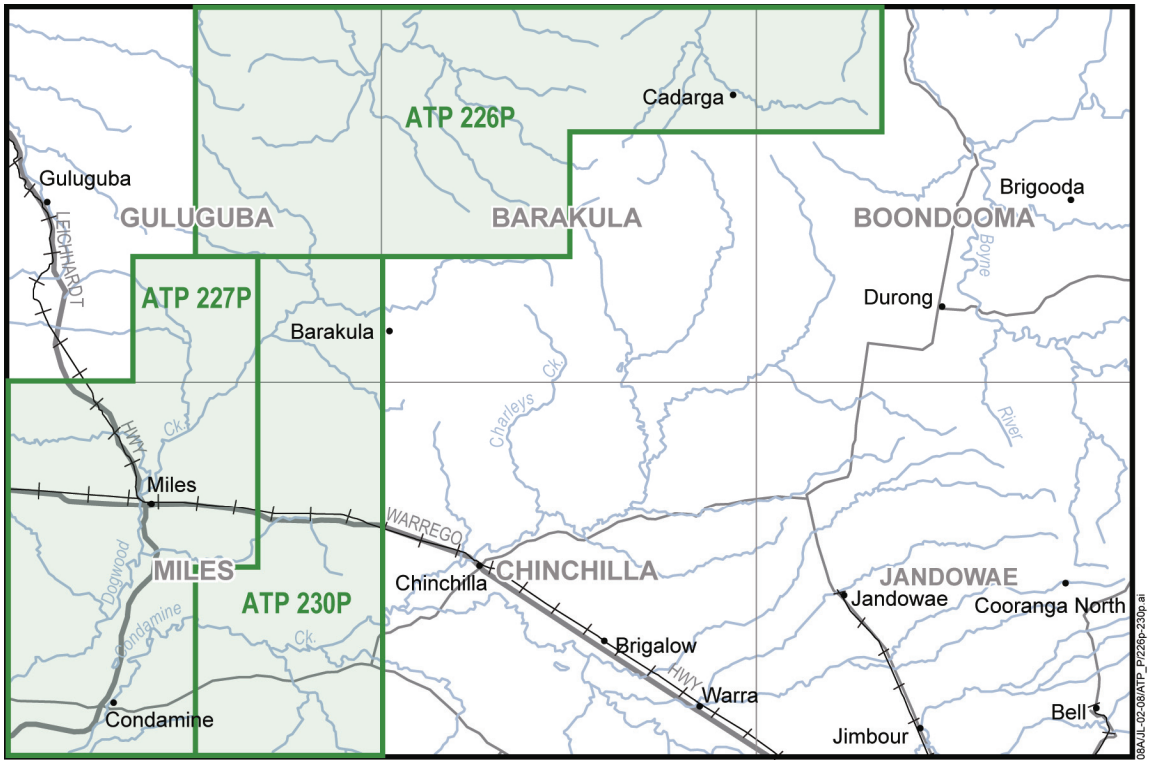

Figure 50: ATP 226P – ATP 230P

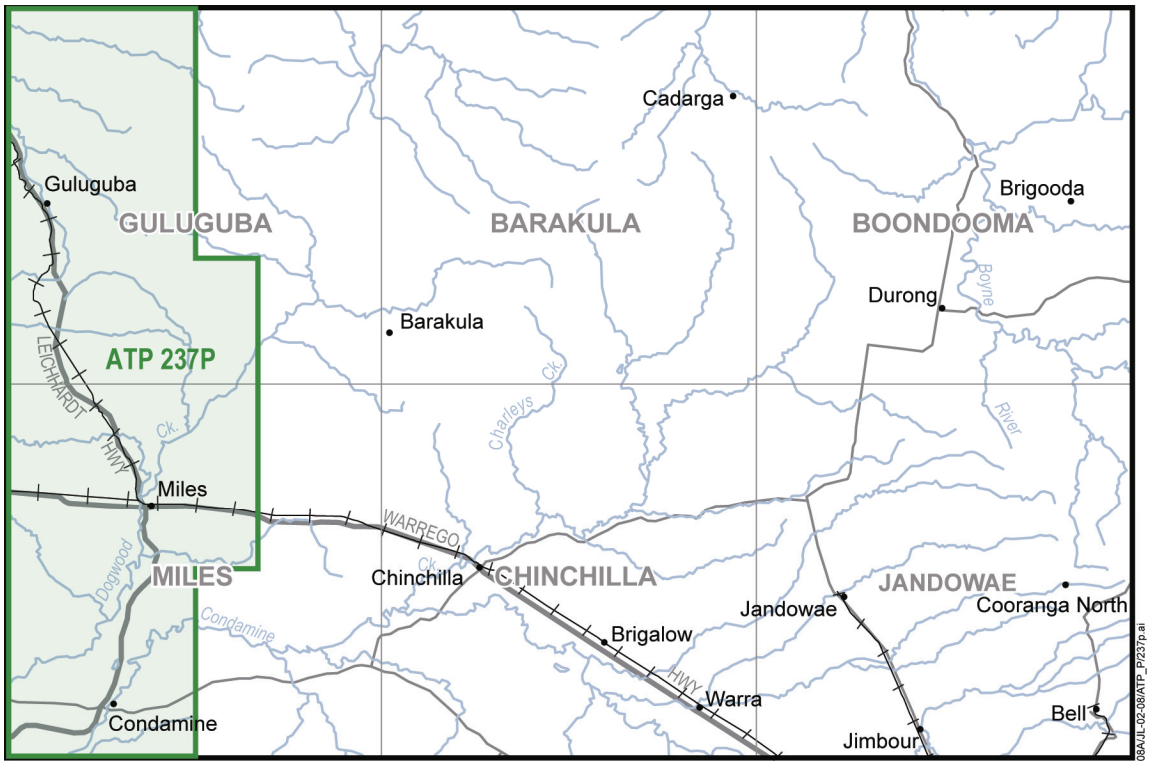

Figure 51: ATP 237P

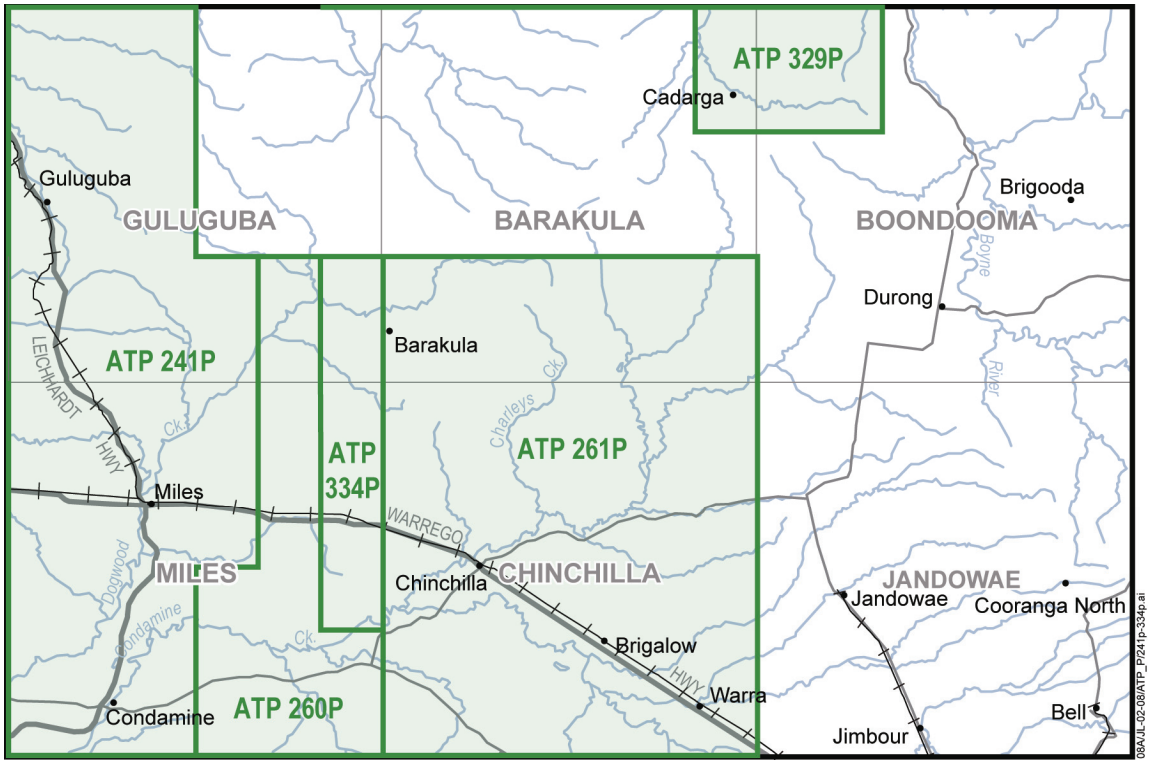

Figure 52: ATP 241P - ATP 334P

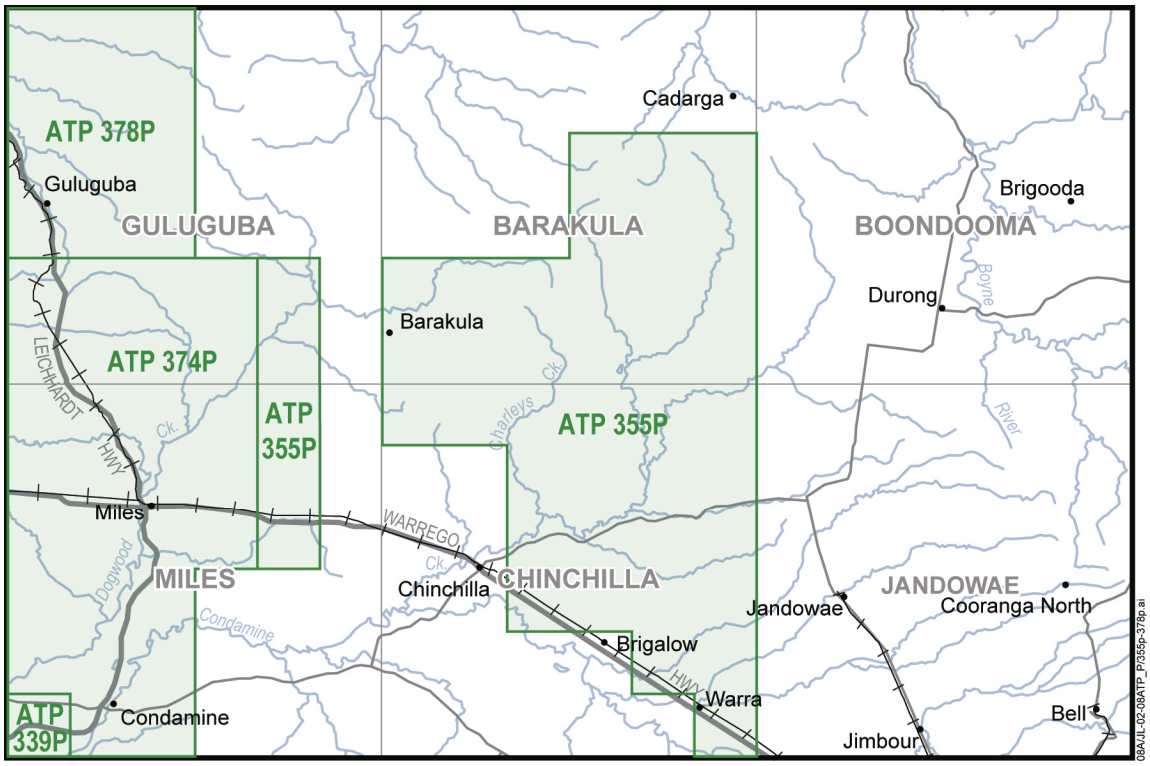

Figure 53: ATP 355P – ATP 378P

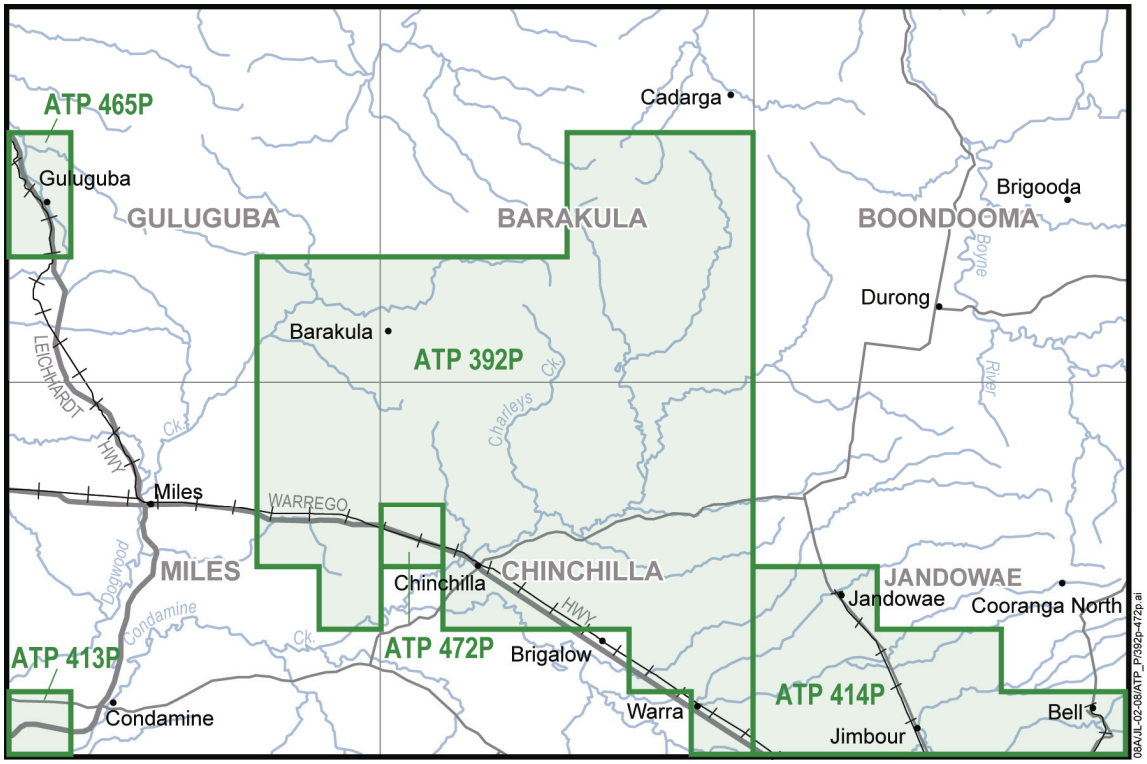

Figure 54: ATP 392P – ATP 472P

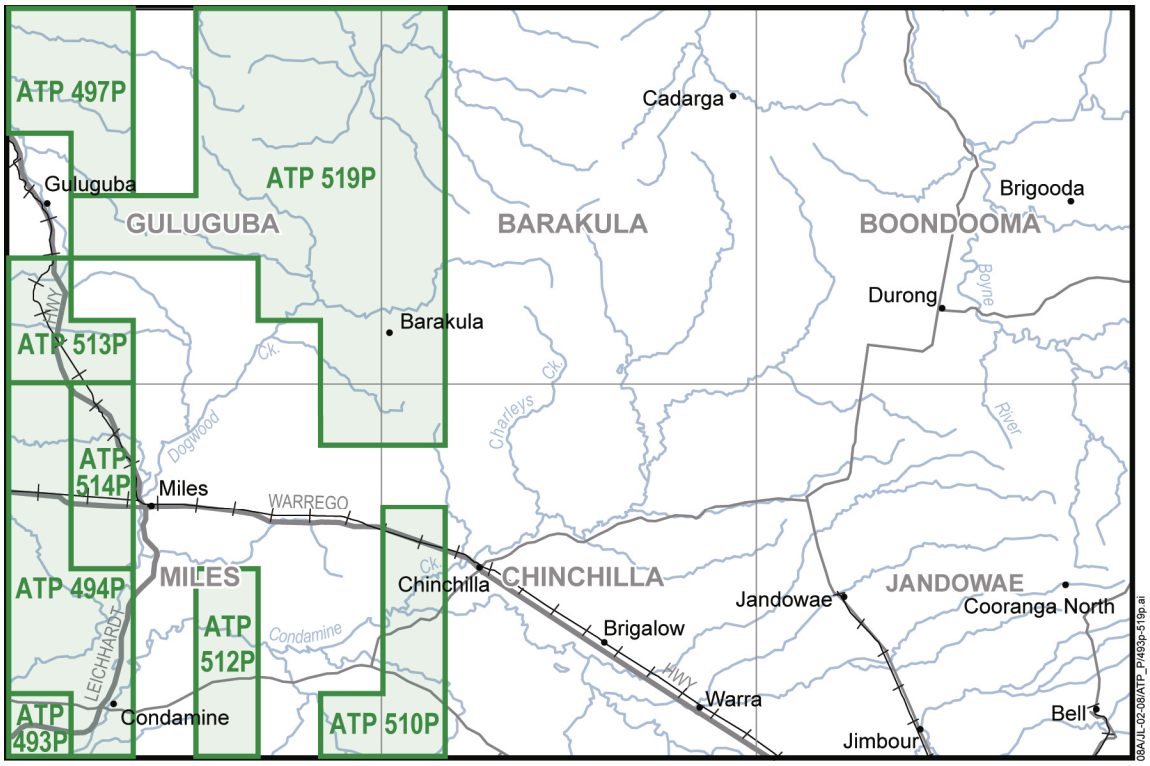

Figure 555 ATP 493P – ATP 519P

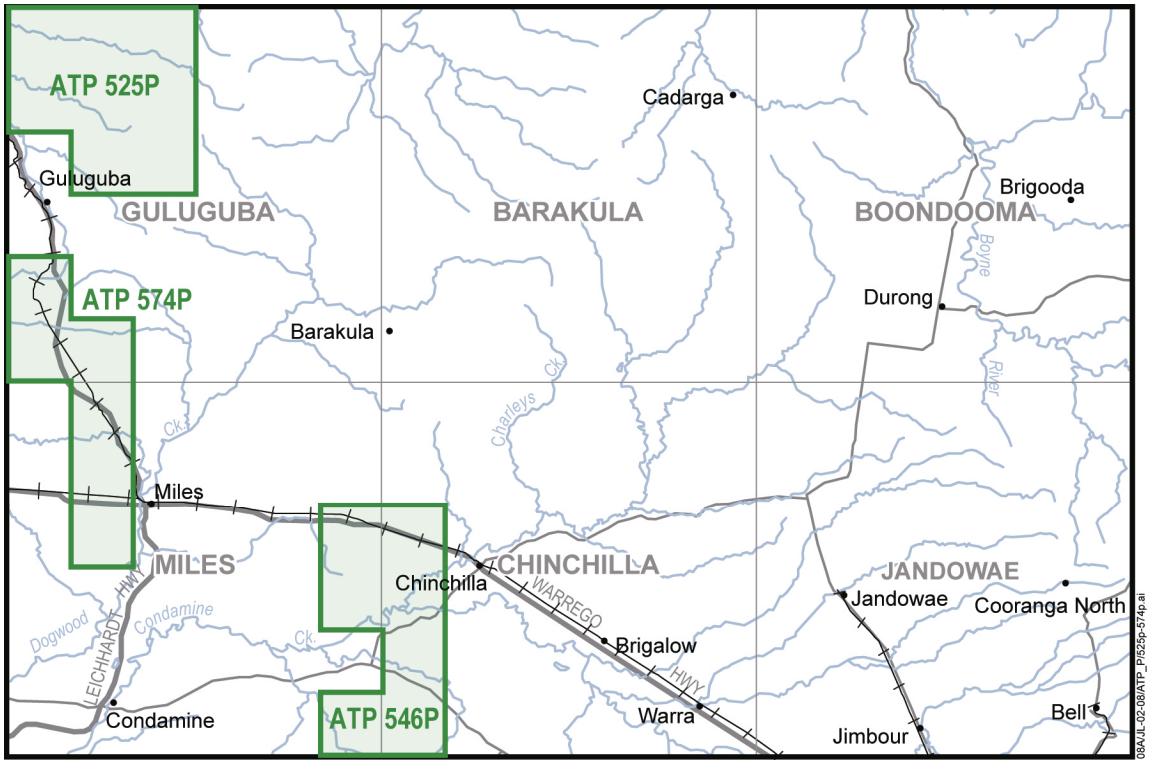

Figure 56: ATP 525P – ATP 574P

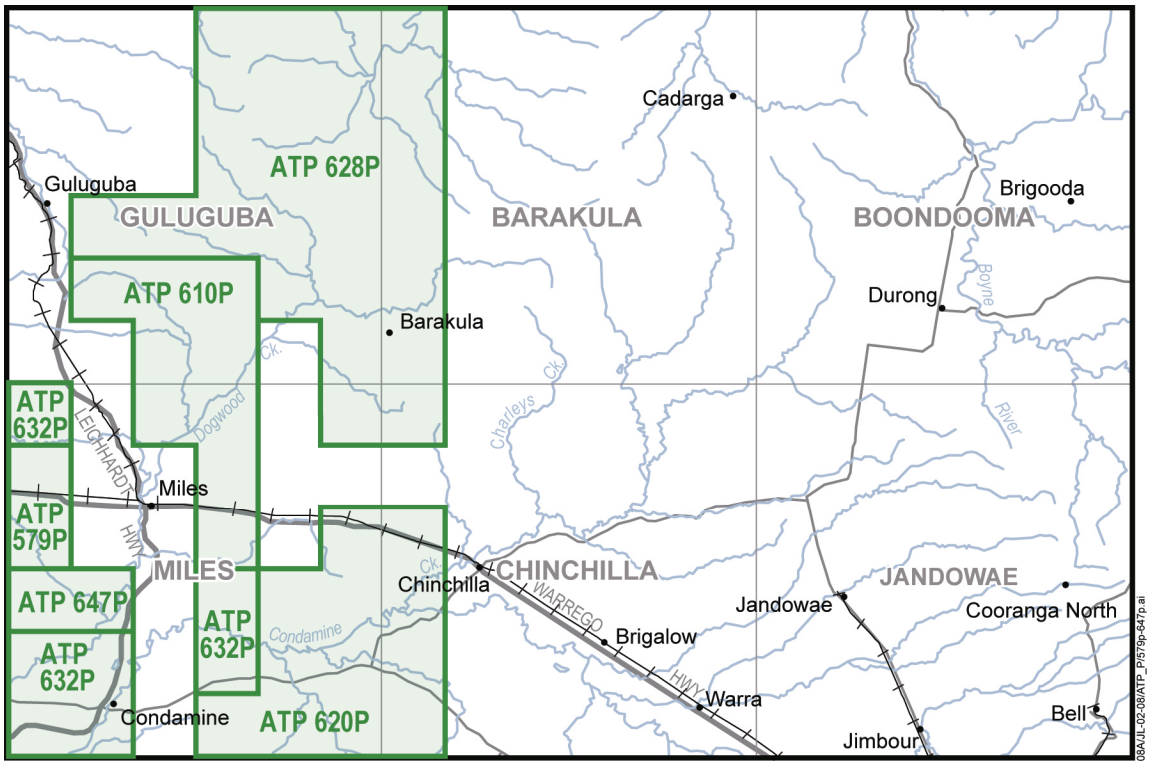

Figure 57: ATP 579P – ATP 647P

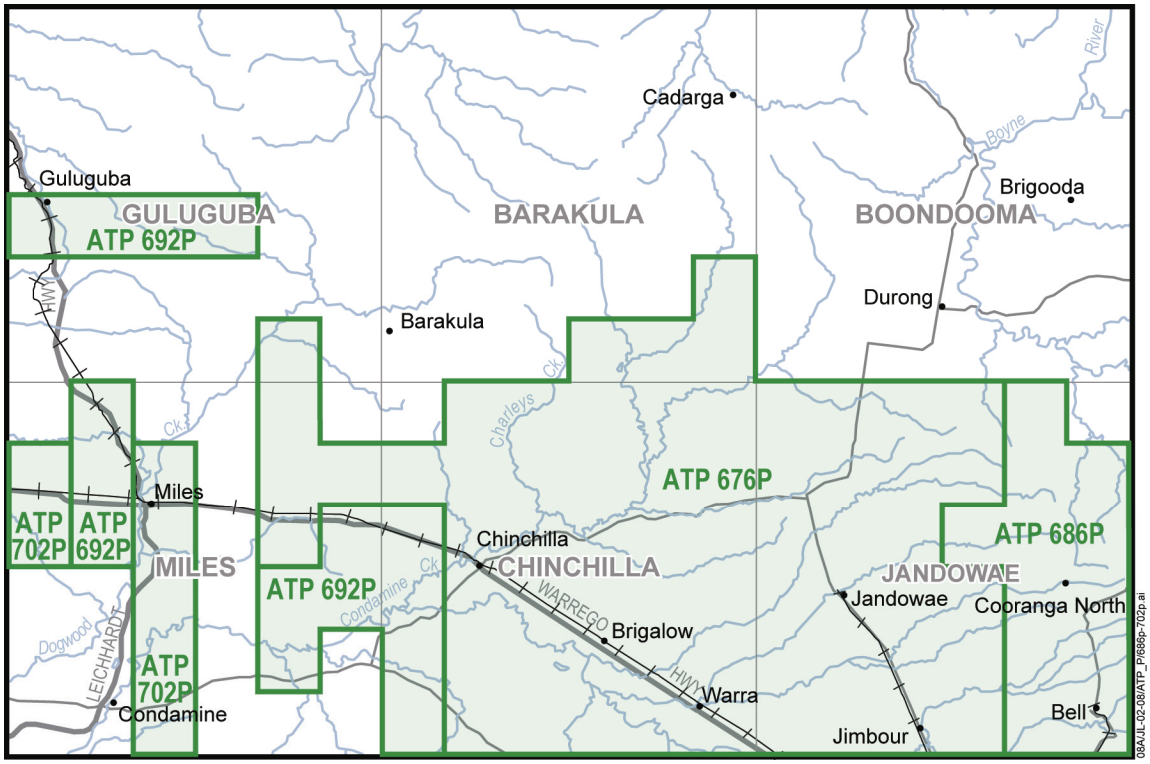

Figure 58: ATP 686P – ATP 702P

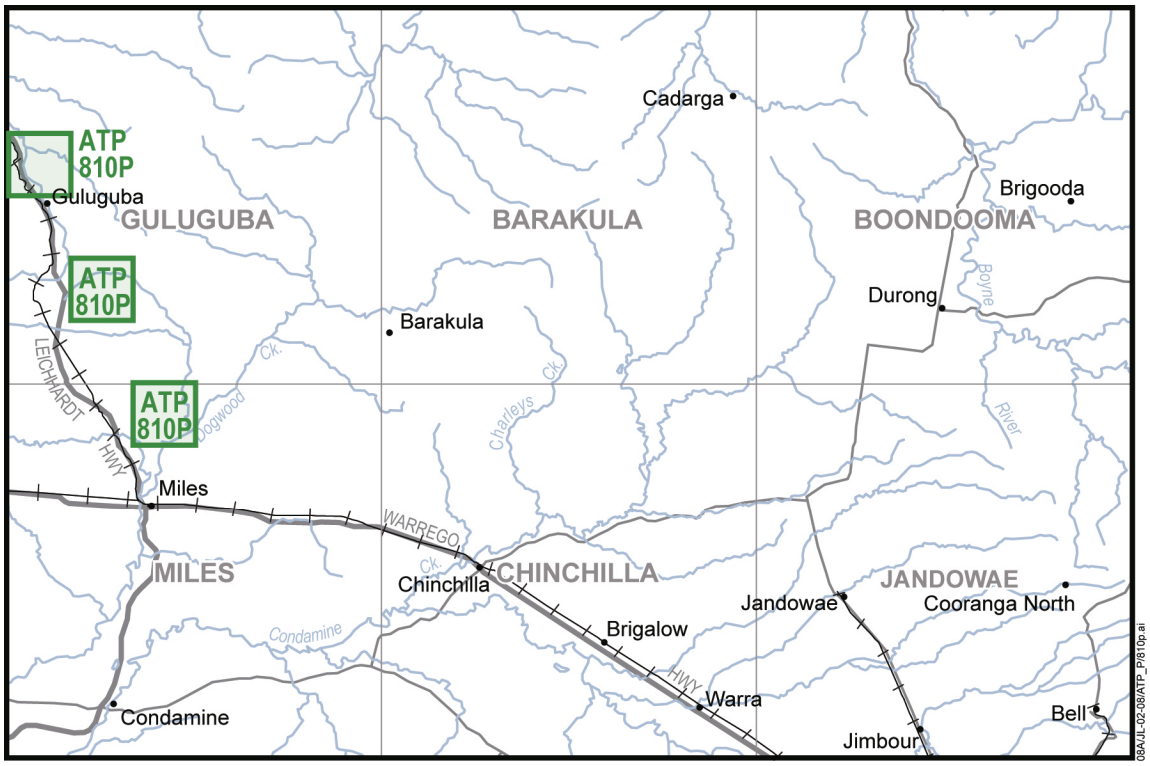

Figure 59: ATP 810P

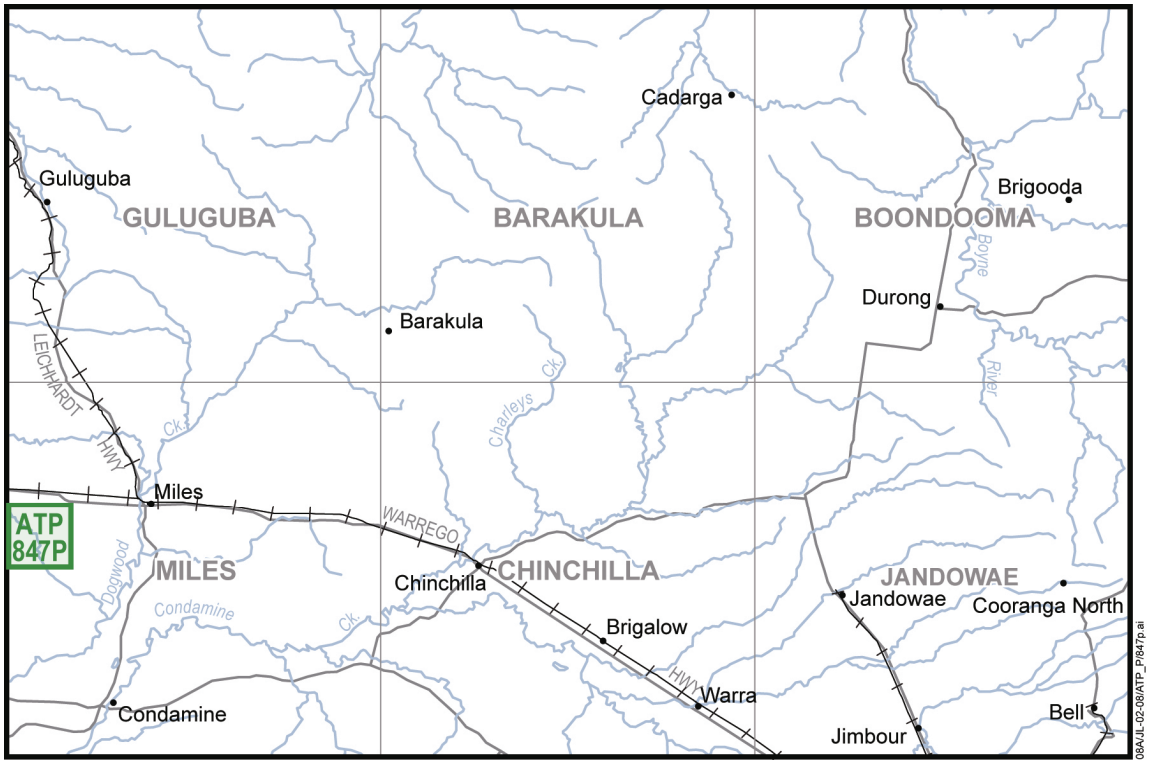

Figure 60: ATP 847P

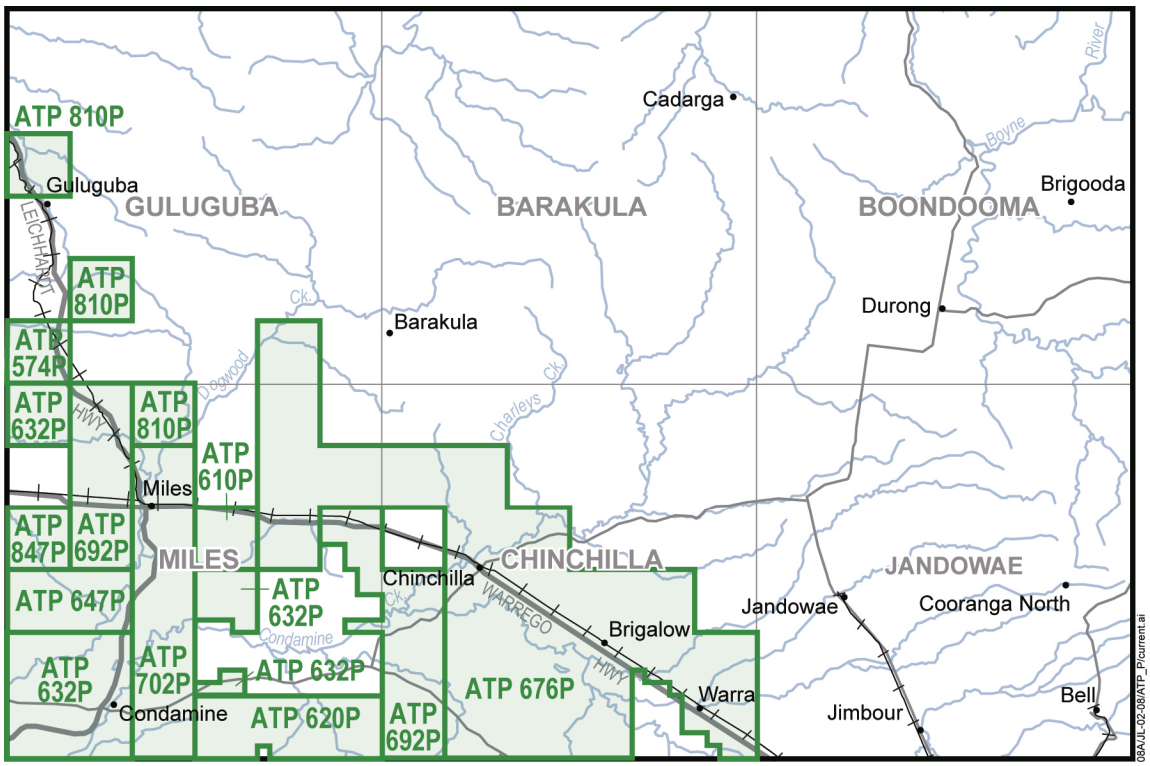

Figure 61: Current ATP 574P – ATP 810P

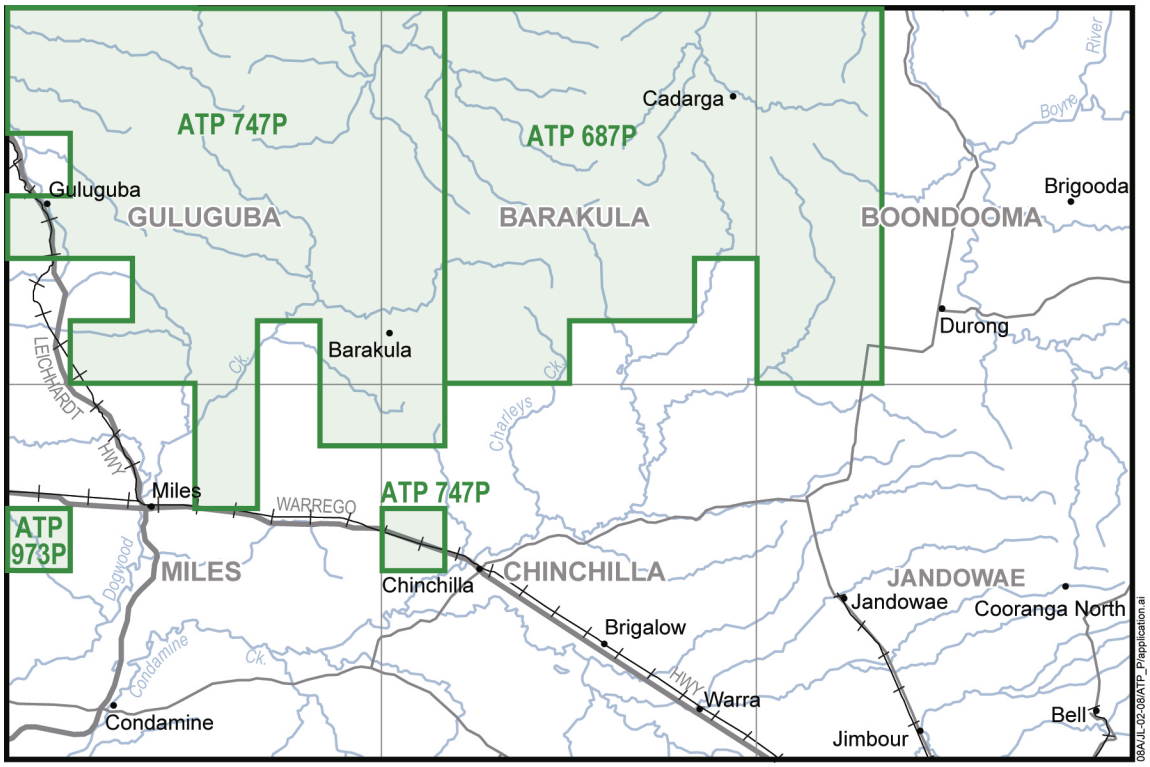

Figure 62: Application ATP 687P – ATP 973P