District–Scale Review of Geology and Mineral Prospectivity in The Georgetown Inlier, Queensland

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1 Introduction

The Georgetown Inlier is a geologically diverse region of Proterozoic rocks that forms part of the North Australian Craton. As with other parts of the craton, it is highly prospective for a wide variety of minerals and deposit types (Withnall, et al., 2013). This report aims to present a review of both the host geology and metallogenic components of the inlier, as well as a discussion of prospective avenues for future exploration.

2 Geological Setting and History (Withnall, et al., 2013)

The Geology of North Queensland is dominated by the Jurassic-Cretaceous Carpentaria Basin and later Cenozoic sedimentary units. The north east is composed of rocks from the Mossman and New England Orogens. Archean and Proterozoic rocks are grouped into the North Australian Craton that is subdivided into inliers, including: Mount Isa Inlier, Coen Inlier, Yambo Inlier Dargalong Inlier the Mac Arthur Inlier and the Georgetown Inlier, which hosts the Croydon Gold Project and is the focus of this report. Similarities between the Georgetown, Yambo, Coen and Dargalong Inliers suggest that they form part of a continuous set of provinces (Withnall, et al., 2013).

The Georgetown Inlier is bordered to the East rocks of the Mossman and Thompson Orogens. It is separated from these by the Palmerville, Burdekin River and Teddy Mount Faults. To the west is the Carpentaria Basin which is composed of Mesozoic to Cenozoic sedimentary units up to 2000m thick (Bain & Draper, 1997). It can be subdivided into the Croydon Province to the West and the Ethridge Province In the rest of the region (Withnall, et al., 2013).

The Ethridge Province is extensive, and crosses the boundary into the Dargalong, Coen and Yambo inliers. Within the Georgetown Inlier, it is represented in the Paleoproterozoic Forsayth Subprovince. The Croydon Province consists of graphitic, s-type rhyolitic ignimbrites and comagmatic granites (Withnall, et al., 2013).

2.1 Paleoproterozoic

2.1.1 The Forsayth Subprovince:

Ethridge Group: Metasedimentary rocks ranging from offshore mudstones to deltaic sequences. Separated into lower and upper by the extrusive tholeiitic Dead Horse Metabasalt. Intruded by dykes and sills of the Cobbold metadolerite. The base is unknown but it is at least of Paleoproterozoic age. Metamorphic grade increases from very low in the west (sedimentary structures largely preserved) to very high in the east (schistose and gneissic textures are common) (Withnall, et al., 2013). Baker et al., (2010), suggest that at the time of the deposition of the Ethridge Group, the Georgetown inlier, Mount Isa Eastern Succession and Broken Hill Block represent dislocated fragments of a 1690–1650 Ma volcanic passive margin of Paleoproterozoic Australia.

> **Einasleigh Metamorphics:** Part of the Ethridge Group. Characterized by biotite and calc-silicate gneiss. Stratigraphic correlation to the units of the Ethridge Group cannot be made. Amphibolites and migmatites are common and are mapped as the Lyndbrook Complex. There are also ubiquitous pegmatitic and granitoid dykes, veins and pods. A proportion are interpreted as being locally derived leucosomes, whilst others are likely of a deeper melt origin.
>
> **Berker Creek Formation:** The stratigraphically lowest known component of the Ethridge Group. It is made up of calcareous to dolomitic, fine, subfeldspathic sandstone, siltstone and mudstone and contains a variety of current-related sedimentary structures. This sequence

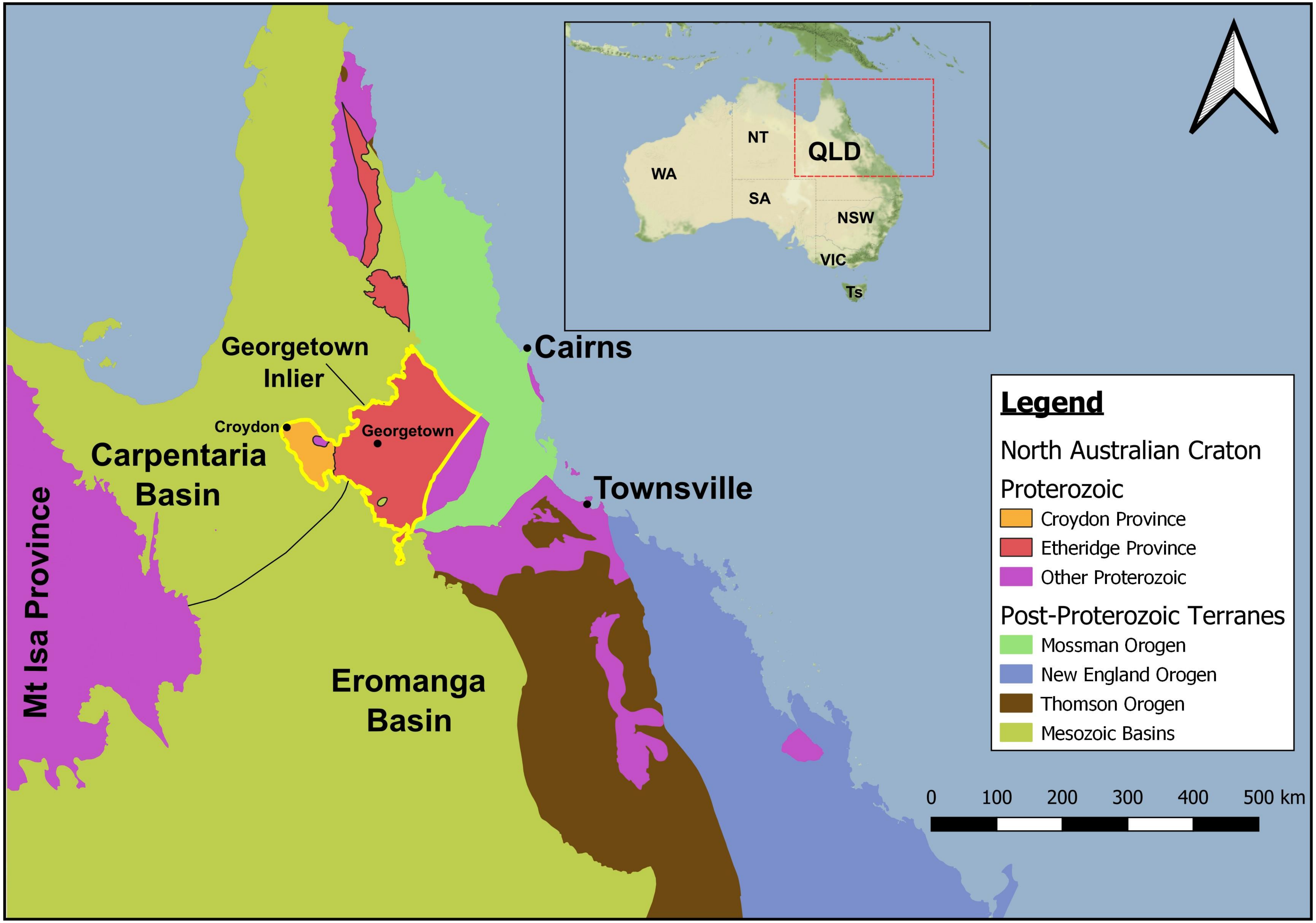

Figure 1: Structural Framework of North Queensland after (Withnall, et al., 2013).

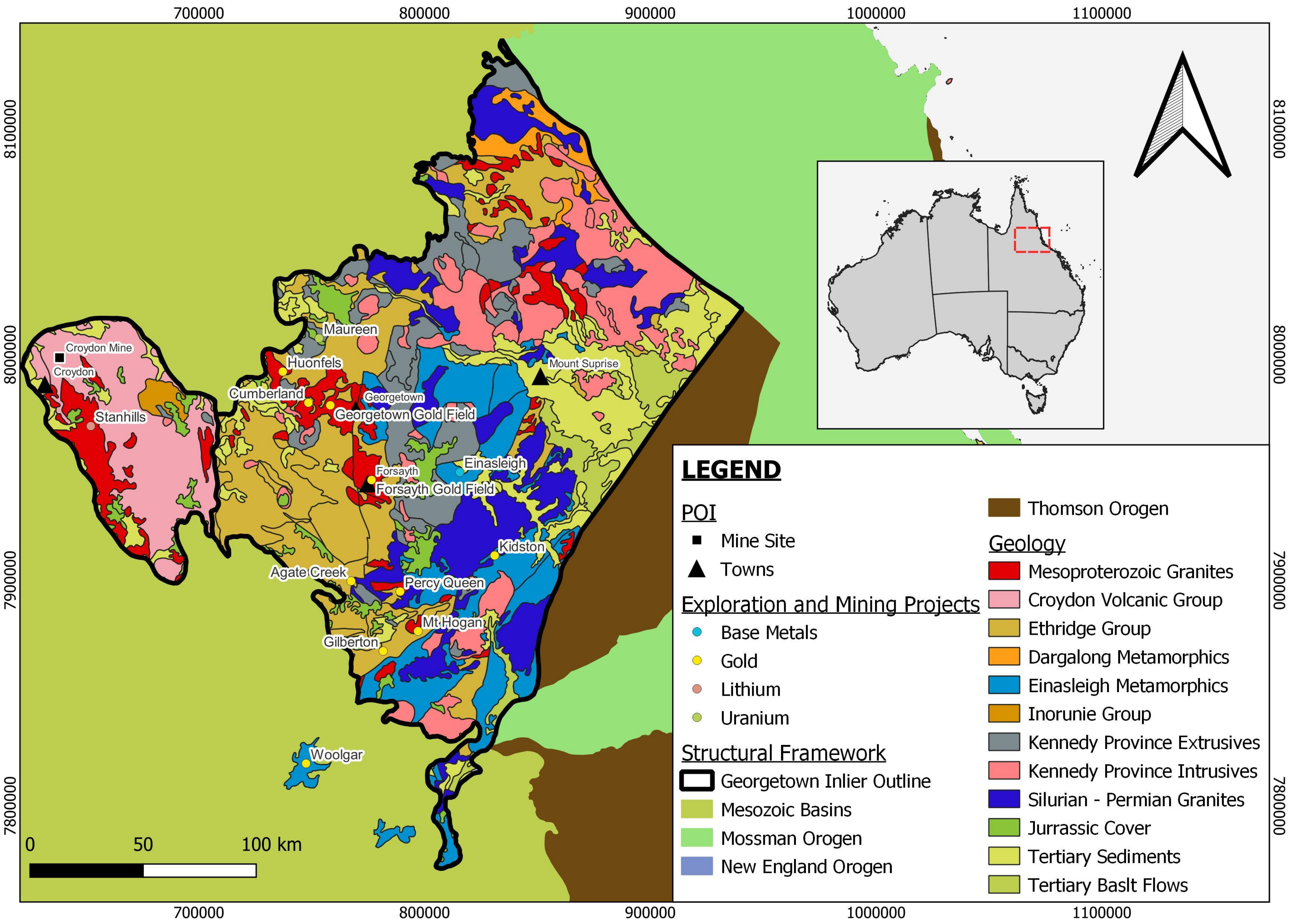

Figure 2: Simplified geological map of the Georgetown Inlier. Note the listed mining projects are not exhaustive and are focused on those mentioned in the report.

likely represents a turbidite environment of deposition. Towards the east, they grade into calcareous mica shist and quartzite, then into gneiss and granofels.

Robertson River Subgroup: Overlies the Berker Creek formation and consists of a series of metasedimentary units: The Daniel Creek Formation, the Corbett Formation and the Lane Creek Formation. They are mostly pelites grading into metapelites (mostly mica-schist) in the east. It also includes the Dead Horse metabasalt between the Daniel Creek and Corbett Formations. It is intruded by dykes and sills of the Cobbold Metadolerite. The Mcdevitt metamorphics are likely correlated with this subgroup.

Upper Ethridge Group: Made up of the Townley, Heliman, Candlow and Langdon River Formations. These are composed of fine-grained sedimentary rocks, with rare limestones and sandstones. The basal Townley Formation grades into mica-schist towards the east. This may either represent a tidal-flat or a deep water environment of deposition.

Langovale Group: Unconformably overlies the Ethridge Group. Grades from fluviatile felspathic sandstones to prograding distal turbidite sequences of mudstone with sporadic sandstone beds.

Yambo Subprovince: The Yambo Subprovince includes the Dargalong Metamorphic Group and occurs in the northern part of the Georgetown Inlier. The Dargalong Metamorphic Group comprises banded migmatitic gneiss, augen gneiss, amphibolite, with schist, quartzite and minor calc-silicate gneiss.

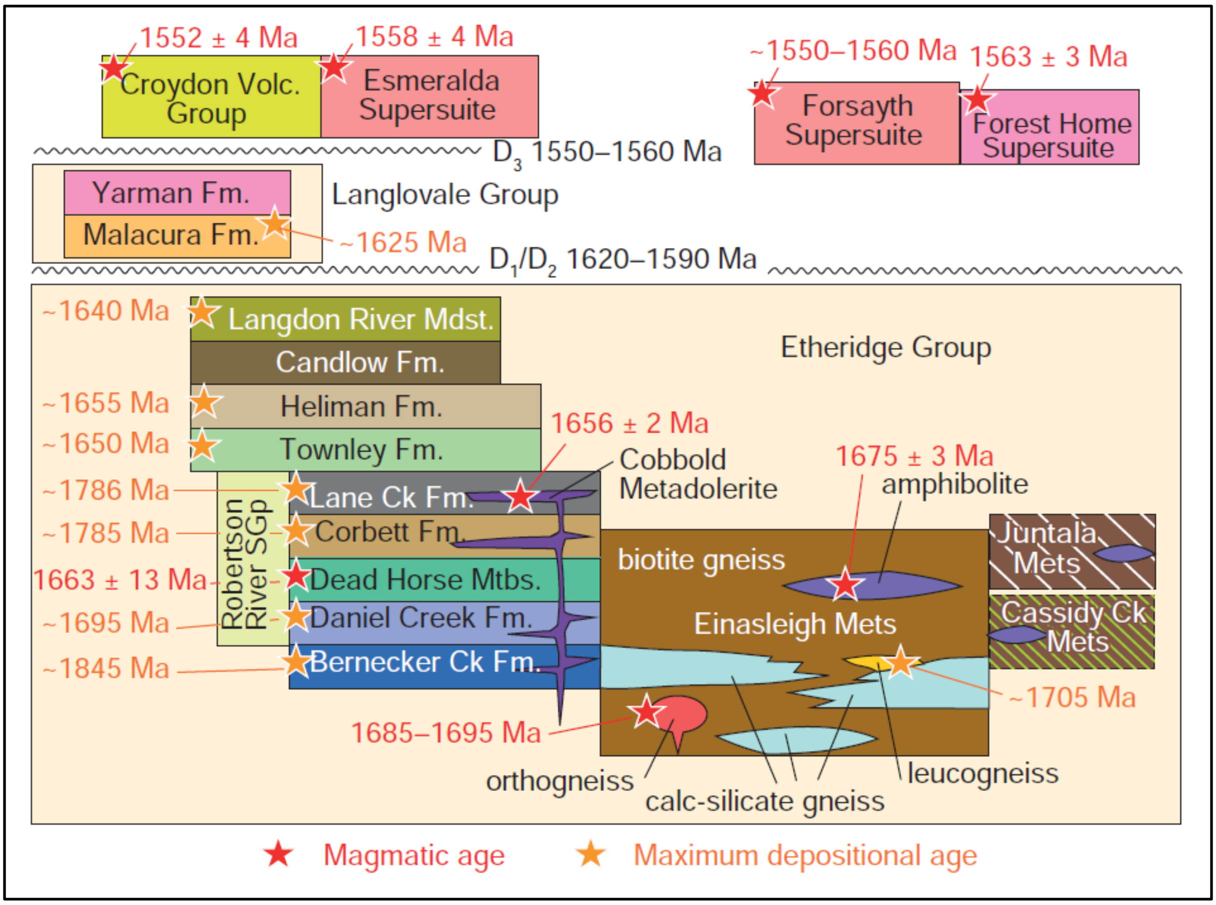

Figure 3: Time-Space Diagram for the Proterozoic Georgetown Inlier (Withnall, et al., 2013).

2.2 Mesoproterozoic

2.2.1 Croydon Province:

Croydon Volcanic Group: The main component of the Croydon Province. Dominated by graphitic, welded, S-Type rhyolitic ignimbrites. Sporadic outcrops of porphyritic rhyolite with contorted flow-banding. Dacitic ignimbrite and unwelded dacitic fragmental rocks, quartzose and quartzofeldspathic sandstones and siltstones, and minor andesite are also present, mostly near the base of the sequence and/or in the north of the outcrop area. It is intruded by S-Type graphitic granites of the Esmeralda Supersuite. The minimum thickness of the ignimbrites is 1.5Km, however, there is no exposure of the top or base of the volcanic succession. Metamorphic paragenesis (biotite, sericite, and chlorite) suggests that the currently exposed rocks have been overlain by as much as 3Km of additional eruptive material. The group is intruded by the Esmeralda Supersuite and displays extensive contact alteration. The ignimbrites were emplaced subaerially and extensional tectonics that accompanied source magma emplacement resulted in the caldera collapse of a 6,000Km^2 and several kilometers thick volcanic pile.

Esmeralda Supersuite: Numerous S-Type granite bodies, ranging from batholith-size (the Esmeralda Granite itself) to small stocks, that crop out in the westernmost part of the Georgetown Region. Most of the components are coarse-grained biotite granites with trace muscovite. Some of the smaller granite bodies contain garnet and can be fine-grained to porphyritic. It contains abundant graphitic pellets and some larger tabular bodies and it is co-magmatic with the Croydon Volcanic Group. It's high carbon and graphite content makes it unique in North Queensland and is likely derived from melting and incorporation of carbonaceous metasediments (Appendix 1).

Budd et. Al. (2001), suggest that some of the rocks of the Esmeralda Supersuite may be I-type and have been misinterpreted as S-type due to their carbon content. The reasons given are: **i)** Many sample of the granite are only moderately peraluminous and show an increasing ASI trend with SiO_2, similar to other fractionated Proterozoic Australian Granites such as the Hiltaba Supersuite which is associated with IOCG mineralisation in South Australia. **ii)** Hornblende was found in two samples of the granite and this was interpreted as relict primary hornblende. **iii)** Several of the granites are oxidized, whilst others are reduced. They suggest that the reduced character of some of the magmas being the result of an incorporation of carbonaceous metasediments. Relatively high magnetic susceptibility also suggests magnetite. The implication of these granites being I-type and oxidized is that they could be associated with IOCG or Porphyry-Type mineralisation. This is discussed later in this report (4.2.4).

2.2.2 Forsayth Batholith:

The largest collection of Mesoproterozoic S-Type granitoids in North Australia. It is hosted almost entirely in amphibolite facies schists. It is composed of 30 different plutons or pluton clusters and outcrops across the Georgetown Inlier, forming a sigmoidal batholith 90 × 20–30 km (Appendix 1). Xenoliths and enclaves of metasedimentary country rock are common. There many small, strongly deformed, irregularly shaped migmatitic bodies, mostly on the northeast side of the northern mass and southern side of the southern mass. Only one pluton displays contact aureole.

Forsayth Supersuite: Composed of the Aurora, Delaney, Forsayth, Goldsmiths, Mistletoe, Ropewalk, Welfem, Mount Hogan, Fig Tree Hill, Mywyn Granites and Digger Creek Granites. Most constituents of the supersuite are light to dark grey porphyritic biotite-muscovite granites, but the Welfem, Mywyn and Mount Hogan Granites are cream to pink or reddish brown. Alkali feldspar phenocrysts (and in some granites, megacrysts) and muscovite are relatively common constituents. Phenocryst size and distribution is variable and orientation commonly reflects an original flow fabric, which is locally modified by tectonic foliation. Enclaves (melanocratic spots and streaks) and locally abundant metasedimentary xenoliths (and some amphibolite) are common, particularly in the Mistletoe and Ropewalk granites, as are pegmatite veins and dykes throughout the batholith.

Forest Home Supersuite: Consists of the Forest Home and Talbot Creek Trondhjemites. The former is made up of I5 small (less than 1-10 km long), elliptical plutons that crop out in the Black Gin Creek area to the south of Forest Home homestead. The latter is a cluster of three main and several smaller, irregularly shaped, possibly interconnected bodies that crop out in the Talbot Creek area on the western side of the Newcastle Range between Georgetown and Forsayth. The Brady Hot I-type felsic granite is also a member of this supersuite. They are intruded into the Ethridge group.

2.2.3 Iourine Group:

Unconformable overlies the Croydon Volcanic Group. Consists of four formations including strongly indurated quartzose sandstone, micaceous sublithic sandstone, siltstone and mudstone. These are interpreted as having been deposited in a fluviatile environment. Intruded by Permian dolerite and granodiorite.

2.2.4 Hall's Reward Metamorphics:

A narrow belt up to 6 km wide adjacent to the western edge of the Broken River Province. The unit consists predominantly of medium to coarse-grained mica schist. The grade of metamorphism was probably in the lower to middle amphibolite facies.

2.3 Cambrian-Ordivician:

- **Balcooma Volcanics:** Rhyolitic metavolcanics, metasediments and minor mafic volcaniclastics.
- **Lucky Creek Metamorphic Group:** The constituent units of this group are from west to east, Lugano Metamorphics, Eland Metavolcanics and Paddys Creek Phyllite.

2.4 Silurian-Devonian

2.4.1 Pama Igneous Association:

Part of an extensive belt of Silurian to Devonian granites outcropping across most of the Tasmanides ranging from the Lachlan Orogen to the Thompson Orogen. In the Georgetown, it is represented by the Copperfield, Dumbano, Dido, Forsayth, Glenmore, Ingham, Robin Hood, Tate and White Springs batholiths.

White Springs: Mainly variably porphyritic to even-grained granodiorites, granites, tonalites and leucogranites. I-Type, mafic to felsic, mostly unfractionated, mostly reduced but some oxidised units (Anning Granite and Nundah, Oak River and Robin Hood granodiorites). Mainly weakly to strongly peraluminous with a large range of K values.

Dido: Commonly foliated; I-type; mafic to felsic; unfractionated; oxidised to reduced.

Eastern Dido Tonalite: Grey, biotite– clinopyroxene– hornblende quartz diorite and diorite; minor gabbro; commonly foliated. I-type; mafic; medium–high K; unfractionated; oxidised.

Mount Webster: Foliated, muscovite– biotite granodiorite to granite; muscovite–biotite leucogranite; biotite and muscovite–biotite granite. I-type; mafic to felsic (mainly); trondhjemitic; reduced; mainly medium K; unfractionated; moderately to strongly evolved.

2.5 Devonian-Early Carboniferous:

- A series of sedimentary rocks with relatively limited exposure. They include the Blue Rock Creek Beds,The Conjuboy Formation, The Gilberton Formation and the Bundock creek group.

2.6 Late Carboniferous – Early Permian:

2.6.1 Kennedy Igneous Association:

Intrusive and extrusive, predominantly felsic, magmatism throughout northern Queensland during the Carboniferous and Permian comprises the most widespread and voluminous magmatic event in the region. Where it overlies the Georgetown Region it can be subdivided into the Tate Subprovince in the north and the Kidston Subprovince in the South.

Tate Subprovince:

- **Pratt Volcanics:** Massive, welded, crystal-rich, rhyolitic ignimbrite commonly containing hornblende. Rare flows of glassy, aphyric to strongly porphyritic dacite and rare basalt and andesite are sporadically distributed in the basal part of the sequence. In places, a thin layer of quartzose sandstone and cobble conglomerate marks the base of the sequence. They are mostly I-Type.
- **Reamba Volcanics:** Massive, intensely welded lithics-poor to rich, crystal-rich rhyolitic ignimbrites and minor rhyolitic crystal-lithic tuff. Likely A-Type.
- **Sundown Volcanic Group:** Outcrops in the NE of the Georgetown province and includes various different ignimbrites. Unconformably overlies McDevitt metamorphics, Blackman Gap complex and the Ootan Supersuite.
- **Scardons Volcanic Group:** A composite cauldron collapse sequence dominated by ignimbrites and bordered by ring faults. The main rock type is massive, welded rhyolitic ignimbrite. Dacitic lithic ignimbrite is an important part of the lower sequence.
- **Newcastle Range Volcanic Group:** The Largest Carboniferous-Permian extrusive complex in the Georgetown Region and forms the 2,500Km^2 Newcastle Range that occupies the central Georgetown Region. It is mainly composed of subaerially-erupted ignimbrites with minor lavas, unwelded pyroclastics and rare sedimentary rocks. Compositionally, they range from rhyolites to andesites. The Group has been separated into 4 main Subgroups:
    1. The Wirra Volcanics in the South.
    2. The Kungaree Volcanics in the centre-north part of the structure.
    3. The Namarrong Volcanics that form the northern rounded lobe of the structure.
    4. The Eveleigh Volcanics that form the eastern lobe of the structure.

  The volcanics in the south and east of the lobe are predominantly I-Type, with high K_2O and low Sr, Rb, Th and U. The A-type rocks have lower CaO, higher K_2O, Ba, Zr, LREE, Zn, and Ga. The group unconformably overlies the Ethridge group metamorphic rocks as well as lenses of Devonian-Carboniferous sedimentary units. They are intruded by numerous comagmatic rocks of granitic to dioritic/andesitic composition.

- **Galloway Volcanic Group:** Outcrops 40Km north of Georgetown. Consists of equal proportions of rhyolitic and dacitic ignimbrites with minor andesitic ignimbrites, and minor rhyolite, dacite and andesite lava. Ignimbrites here are particularly rich in lithic clasts, with an abundance of granitic clasts derived from the underlying Silurian intrusive units. These rocks represent a near-vent and vent-fill facies. Geochemically, the rocks are of mixed character, with the rhyolites being predominantly I-type and the dacitic to andesitic rocks being closer to A-Type. The group is intruded by comagmatic, granitic stocks and dykes. It overlies and is faulted against the Ethridge group and the Forsayth Supersuite.

- **Maureen Volcanic Group:** A small exposure (80Km^2) 30Km north of Georgetown. The rocks are largely bimodal and is largely composed of crystal-poor to rich, lithic-rich rhyolitic ignimbrites and lavas; quartzose sandstone to siltstones; vitric tuff and augite andesite. The majority of this unit is overlain by sedimentary rocks of the Carpentaria and Karumba basins.
- **Silent Creek Volcanic Group:** Rhyolitic ignimbrites of mixed I and A character.

Tate Batholith: Consists of the Almaden, O'Brien's Creek and Ootan Supersuites. These are large supersuites mostly known from the Cairns region.

• The Almaden Supersuite is represented by a 1300m diameter stock of pyroxene-biotite-hornblende granodiorite grading into biotite granite in the centre. It is accompanied by of pipe-shaped stocks of vuggy augite-biotite-hornblende quartz diorite and porphyritic rhyolite grading into microgranite.

• O'Brien's Supersuite consists of large plutons of pale pink to white, alkali feldspar-rich biotite granites, leucogranites and microgranites, some of which are porphyritic and some of which are miarolitic. There are many small bodies of felsic, fractionated, miarolitic / porphyritic granites in the area, some of which contain topaz and fluorite. All rocks of the O'Brien's Creek Supersuite are altered, with greisen alteration being widespread and associated with Sn ± W ± Mo and F mineralisation. The supersuite is highly fractionated and has high proportions of HFSEs, HREEs and fluorite (in the most fractionated granites). Bain & Draper (1997) highlight that increasing frctionation in the late granites is correlated with decreasing SiO2 and increasing K2O, K/Rb, Na2O, HFSE, Sn, Ga, F. They suggest similarities to Li-F-rich peraluminous magmas. The high K2O, Th and U in the granites produce a bright γ-ray signature in spectroscopic pseudocolour images. Plutons from this suite have intruded the Ethridge, Dargalong and McDevitt metamorphics, as well as the Blackman Gap complex. It is intruded by the Ootan and Claret Creek Supersuites. It is overlain by volcanic rocks of the Scardons, Sundown and Newcastle Range Volcanic Groups. Mineralogically and chemically similar granites occur in the Herbeton-Emuford area, the eastern part of the Tate Batholith (east of the Palmerville fault) and the Coolgara and Herbeton Batholiths.

• Ootan Supersuite: The largest Carboniferous-Permian granite supersuite in North Queensland. It consists of a wide variety of rocks, from hornblende-biotite granodiorite to biotite leucogranite. Rock textures are also highly varied, with larger bodies tending to be coarser-grained, less porphyritic and more felsic than smaller ones. Geochemically, the supersuite has very felsic, high-K20, K/Na major-element compositions, with high Rb, low Ba, Zr, Nb and LREEs.

Kidston Subprovince:

- **Cumberland Range Volcanic Group:** Outcrops in the four different areas: the northern edge of the Georgetown Region, 26Km south-west of Georgetown in the Cumberland Range, the Mount Darcy area 25Km west of Georgetown and the Marquis Rhyolite near Mount Tabletop. The group is mostly comprised of 5 100-200m thick sheets of rhyolitic ignimbrite that are crystal-rich and contain up to 30% lithic fragments (mostly Ethridge group metasediments). These sheets are separated by arenites, siltstones, mudstones and limestones. The group is cut by the Comagmatic intrustions: The Mount Sircom Granodiorite, The Mount Darcy Granodiorite, The Prestwood Microgranite and the and unnamed rhyolite.

- **Butlers Volcanic Group:** This group outcrops at the Ballynure and the Glenmore homesteads South of Georgetown. The Group consists of crystal-rich rhyolitic ignimbrites that are lithic poor to rich. There are also some minor porphyritic rhyolites and arenites. Geochemically, they are K_2O-rich and variably oxidised I-type. It unconformably overlies Ethridge group and Silurian granites. It is intruded by various granites, rhyolites and micromonzonites.
- **Bally Knob Volcanics:** Various tuffs, lavas and ignimbrites intruded by a small microgranite pluton and porphyritic andesite.
- **Agate Creek Volcanic Group:** The units of this group occupy 3 small graben structures in the south of the Georgetown region. The top of the unit is a moderately porphyritic basaltic andesite up to 400m thick. The top of these andesitic flows are amygdaloidal and agate-bearing. In some areas the basalt is interlayered with mudstones and siltstones. In some the andesite is overlain by spheluritic rhyolite. Geochemically, the andesites are moderately evolved, high in Sr and LREE. The rhyolites are highly felsic I-types. The group is intruded by comagmatic dolerites. It unconformably overlies the Gilberton Formation.
- **Mount Little Volcanics:** Amygdaloidal, agate bearing andesites, moderately welded rhyolitic ignimbrite with dacite lava interbeds, hornblende-biotite dacite and fluviatile cobble to boulder conglomerates. The andesites are I-type with high levels of incompatible LILE. The rhyolites form two groups: oxidised, fractionated I-type and reduced K_2O A-types.
- **Bonnor Creek Granite:** Restricted to the Warby Ring Complex 20Km north of Mount Surprise, it is the only representation of the Claret Creek Supersuite in the Georgetown Region. It is described as a coarse to very coarse-grained leucogranitic, horneblende-biotite granite to granodiorite. The granite is geochemically distinct: it is a sodic granite high in Al_2O_3 and NaO_2 but low in K_2O relative to the other supersuites in the area.
- **Yataga Supersuite:** Two plutons 30Km north of Georgetown. They are composed of a main, outer zone of hornblende-biotite tonalite grading inwards to hornblende-biotite granodiorite containing abundant enclaves of earlier-emplaced fine-grained porphyritic hornblende-biotite tonalite. It is of I-type composition and intrudes the Ethridge Group, forming a 500m wide contact aureole.
- **Glenmore Batholith**: Two plutons of pink, fine to medium-grained, leucocratic biotite granites and porphyritic variants. They are named the Bagstowe and Lochaber Granites. The centre of the Lochaber hosts hornblende, topaz and fluorite. In the north of the granite there are several quartz veins up to 2m thick with greisen altered halos and scattered Mo-W mineralisation.
- **Kangaroo Creek Supersuite:** A series of composite granite plutons 50Km north of Georgetown. Most intrude the Galloway Volcanic Group and were likely emplaced at depths of 2-3Km. Granites in this supersuite are commonly granophyric, seriate to porphyritic textured biotite to hornblende-biotite granites. The Bull Creek Granite in this supersuite is notable for its extensive propylitic alteration. The Copper Bush Granite has a 1Km-wide halo of sericitic alteration.
- **Unassigned Intrusives:** There are many unassigned intrusive rocks through ought the Georgetown region that are likely of a Carboniferous to Permian Age. However, these have not been assigned to a group due to a lack of data. One granite of note for this report is the Purkin Batholith. This is located in the headwaters of George Creek. Cassiterite and fluorite were reported from a sample of fine-grained porphyritic biotite granite collected in this area.

Mesozoic

- There are scattered outliers of Jurassic to Cretaceous Carpentaria Basin sedimentary rocks overlying the Georgetown province in the west.

Cenozoic

- **Sediments:** Sedimentary rocks from the Bulimba formation of the Karumba Basin to the West occur as mesas and valley infills.
- **McBride Subprovince:** A significant part of the Eastern Australian Cenozoic Igneous Province (EACIP) that extends from the Torres Strait to Tasmania. In the Georgetown region they overlay the Ethridge and Thalanga Provinces. They are mostly basaltic in composition with relatively little geochemical variation.
- **Chudleigh Subprovince:** Another major component of the EACIP, the subprovince is characterised by broad, partly dissected lava plains with numerous pyroclastic cones, some composite cones and several lava shields. Moderate to strongly-nepheline normative basaltic rocks are common. The Subprovince is notable for an abundance of lower-crustal to upper-mantle xenoliths. The Undara volcanics are included in this.

2.7 Structural History

The metasediments of the Ethridge Group are complexly deformed. The deformation history can be subdivided into three periods: **i)** An early north–south shortening event of unknown age (possibly ~1590 Ma) associated with minor metamorphosis. **ii)** East–west shortening and granite emplacement of the Forsayth Batholith at ~1550–1560 Ma. Major metamorphism is associated with this event. **iii)** Several folding events of Silurian to Devonian age. These are accompanied by significant retrograde metamorphism events and emplacement of I-type granites and most of the gold deposits hosted in the Ethridge Group.

The Croydon Volcanic Group is younger than most of the deformation in the area, and is relatively undeformed, with minor burial low-grade metamorphism and faulting related to an episode of cauldron collapse.

Table 1: Simplified summary of deformation / structural history of the Georgetown Inlier (Withnall, et al., 2013).

Designation	Age	Structural Regime	Metamorphism	Comments
Early Metamorphism and Deformation	Pre-1675Ma			
D_1	1620 Ma	N-S Shortening		
D_2	1590 Ma	E-W Shortening	Medium-Grade Metamorphism	
Uplift	1590-1560 Ma	Uplift	Retrograde Metamorphism	
D_3	1560-1550 Ma	NW-SE Shortening	Low P – High T Metamorphism	Emplacement of S-Type Forsayth Supersuite
Mesoproterozoic Igneous Episode	1550 Ma	Extensional		Emplacement of Esmeralda Supersuite. Mineralisation of Croydon Goldfield
D_4	1510 Ma			
Silurian-Devonian Folding	400 Ma		Retrograde	Emplacement of I-Type Batholiths. Mineralisation of metamorphic-hosted gold fields.

2.8 Short Geological History with Relation to Metallogenisis

Archean: Detrital zircons indicate a possible archean source for the Paleoproterozoic metasediments in the Ethridge Groups (Nordsvan, et al., 2018).

Paleoproterozoic: Deposition of the Ethridge group precursor sediments during the sag phase of a passive margin or during intercontinental rifting (Nordsvan, et al., 2018). The same rift setting led to the emplacement of basaltic magmas, including the Dead Horse Basalt that separates the upper and lower Etheridge groups.

Mesoproterozoic: The Ewamin and Jana orogenies were major deformational and metamorphic events that occurred between 1580-1550Ma as the tectonic setting transitioned to contractional. Deformation was accompanied by emplacement of I and S-type granites in the eastern parts of the Georgetown Province, metamorphosis occurred shortly after. Towards the end of the deformational period, The Croydon Volcanic Group was emplaced contemporaneously and comagmatically with granites of the Esmeralda Supersuite (Bain & Draper, 1997). The mesothermal gold deposits of the Croydon Gold Field were likely emplaced during this time.

Paleozoic: Alternating periods of contractional and extensional tectonics that caused deformation of the existing rocks and emplacement of both granitoids and basaltic intrusives (Withnall, et al., 2013).

Silurian-Permian: Emplacement of the I-type granites of the Pama Province and the Kennedy Province that outcrop as batholiths throughout the region. These likely acted as a source for the Devonian-age gold mineralization in the Forsayth, Georgetown and Gilberton goldfields. Carboniferous dykes and associated batholiths acted as the source for the Kidston ore deposit. Emplacement of Galloway and Maureen Volcanic Groups that are associated with uranium and fluorine deposits (Withnall, et al., 2013).

Mesozoic: Deposition of mesas of sedimentary rock that overlie the Georgetown Province as outliers of the Carpentaria Basin to the West and the Eromanga Basin to the South (Withnall, et al., 2013). These may host uranium deposits along the unconformable boundaries with metamorphic basement rocks.

3 Metal Deposits

There is a wide range of mineral deposits in the Georgetown Inlier. The following is a list of the most significant and representative of those deposits. Numerous other small deposits and occurrences exist but are not included here due to a lack of information or low relevance.

3.1 Lithium and Tin

Tin in the Georgetown region has historically been mined from alluvial cassiterite sources. Modern-day exploration is focused around the greisen-type deposits proximal to the region's s-type granites. Companies exploring for this type of deposit are primarily targeting discovery of lithium, with tin as a side-product.

Alluvial cassiterite fields have historically been extensively mined in the region. The remaining deposits have largely been classified as uneconomic to mine.

3.1.1 Buchanan's LCT Pegmatite Field

This Lithium prospect is situated south of Georgetown and is held by Strategic Metals Australia. It consists of a series of highly fractionated pegmatites enriched in Li, Ta, Rb and Cs. These are related to the Buchanan granite of the Forsayth Supersuite. Closure of the pegmatite system is reported as 100Ma after the emplacent of the parent granite. Fractionation and Li enrichment increase with distance to the parent granite. The main ore mineral is the lithium mica lepidolite, with the average grade of pegmatites at 1.32 % Li_2O, 250 ppm Ta_2O_5, 620 ppm SnO_2, 0.13 % Cs_2O and 0.5 % Rb_2O. These pegmatites have associated alteration halos that are also enriched in these elements. Metallurgical processing of the lithium micas will likely be the main obstacle to the economic viability of this project (Strategic Minerals Corporation, 2019).

3.1.2 Stanhills Tin Field

This area lies just south of the Plethora tenements at Croydon. 260 tons of cassiterite ore was extracted from the tin field between 1900 and 1936. The tin ore is hosted within greisen-altered granites of the Esmeralda Formation. The lodes commonly contain cassiterite, quartz and fluorite as well as sulphide minerals including chalcopyrite, pyrite, sphalerite, galena and arsenopyrite.

The greisen's are also reported to host lithium mineralization in the form of zinnwaldite and lepidolite micas. These are currently being explored for by Boadicea resources on EPMA 28125 (Boadieca Resources, 2022).

3.2 Gold

Morrinson, et al., (2019) provides a classification for different deposit types in the Georgetown Region: **Epithermal-related** systems charachterised by chalcedonic and boiling textures; **Intrusion-related** deposits which are pollymetallic and have prominent Te-Bi and As-Sb signatures, these are further subdivided by ages into Permian, Early Carboniferous and Late Carboniferous; **Plutonic** deposits of Devonian age that have no clear spatial or temporal link to intrusive episodes, these are often hosted in shear zones.

The epithermal deposits in the region have similar geochemical characteristics (Significant Te and Ag>Au) to the intrusion related epi/meso-zonal deposits. Both deposit styles can also be linked to rhyolitic dykes. Morrinson, et al., (2019), suggest that this implies a genetic link between both deposit styles. This model enhances the likelihood that the epithermal systems are linked to a deeper feeder zone.

3.2.1 Plutonic Gold Veins

The Proterozoic metasediments of the Georgetown Inlier are host to a number of gold-bearing systems where mineralisation is associated with Early Devonian shear zones. They can be shallow or steep dipping and often extend for kilometres along the structure. There are three main camps in for this type of deposit: Georgetown, Forsayth and Gilberton.

Georgetown and Forsayth: Gold at both of these camps is hosted by intermittently mineralised, multiple, steeply-dipping shear zones 5-25Km in length. There is evidence that the shear zones are long-lived structures, as multiple phases of shearing, brecciation and veining are observed. In some areas, high-grade lodes are continuous and were exploited by historic miners, in other places, the lodes were disturbed after formation, brecciating and shearing them, causing incorporation of wall rock and dilution of the grades. The primary texture of these lodes is buck quartz. However, breccias are common where systems have been re-activated, and these show silica and sulphide replacement textures. Finer-grained textures often show higher gold grades. The shear zones cut both metasediments and granites. Grades are often higher in the latter, likely due to more brittle fracturing resulting in more open space for the precipitation of minerals. On a district-scale, there is a geochemical zonation whereby occurrences in the cores of the districts are enriched in bismuth and tellurium and the peripheral deposits tend to be more silver and arsenic dominant. This may suggest that the cores of these districts are closer to the magmatic fluid sources (Morrinson, et al., 2019).

Gilberton: The Gilberton Camp is hosted along a NE- trending lineation that marks the boundary between the Ethridge Group and the Einasleigh Metamorphics. Mineralisation is hosted in sets of narrow (<2m) steeply dipping shears. Gold is found in quartz veins and silicified breccias within these structures. The shear zones are normally parallel to the dominant foliation in the region, although there are a few exceptions (Commissioner Hill and Oratava). The largest deposit in the camp is Comstock. It consists of a broad, linear, northeast striking, steep northwest dipping zone of breccia, cemented and replaced by buck quartz, iron carbonate, magnetite and pyrite. Where these deposits are hosted in metadolerite, they will include iron carbonates as infill and alteration minerals (Morrinson, et al., 2019).

3.2.2 Intrusion- Related

The are split into three age groups: early Permian, and early Carboniferous, and two possible late Carboniferous examples (Mt Turner, Log Creek). All the deposits have prominent Te-Bi and As-Sb and are mesozonal to epizonal. Kidston and other nearby early Carboniferous deposits are Au-rich mesozonal hydrothermal breccias, whereas the deposits west of Georgetown are early Permian – late Carboniferous Au>Ag lode deposits (Electric light, Cumberland Mine, Beverley, Double Z) or Ag>Au epizonal-mesozonal lodes, stockworks and breccia deposits (Ironhurst, Phyllis May, Mt Turner, Bald Mountain) (Morrinson, et al., 2019).

Kidston (Morrison, 2007)

Kidston was the most productive gold mine in Eastern Queensland, having produced 5Moz Au from 109Mt of ore between 1985 and 2001. Gold mineralization occurs within a funnel-shaped breccia pipe 1100 m by 900 m at surface and at least 1300 m deep. It is hosted in Proterozoic migmatites of the Einasleigh Metamorphics and is situated at the boundary between granodiorite and banded biotite gneiss-amphibolite metamorphic phases. Pre- and post-breccia dykes are common within the structure. The character of the breccia grades from milled clasts in a rock flower matrix at the core to shingle texture at the margins and towards the top of the pipe. The precursor lithology of the breccia can be traced by the clast composition, indicating a relative lack of clast movement. The boundary of the pipe is a mix between reginal faults and fractures related to the brecciation event. It is estimated that the pipe formed at 3.5Km from the surface.

Mineralisation occurs as sheeted veins of comb quartz, carbonate, base metal sulphides; breccia infill and replacement. The gold is primarily hosed as inclusions in the sulphides. There are 5 phases of porphyry, with each having different variations of potassic-phyllic alteration and being related to different stages of breccia development and mineralization. The third stage was the main period of breccia development whilst the fourth is responsible for the main mineralization event. There is top-down metal zoning in the deposit from barren carbonate to gold + basemetals; Zn+Pb+Cu+As; Cu+Zn; Mo+Cu; Mo+W; and Mo. Gold orebodies do don’t extend below 250m from the top of the pipe. Morrison (2007), provides an overall model for the development of the deposit:

1. Progressive refinement of magmatic fluid related to successive batches of magma tapped off an underlying zoned magma chamber;

2. Confinement of the final fluid aliquot within the cylindrical closed breccia pipe and thermal zoning of the trapped fluid concentrating gold and basemetals in the upper part of the cylinder;

3. Emplacement in the upper part of the cylinder of piston-like sills and dikes that heated and over-pressured the trapped gold-bearing fluid;

4. Collapse of the underlying magma chamber and withdrawal of the piston leading to pressure drop, phase separation and gold-basemetal mineralisation in the upper part of the cylinder.

This type of deposit is not easily replicated, as these breccias are not inherently permeable and a stage of gas excavation is needed to generate the porosity for magmatic porphyry fluids to infill. A later stage of dyke emplacement is needed to trap and heat the fluids in order for gold zonation to occur, followed by a collapse event that creates a drop in pressure and subsequent mineralization event. It is therefore very difficult to both explore for buried breccias and to recognize mineralized ones (Morrison, 2007).

Cumberland Mine

The Cumberland Mine is the biggest individual, historical producer close to Georgetown, producing 1581 kg gold at an average grade of over an ounce per tonne. The deposit is hosted along a northeast striking Early Devonian structure with mineralisation related to Permian dykes. Mine records show that the shape of the ore shoots were complex, controlled by jogs in the host structure and overprinting of early quartz vein material by gold- bearing sulphides. The mine reached a maximum depth of 310m and was only mined along strike for around 400m, and although the lode was recorded to have pinched out at depth the host structure was still present (Morrinson, et al., 2019).

Mount Turner

Located 11Km north of Georgetown, this deposit is classed as a Co-Mo porphyry system. It is hosted in the Proterozoic Forsayth Granite and metasediment of the Lane Creek Formation. Morrinson, et al., (2019) describe a magmatic hydrothermal system 6Km in diameter with an early phase of Cu mineralisation associated with a NNE-trending rhyolite dyke swarm and associated potassic and sericitic alteration. A set of micro-granodiorite plugs with local dykes form a second phase of intrusion and is associated with breccias and potassic-sericitic alteration. It is this secon phase of intrusions that is responsible for significant Cu-Mo mineralisation and As-Pb-Zn-Cu-Ag-Au veins (Morrinson, et al., 2019).

3.2.3 Epithemal

Agate Creek Epithermal Gold

Currently held by Laneway Resources, the Agate Creek epithermal gold prospect is estimated to contain 381,000Oz Au at a cutoff of 0.5g/t Au. Mineralisation is hosted in breccias and veins in and around shallow-dipping Permian rhyolite dykes, which intrude a body of Silurian granodiorite. The rhyolite dykes are centered on thrust faults that also separate the granodiorite from adjacent Proterozoic metamorphics. Mineralisation is terminated by N & NW-trending steep normal faults. Gold is present in irregular swarms of narrow chalcedonic quartz veins that grade into breccia and stockwork. It is one of a series of similar deposits along a NW-SE trending fault zone occupied by dykes and volcanic complexes, possibly linking to a deeper, high grade feeder zone at depth (Morrinson, et al., 2019).

Woolgar Epithermal Gold

Developed by Strategic Minerals Corporation. The Woolgar project is located in an exposed window of the Einasleigh Metamorphics surrounded by sedimentary rocks of the Carpentaria Basin. The deposit has measured, indicated and inferred resources of almost 2Moz spread across 5 orebodies. The deposit represents three styles of mineralisation: epithermal vein deposits at Sandy Creek, mesothermal veins along the NE-SW trending Woolgar Fault Zone and intrusive related mineralisation (“IRGS”) in the Upper Camp (Strategic Minerals Corporation, 2019).

3.2.4 Croydon Gold Field

The Croydon Gold Field extends across the central and northern portions of the Croydon Volcanic Group. Mineralisation is hosted in rhyolitic ignimbrites and takes the form of quartz – pyrite – galena – arsenopyrite veins. These veins grade into breccia locally and pinch and swell heavily, going from 1.5m wide to centimeter-scale stringers. Veins have two sets of orientations: Shallow (30^o) east-dipping, N-S trending; and sub-vertical N-S trending hosted in shear zones. There seems to be little geochemical variation between the two sets of veins, indicating a common fluid source and mode of mineralisation.

Grades of gold are highly variable within the veins, likely due to coarse gold having a nugget effect. There is a strong positive correlation between lead and gold in these veins, particularly in the highest-grade samples. Alteration is fairly limited in the host rock, with local, minor sericite and some chlorite-epidote alteration.

Mineralisation was likely generated by the emplacement of the Esmeralda Granites at 1550Ma. The current exposure represents a paleo depth of up to 3Km in places, although it is likely shallower in most of the region. The Croydon Volcanic Group has been interpreted as a collapsed caldera, but it is unclear how the caldera relates to mineralisation.

3.2.5 Mount Hogan

Held by ActivEX ltd. This is a historic Au-Base Metal-U deposit. It is the largest in the Gilberton gold field. It is hosted in the Proterozoic Mt. Hogan Granite. Mineralisation is hosted by a series of stacked, lenticular, SW-dipping (15-20^o) quartz-sulphide veins with medium-grained, buck-textured quartz. The veins show evidence of later brecciation caused by movement along the vein. Sulphides are usually hosted in vein cores. Veins can be up to 60cm wide but are normally on the order of 10-20cm. They are surrounded by a proximal halo of sericitic alteration and a distal chlorite-epidote alteration assemblage. Uranium is hosted as uraninite in the veins and sericitic alteration zone, with secondary uranium as torbernite dispersed around these. It is unclear if uranium is actually a significant component of the deposit, as most of the discussion originates from the 1970s uranium boom and modern publications make no mention of it. The shallow-dipping lodes have only been drilled to shallow depths, leaving potential for extension of the mineralized system (Morrinson, et al., 2019).

There are clear similarities between the style of mineralisation at Mt. Hogan and the Plethora-owned Croydon prospects. Namely the shallow dipping, buck textured quartz and spatial (if not genetic) association with S-type Proterozoic granites (Forsayth Batholith at Mt. Hogan, Esmeralda Supersuite at Croydon). These granites seem to be prospective in the Georgetown Province, yet they are relatively unexplored for gold, only recently receiving attention for their lithium prospectivity.

3.3 Uranium

The Georgetown province was extensively prospected for Uranium during the 1970s. Despite this, the Maureen deposit is the only Uranium project in advanced stages of exploration (Hurtig, et al., 2014).

Uranium in the Maureen deposit is structurally controlled by the intersection of steep east-west fractures with an unconformity between a Proterozoic basement and a Paleozoic cover sequence of continental sedimentary rocks and abundant rhyolitic volcanic rocks. The ore takes the form of pitchblende + Fe-rich molybdenite + arsenopyrite + arsenian pyrite + fluorite + dickite + chlorite + goyazite ± graphite or hematite. Zonation within orebodies is a tabular zone of U-Mo rich ore surrounded by a fluorite-rich halo. Evidence points to mineralization forming along a strong chemical gradient between the reduced basement and oxidized cover sequence (unconformity model), although it has also been described as a volcanogenic uranium deposit (Hurtig, et al., 2014).

3.4 Copper, Zinc, Lead

3.4.1 Einasleigh Copper Field

A diverse set of Copper deposits hosted in the Einasleigh Metamorphics.

Einasleigh Copper Mine

Currently held by Aurora Metals. This copper deposit is hosted in the Einasleigh Metamorphics. It is an old operating mine. Modern Indicated and Inferred Resources are include of 825,000 tonnes at 3.0% Cu, 0.17 g/t Au, and 14 g/t Ag. There are two main ore bodies hosted within calc-silicate and biotite gneiss:

> **The Big Orebody** is a structurally controlled semi-massive sulphide deposit. Mineralisation is hosted in tabular, steeply dipping bodies of breccia up to 20m wide. Clasts are composed of biotite-chlorite-silica altered wall rocks, including gneiss and pegmatite, in a matrix of semimassive to massive sulfide. The orebody is haloed by a dense network of fractured infilled by biotite that has been replaced by sulphides, forming a low-grade envelope 10s of meters from the deposit. Host rocks show enrichment in Au, Ag, Ba, Bi, Ca, Cu, Fe, Mo, P, S and Zn; with depletion of Al, Na, K, Mg and Rb (Lees & Bucke, 2014).
>
> **The New Orebody** is a 100mx30m tabular skarn-like orezone plunging 30^{o} south within a synform. The host rock is a calc-silicate gneiss. Mineralisation takes the form of disseminated, vein and replacement pyrrhotite-pyrite-chalcopyrite in a matrix of various amounts of pyroxene, amphibole, garnet, magnetite, barite, epidote, quartz, apatite and chlorite.

The orebodies intersect each other and form a higher-grade zone. Mineralisation ages for the orebody place it at 1400-1430Ma. They were likely remobilized into their current form during a coincident structural event which also upgraded the skarn of the New Orebody (Lees & Bucke, 2014).

Kaiser Bill

An IOCG deposit held by Aurora Metals. It is currently in exploration stage and is historically undeveloped. The mineralisation occurs as chalcopyrite, associated with quartz-pyrite-pyrrhotite-magnetite as disseminations, stringers and breccia hosted by quartz-feldspar-biotite gneiss. The deposit outcrops as a 1Km-long gossan, with a Cu-enriched supergene zone occurring 10m below surface. The deposit dips 40° south-east and plunges ~20° south-west. Alteration forms a relatively broad zone up to 120m wide with magnetite and weak quartz-chlorite and lesser epidote with very minor actinolite. The main ore zone occurs within quartz-feldspar-biotite gneiss close to the contact with a felsic gneiss that forms the hanging-wall. The most recent resource included 16.91Mt at 0.83% Cu and 5.83ppm Au (Aurora Metals, 2022; Lees & Bucke, 2014).

Chloe and Jackson Deposits (Lees & Bucke, 2014)

Two deposits with similar characteristics held by Aurora Metals. The Chloe (2.7 Mt @ 2.0% Pb, 5.1% Zn, 0.3% Cu, and 38g/t Ag), and Jackson (1.9 Mt @ 2.1% Pb, 4.5% Zn, 0.2% Cu, and 73 g/t Ag) ore bodies are part of the same Broken Hill – Type SEDEX system. They occur within a complexly deformed metamorphic sequence of metasedimentary biotite quartzo-feldspathic ± garnet ± sillimanite gneiss and interbedded psammitic gneiss and minor calc-silicate. Numerous amphibolite units are present. Mineralisation is intimately associated with a folded, disrupted quartz-epidote-garnet unit, interpreted as altered calc-silicate.

Chloe mineralisation occurs predominantly as a single large lens with several adjacent smaller lenses. The lens dips 60–70° north and plunges ~50° east and parallels the main foliation. It is up to 30 m thick, extends over 100 m downdip and for at least 300 m down plunge. The Jackson resource, located ~1 km west of Chloe, is contained within a sheet-like structure that dips 50° north, is of variable thickness (2–16 m), and is continuous along-strike for 500, extending at least 300 m downdip.

Both ore bodies display similar high-temperature alteration and mineralisation assemblages, and overprinting relationships. There are four main stages of mineralisation:

1) Quartz-epidote usually occurs as an outer barren zone comprising quartz and epidote-zoisite, ranging from textural replacement of calc-silicate to coarsely granoblastic and grading into the garnet assemblage.
2) Garnet-quartz-pyrrhotite-sphalerite with magnetite, galena, chlorite, pyroxene and amphibole.
3) Pyrrhotite-calcite-pyroxene-amphibole-sphalerite and minor magnetite, garnet, galena and chalcopyrite, typically in the core of thicker mineralisation.
4) A minor assemblage of magnetite-andradite with pale (low Fe) sphalerite. This is suspected to represent a retrograde facies.

3.5 Toolebuc Vanadium

Owned by Wilson Minerals. Potentially economic concentrations of vanadium have been reported in the Toolebuc Formation of oxidized shale occurring within a 6.5Km x 25km corridor west of Croydon. The deposit model is unknown, but there is reportedly potential for economic molybdenum, uranium and nickel mineralisation.

3.6 Gemstones

There are a diverse range of occurrences of different types of gemstone in the Georgetown inlier:

Agates: Occur mostly in amygdules found in lava flows and derived sediments.

Aquamarine and Beryl: Occur in pegmatite dykes and veins in various Carboniferous granites.

Sapphire and Zircon: Have been found in alluvial cassiterite fields in the region.

Other gemstones are found sporadically as xenoliths in Cenozoic basalt flows.

3.7 Cadnium – Gallium – Germanium – Indium

Several reports reference the Wallabadah area, north of Croydon as having some degree of Cd – Ga – Ge – In, mineralisation in veins. However, this has only been noted in passing and the source for this information is not clear. It is unknown if this is the same Wallabadah area as the one in the north of Plethora's Croydon exploration tenement (Bain & Draper, 1997; Withnall, et al., 2013).

3.8 Silica

There are numerous mentions of silica projects in the Georgetown Inlier. These include the Mt. Eliza silica sands prospect and the Lighthouse hard quartz mine. However, details on the geology or production of these are not available.

4 Exploration Potential

4.1 Under Cover Exploration

Virtually all of the exposed portions of the Georgetown inlier have been staked by mineral exploration companies. However, the inlier continues under cover of the Carpentaria Basin to the west, north and

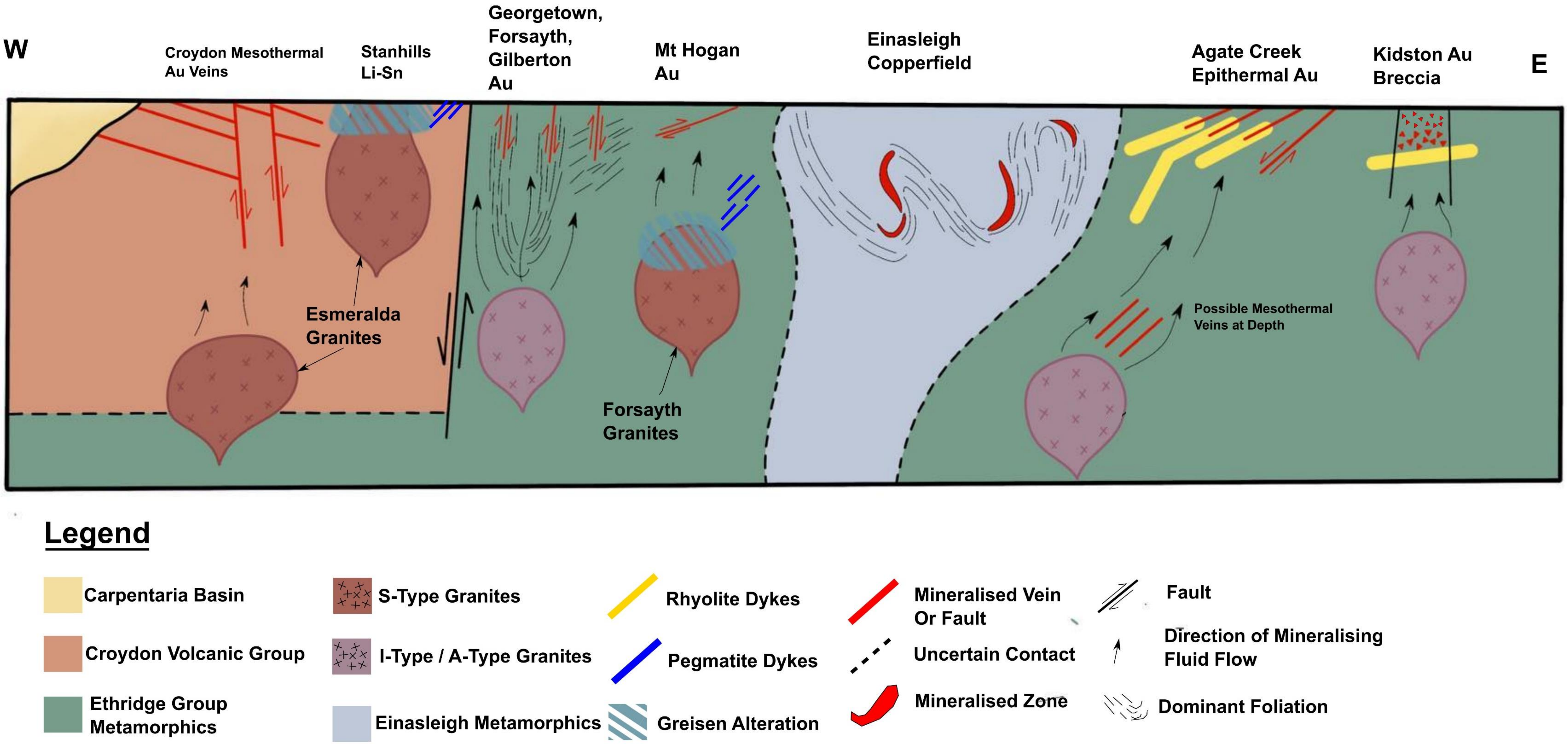

Figure 4: Simplified block model of the metallogenic environment of the Georgetown Inlier. Sizes / distances are not to scale and are exaggerated for illustrative purposes.

south-west. Whilst the most proximal areas under cover have also been staked, there are several regions where cover is between 100m and 200m thick and is underlain by basement rocks of the Georgetown Inlier.

Exploration of the basement rocks beneath the Carpentaria Basin has yielded great success in the areas around the Mt. Isa region (a major prospective inlier of the North Australian Craton), with deposits such as Osborne and Ernest Henry being found under 50-100m of cover. The type of deposit in Mt. Isa is highly magnetic, compared to the non-magnetic deposits in Georgetown. This has resulted in stronger magnetic anomalies that have garnered more attention near Mt. Isa for under-cover exploration. This presents an opportunity for explorers to use other methods to identify prospects beneath the cover near Georgetown.

Methods for exploring this terrain could include:

- Soil sampling surveys with samples digested using selex methods (Eg. MMI) or similar techniques that attempt to amplify the signals of elements migrating up through cover from buried deposits. This has been successful in delineating actionable anomalies in lithified Mesozoic cover near Mt. Isa (Hannan, et al., 2018).
- Biogeochemical surveys of deep-rooting plants common in the savannah terrain of North Queensland. These techniques have also had some success in the area around Mt. Isa (Hannan, et al., 2018).
- Groundwater sampling of the many boreholes in the region could be an effective prospecting medium. For examples, at Ernest Henry, pre-mining samples of groundwater show anomalous metal values up to 2Km from the deposit. This type of survey must be done with caution, as the interaction between groundwater and mineral deposits is poorly understood and is very complex. A good hydrological understanding of the aquifers in the region will be necessary for interpretation of the results (Hannan, et al., 2018).
- High-resolution mapping may reveal small outcrops in what was thought to be covered terrain.
- Base-of-cover drilling and sampling.

4.2 Gold

The Georgetown Inlier has a long history of gold extraction and prospectivity. Despite this, the area has received little attention and no large gold deposit has been mined since Kidston Mine closed in 2001. The reason for this is unclear, but it is unlikely that there are no other large gold deposits in the area considering the large number of small to medium – sized deposits throughout the region. An overview of prospectivity by deposit type is given below:

4.2.1 Mesoproterozoic Gold (Croydon Type)

The known instances of gold mineralisation related to S-type Mesoproterozoic granites are mainly found in the Croydon Province, with the notable exception of Mt. Hogan in the Ethridge Group. Surface expressions of the gold-bearing quartz veins in the Croydon region are well-delineated. Further study should focus on understanding which veins are prospective enough for follow-up exploration through trenching to test along-strike, and drilling to test at depth grade continuity.

Outside of the Croydon Province, exploration should focus on regions around occurrences of s-type granites of the Forsayth Batholith, as well as in rhyolites adjacent to these. Geochemical surveys would be a good exploration vector in areas of cover proximal to these granite outcrops. Base metal associations, particularly Pb, would serve as useful pathfinders.

At both Croydon and Mount Hogan, there is a significant lack of drilling at depth down-dip of the lodes. This is an obvious target for further exploration to delineate these structures at depth.

4.2.2 Devonian-Permian Shear Hosted Gold (Georgetown Type)

This type of gold deposit is heavily controlled by the orientation of the structures it is hosted in. An obvious vector for exploration would be investigating the continuation of these structures along-strike, including where that strike would intersect granites as the more brittle type of fracturing in these rocks would create more space for the mineralisation of gold.

4.2.3 Devonian-Permian Intrusion Related Gold

The most significant gold-producing mine of the region was the Kidston breccia deposit (5Moz). This has placed a lot of attention on other intrusion-related breccia deposits such as Mt Borium, Beverly and Ironhurst. However, none of these have resulted in significant discoveries. It is likely that this type of deposit in not generally prospective in the region. As discussed, mineralisation at Kidston is highly dependent on several overlapping geological phenomena, making discovery of a similar deposit unlikely. There may be a mineralisation related to a more proximal porphyry environment, although no discovery of this type has been made.

4.2.4 Esmeralda Supersuite as I-Type, After Budd, et al., (2001)

The hypothesis that the Esmeralda Supersuite is in fact an I-Type granite was discussed in section 2.2.1. Whilst there is some possibility that the S-type assignment derives from a confusion given the carbon content of the granites, there is no doubt that there was significant incorporation of metasediments at least in the latest stages of granite emplacement, giving the granites a reduced chemistry that would have made the metallogenesis more akin to that of S-types. Indeed, this is what is observed at present (greisen alteration, Sn and Li mineralisation, etc.). An analysis of alteration minerals may be able to differentiate between hydrothermal events originating from reduced vs oxidized magmas and determine their fertility for related deposit types (Cooke, et al., 2016).

4.3 Graphite

There have been a few historical and one modern (Graphinex) companies carrying out investigations on the possibility of mining the graphite present in the Croydon Volcanic Group rhyolites and the Esmeralda Granites. Whilst there are records of significant intercepts grading up to 6% carbon, metallurgical studies have shown that recovery of the graphite is too low for them to be economically mined. There is some minor potential in exploring 50-100m below the paleo-roofs of the Esmeralda Granite intrusions for larger tabulated bodies reported in (Withnall, et al., 2013), although the likelihood of an economic discovery remains low.

4.4 Base Metals

The Einasleigh metamorphics are an obvious target for further base metal exploration, as they host the Einasleigh, Kaiser Bill IOCG and Chloe-Jackson BHT deposits. There may be a possibility of finding more massive sulphide type deposits in the Ethridge Group Metamorphics, although it is not possible to follow the stratigraphy of the mineralised horizon from the Einasleigh Metamorphics into the Ethridge group. Geophysical techniques such as IP surveys would be a good way to explore for these given their distinctive conductivity signatures. Any form of geochemical technique would also be useful due to the strong geochemical fingerprint of the systems.

Whilst many of the lode gold deposits have strong geochemical associations with base metals, it is unlikely that any would be prospective due to the low tonnages.

4.5 Uranium

There remains some potential for unconformity-related uranium deposits anywhere the metasedimentary Proterozoic basement is unconformably overlain by younger sediments. As many of these areas are interpreted as post-mineral cover, there has been relatively little attention given to them.

4.6 Tin

Tin deposits in the area would be heavily associated with the hard-rock Li deposits (pegmatites and greisen alteration). Greisen altered granites are a major source of Sn globally. There may be alluvial cassiterite deposits in paleo channels buried by more recent sedimentary rocks.

4.7 Lithium

Theoretically, the Georgetown region is fertile for Lithium mineralization. S-type magmas remobilize lithium from sediments and metasediments. As lithium behaves like a LILE, it will become concentrated in the melt as the magma fractionates and eventually it is economically deposited in highly fractionated pegmatite dykes (spodumene and lepidolite) or in greisen alteration zones (zinnwaldite). The Esmeralda Supersuite and Buchanan's Batholith are Publicly available reporting indicates that virtually all exploration for this type of deposit is focused on areas with surface expressions, despite much of the cover west of the Georgetown Region being underlain by S-Type granitoids. A depth to basement study in covered areas may prove useful as a first-pass exploration technique to identify prospective regions. Sampling of groundwater from boreholes could be used as a follow-up.

Müller (et al., 2022), describe a process of Li enrichment caused by partial melting of peraluminous metasediments during migmatite development in shear zones. The Ethridge Group is a prime candidate for this kind of Li enrichment. Targets for this would be the known migmatites and structures representing periods of tectonic compression / transpression. As this is a fairly new model for Li enrichment, it is not known if many of the migmatites have been sampled for Li in the Georgetown Region.

The Mesoproterozoic setting of the Croydon Province was favourable to the development of both Li-clay and salar-type Li-brine deposits as seen in the Andes of South America:

- Li-Clay Systems: These form in caldera setting where Li-enriched fluids accumulate in endoheric caldera lake sediments. The Li-enriched sediment then undergoes diagenetic low-T alteration and forms the Li-bearing clay, Hectorite (Benson, et al., 2017). Suitable calderas with mapped lacustrine sediments are found across the georgetown region. Exploration for this kind of deposit would focus on the aformentioned sedimentary units and could take the form of detailed mapping. Preliminary remote sensing could utilise sattelite imagery as the clays are charachteristically bright-white. Unfortunately, these clays do not have a charachteristic hyperspectral signature that can be identified from sattelite-based spectroscopic analysis. These clays occur in stratiform bodies, so even if there is only a small surface expression, there is postential for a larger resource along-strike or down-dip. The Li-clays formed in this type of deposit are metalurgically favourable.
- Salar-Type Li: These form through meteoric water leaching Li from S-type ignimbrites and accumulating in endorheic basins, enrichment follows prolonged periods of evaporation. The residence time of these brines can be on the order of 10s of millions of years, giving the oportunity for the basins to be buried, generating sub-surface paleo-salars (Bunker, et al., 2022). These paleo-salars can become mobilised and accumulate in areas beneath fluid traps,

much like the current model for hydrocarbon resource development. If these kinds of systems ever formed in the Georgetown Region, it is likely impossible for them to have been preserved to the present day due to their sheer age and the degree of metamorphism. Additionally, many of the potential source rocks have no overlying resevoir or trap system that would preserve them. However, sedimentary rocks of the Carpentaria basin to the west overlie suitable units of the Georgetown Province and may have generated fluid transport-trap-resevoir structures that hold Li-enriched brines. This type of deposit would be extremely difficult to explore for as it would require seismic exploration techniques and infrastructure on the scale of on-shore hydrocarbon exploration.

5 Conclusion

The Georgetown Inlier is a Paleoproterozoic region within the North Australian Craton. It is bounded by the Palmerville, Burdekin River and Teddy Mount Faults to the east, near Mount Garnet. To the west and south-west it is unconformably overlain by sedimentary rocks of the Carpentaria and Eromanga Basins. The Inlier can be sub-divided into the Ethridge Province (Dominated by Metasediments) and the Croydon Province (Volcanics and Granites). These are separated by faults formed during a cauldron collapse event. The Ethridge province is subsequently intruded and overlain by a diverse set of Devonian igneous rocks. Periods of volcanics, magma intrusions and sedimentary deposition events continue into the Cenozoic.

The Georgetown Inlier is prospective for a wide variety of minerals and deposit styles. In the Croydon Province, these are related to the emplacement of the S-Type granites of the Esmeralda Supersuite and are of Mesozoic Age. Mineralisation takes the form of mesothermal gold lodes and Li-Sn mineralisation in greisen alteration and pegmatite dykes. The types of mineralisation present in the Georgetown Province are more diverse and are mostly related to younger Devonian-Permian I-Type intrusives and include shear-hosted lode gold, epithermal gold and intrusion-related breccia-hosted gold. Older mineralisation includes Li-Sn mineralisation related to Mesoproterozoic pegmatites and greisen alteration originating from s-type granites. Paleoproterozoic mineralisation includes IOCG and massive sulphide deposits hosting Cu-Pb-Zn-Ag-Au.

The region is still prospective for many of the mineralisation types mentioned above. However, these will be found at depth or under cover, as many of the surficial deposits were discovered by the intense exploration activity during the late 1800s and 1980s. During the latter period, drillholes were rarely extended beyond 100m, even in mineralized zones, so there’s a lot of potential in revisiting areas previously investigated during this period.

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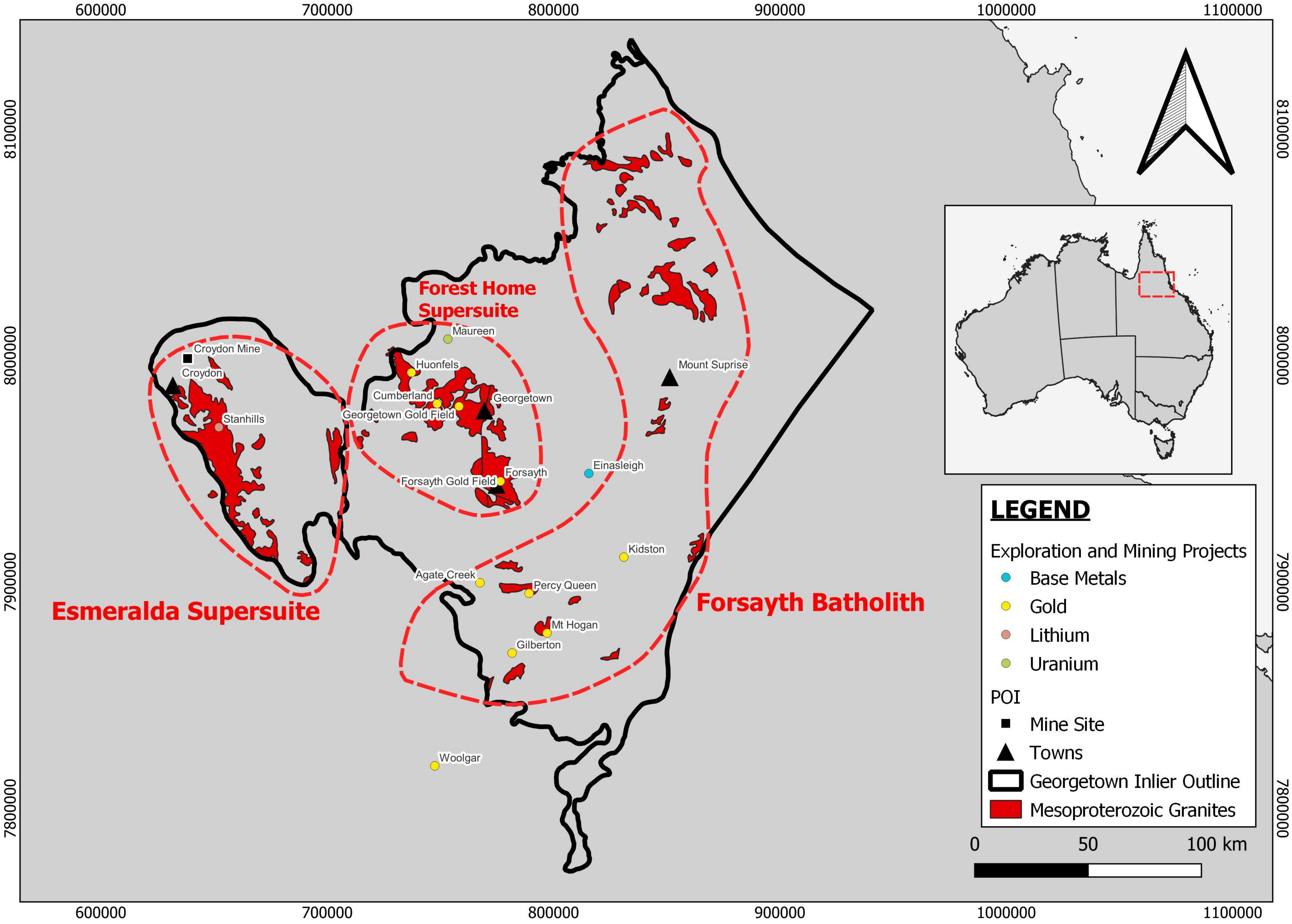
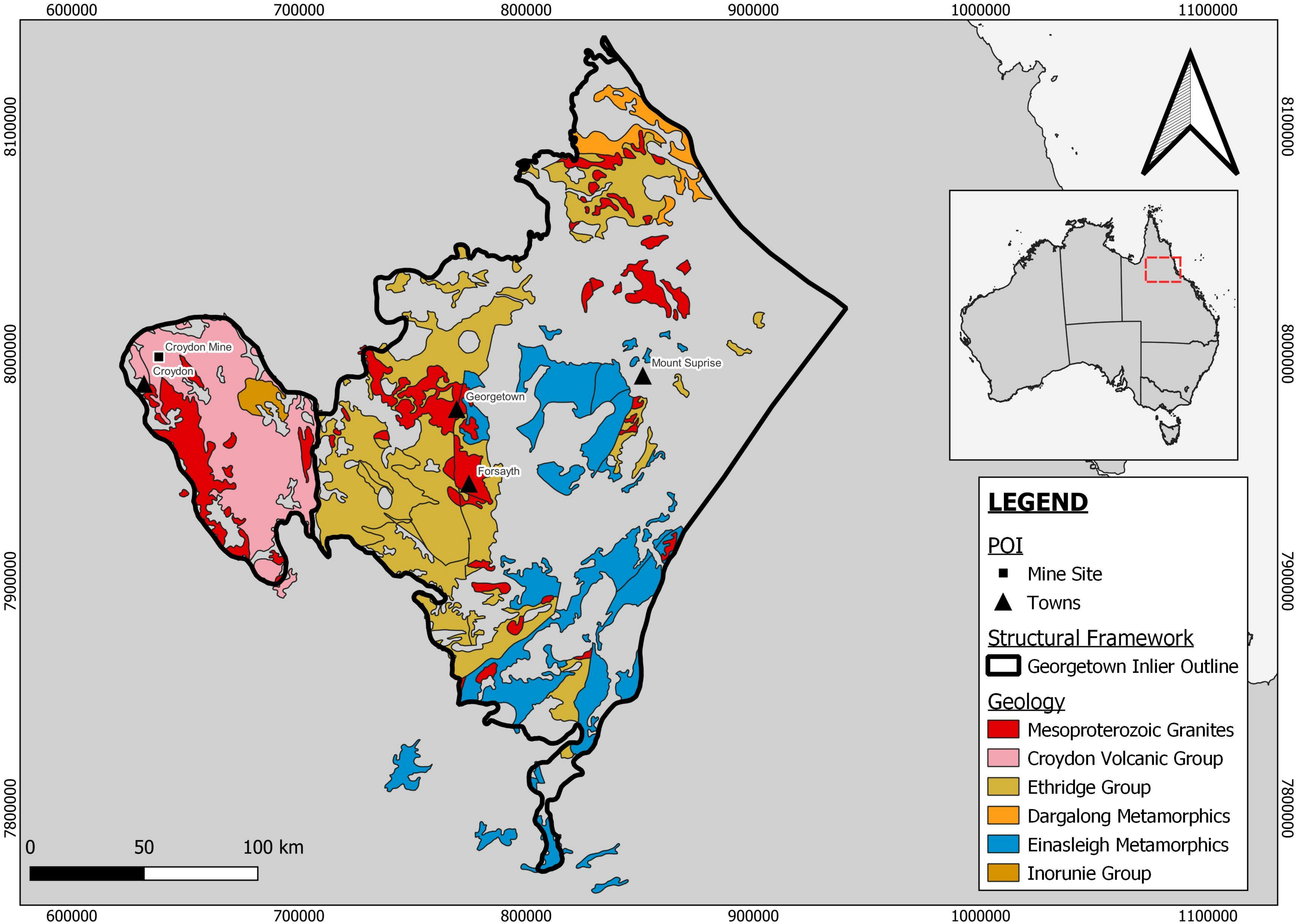


Appendix 1: Proterozoic Granites of the Georgetown Inlier (Withnall, et al., 2013).



Appendix 2: Simplified Proterozoic geology of the Georgetown Inlier (Withnall, et al., 2013).