Baal Gammon and Gift (Silver Valley Tin Field)

Figure 4.1: Aerial Image of Baal Gammon mine. Image shows location of sealed road access to the south of the mine, the main open pit (left) and tailings storage facility (right). (Photo provided by Dr A. Parbhakar-Fox and taken by the QLD Department of Resources, 2019)

OVERVIEW

Baal Gammon is the 12th largest tin deposit in the Herberton region (Chang et al, 2017). Located 70km south west of Cairns, with sealed road access from the south of the mine (Figure 4.1). The mine is a classic example of the dominant form of mineralization exhibited elsewhere in the Herberton Tin Field, with granitic intrusive rocks hosting significant concentrations of cassiterite, pyrite and chalcopyrite. Baal Gammon is also reported to be a viable source of indium and tungsten. Baal Gammon is now classified as an abandonned mine site.

Gift is a historic tin mine located 23 km to the north east of Mt Garnet and approximately 80km soth west of Cairns (Figure 4.2). The mine is the largest tin producer in the Silver Valley tin field with a recorded 93 tonnes of cassiterite concentrate. Other significant mines in the area include Mt. Ogston, White Elephant and Sailor (Norum, 2012). The mine is currently inactive.

LOCATION

Geological Domain

Atherton region, Hodgkinson Province

Co-ordinates (GDA94)

Baal Gammon: Latitude: 17° 38’ 38” S, Longitude: 145° 32’ 86” E

MGA Zone 55: 322254E, 8077569N

Gift: -17.540 Lat. / 145.290 Long.

MGA Zone 55: , 319059E, 8059173N

NATURE OF MINE

Mined Commodities

Baal Gammon: silver, copper, tin and (briefly) indium

Gift: Tin as cassiterite ($Sn0_2$) and minor antimony, bismuth, fluorite and tungsten.

Depth of Mining

Baal Gammon: 55 m (open cut), information on underground operations is not publically available.

Gift (Silver Valley): The mining at Gift and Sailor involved underground mining accessed by adits and shafts, however, no details on the history or detailed nature of the workings are available.

ORIENTATION AND DIMENSIONS OF MINERALISED BODIES

Baal Gammon

The main body of mineralization occurs in stockwork veins, dominantly in the UNA porphyry sill, which is interpreted as part of the Late-Carboniferous – Early Permian Elizabeth Creek Granite. The granite intrudes the Devonian age Hodgkinson Formation. A small number of drillholes intersect minor amounts of massive sulphide directly above the UNA porphyry.

Dimensions: Only small amounts of the Baal Gammon deposit have been mined, with the existing open pit mine covering an irregular-shaped area approximately 120m long and 80m wide (Douglas, 2014). The UNA porphyry, which is broadly coincident with mineralisation has been modelled, based on extensive drilling operations conducted throughout the past twenty years, for this atlas, which indicates that the assocaited mineralisation (Figure 4.7) may extend approximately 700m along the longest axes of the mineralised intrusion (to the south-west), and 400m along the axes perpendicular to the direction of body elongation (striking to the north-west).

Orientation of Mineralised bodies: The UNA Porphyry deposit dips 35° west, with a deep zone beginning to dip to the south, suggesting a cone-like shape to the porphyry ore body (Fraser, 1972).

Gift (Silver Valley tin field)

The Gift tin mine is approximately, 300m long x 50m wide x 15m deep (GSQ Mineral occurrence database).

The Sailor tin mine comprises ‘domal’, sub-horizontal to shallowly dipping, pyritic greisen lenses at the contact granite – greywacke contact (Figure 4.14A). These mineralised zones are generally 20 to 60m below surface, however, they can be deeper at 80 – 100m (Figure 4.14, Cochrane and French, 1981).

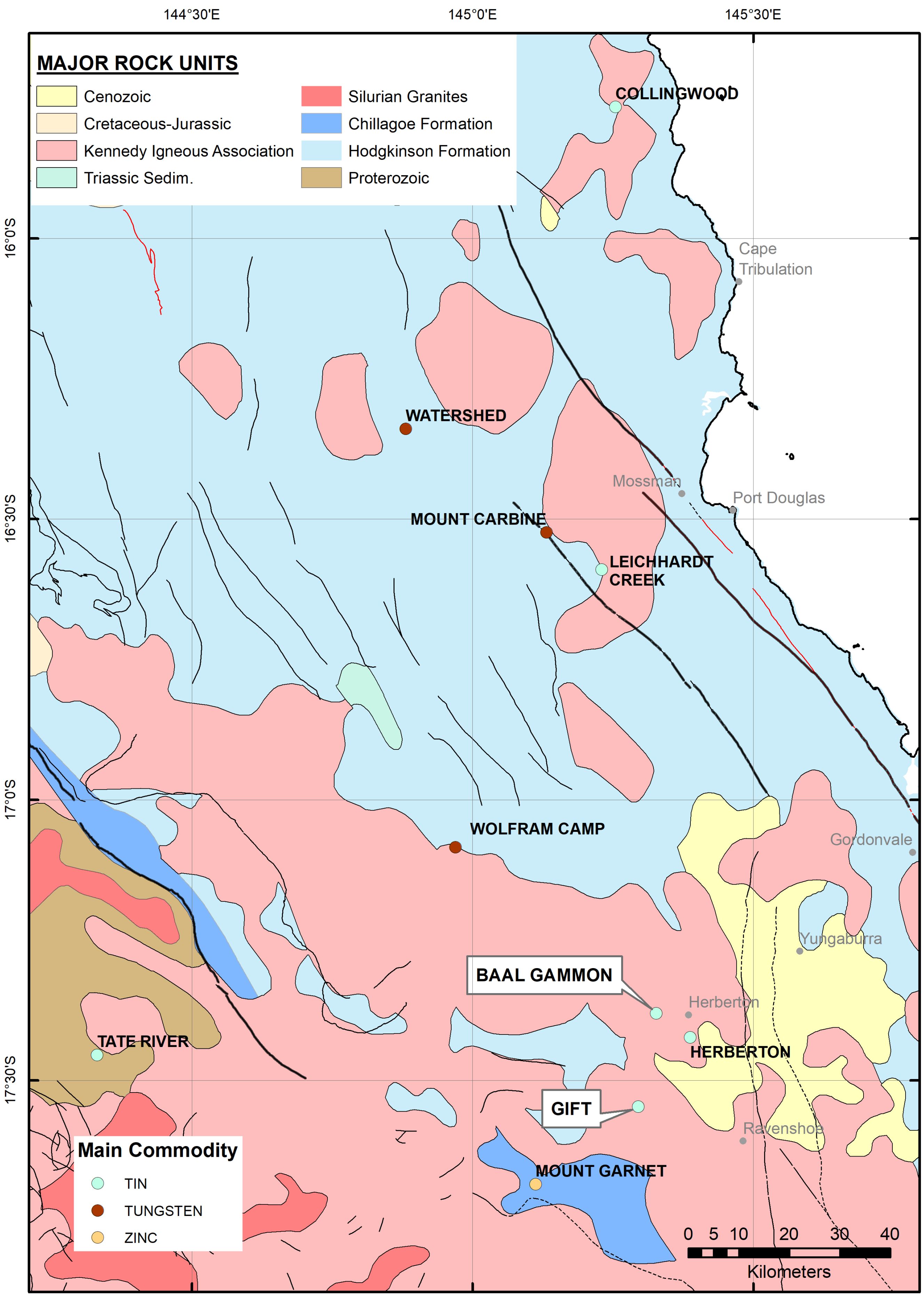

Figure 4.2: Location of the Baal Gammon and Gift tin deposits in the Hodgkinson Province in NE Queensland, within the Kennedy Igneous Association.

PRODUCTION

Baal Gammon

Historic Production: No production quantities have been reported publicly.

Recent Production: Baal Gammon Mine is now registered as an abandoned mine (inactive prospect) with the Department of Natural Resources, Mines and Energy, QLD. The site is subject to ongoing environmental issues stemming from reports of waterway contamination (Fox et al, 2017; Douglas, 2014).

Gift (Sliver Valley tin field)

The Gift Mine production was 93.2 tonnes of cassiterite (von Gnielinski, 2016).

Mount Ogston Mine production was 63.3 tonnes of cassiterite (Norum, 2012).

The White Elephant Mine production was 35.3 tonnes of cassiterite (Norum, 2012)

RESERVES AND RESOURCES

Baal Gammon Resources and Reserves

Baal Gammon has a JORC-compliant Indicated Resource of 2.77Mt @ 1% Cu, 40 g/t Ag, 0.2% Sn and 39 g/t In. Included within this is a higher grade body of 825kt @ 2.5% Cu, 96 g/t Ag, 0.4% Sn and 96 g/t In, with some zones of particularly high grade Cu reported at up to 11.89% (Mineral Occurrence Data Sheet 2019).

Current reserves are estimated at 0.317Mt of ore at 1.02% Cu and 0.5 g/t Au for 607kT of Cu and 964kOz Au (Mineral Occurrence Data Sheet 2019)

Gift Resources and Reserves

Gift Mine: Resources at Gift are listed as 1030 tonnes of cassiterite (von Gnielinski, 2016).

Sailor Mine: Newmont carried out two significant drilling programmes at the Sailor granite greisen-hosted tin deposit. Drilling was of a sufficient density to enable the generation of a non-code-compliant resource of approximately 10Mt @ 0.2% Sn (Allchurch, 2015).

GEOLOGICAL SETTING

Baal Gammon: The Baal Gammon deposit occurs within the Hodgkinson Province of the Mossman Orogeny, comprising Silurian to Devonian age, deep marine sediments of the Hodgkinson Formation, which hosts a large number of Au, W and Sn deposits. The Mossman Orogeny forms a belt 500 km long and up to 200 km wide, which formed in a Permian-Carboniferous, convergent margin system abutting the North Australia craton along the major Palmerville Fault (after Poblete, 2019). Henderson et al (2013) provide an upper age of 360±7 Ma for the Hodgkinson Formation from a U-Pb zircon date, which is at the Devonian – Carboniferous boundary.

The Hodgkinson Formation contains a series of turbidite sequences, which have undergone multiple deformation events. Metamorphism in the unit reaches the greenschist facies in some areas, including the edges of the Baal Gammon region (Fraser, 1972). Bedding is generally steeply dipping and mesoscopic folds are widespread (Henderson and Donchak, 2013). The Hodgkinson Formation is intruded by Carboniferous to Permian granitoids of the Kennedy Igneous Association (~345 – 250Ma; Cheng et al, 2017), such as the highly mineralised Elizabeth Creek granite.

Gift: The deposits of the Silver Valley tin field, which include the Gift, Sailor, Mount Ogston, White Elephant and Zig Zag tin deposits (among others), are dominantly hosted within greisens which occur between the Go Sam Granite and overlying hornfelsed greywacke of the Hodgkinson Formation (Figures 4.4 and 4.6). These mainly occur along the eastern edge of the Go Sam granite, although at Gift the mineralisation is hosted within the Hodgkinson Formation sediments close to the outcropping Nettle granite to the east.

BAAL GAMMON

HOST ROCKS

Hodgkinson Formation

The Siluro-Devonian Hodgkinson Formation (Dh/am) comprises mainly pale to dark or greenish grey, fine to medium-grained, medium to thick-bedded, quartz-intermediate arenite, rhythmically interbedded with siltstone and mud-stone; minor conglomerate, conglomeratic arenite (Hill, 1960).

Mine Stratigraphy

The Baal Gammon orebody is hosted in the UNA Porphyry, a derivative of the Elizabeth Creek Granite (Fraser, 1972; Monto Minerals, 2014; Fox et al, 2017). These intrusives sit within the metasedimentary rocks of the Siluri-an-Devonian Hodgkinson Formation, occurring as stockwork veins in greisenised regions of the host rock (Schwarz-Schampera and Herzig, 2002).

Major Host Rock

The main host rock is the late-Carboniferous UNA Porphyry, which is interpreted to be derived from the Elizabeth Creek Granite (Fraser, 1972). The UNA Porphyry is chemically similar to a rhyolite, and the unaltered UNA porphyry comprises phenocrysts of quartz (25%), alkali feldspar (10% and plagioclase (5%) which vary from 2-7mm diameter. The phoenocrysts are presetn in a well-developed granophyric groundmass. (Fraser, 1972). The number and size of the phenocrysts decreases markedly near the base of the porphyry where the granophyric matrix is poorly developed and slightly more irregular. Combined with the lack of flow banding near the margin, Fraser (1972) interprets this to imply the porphyry was intruded passively.

Small amounts of massive sulphide are presetn the top of the UNA porphyry, near the contact where the Hodgkinson Formation overlays the porphyry.

INTRUSIVE UNITS

Granitoids

The geology of the Herberton tin field as a whole is characterized by a plethora of late-Carboniferous to early-Permian granites and acid volcanic rocks, intruding through the arenite, siltstone and mudstone of the Devonian Hodgkinson Formation that dominate the region.

Watsonville Granite: The Watsonville Granite is part of the Permian Ootann Supersuite, with an approximate 325 Ma age (Australian Stratigraphic Units Database) . The topography over this unit is gentle and characterized by rounded granite boulders (Fraser, 1972). The Watsonville Granite is a pale, medium-coarse grained granite with porphyritic biotite in an otherwise equigranular texture (Geoscience Australia, 2021).

Elizabeth Creek Granite: The Elizabeth Creek Granite is part of the Carboniferous O'Briens Creek Supersuite, with an approxiate age of 320 Ma (Australia Stratigraphic Units Database), and represents the most chemically evolved I-type granite in the Kennedy Igneous Association (Jell, 2013). Mineralogically, the Elizabeth Creek Granite is dominated by alkali feldspar (~40%), plagioclase (20%), quartz (25%) and biotite (5%) (Fraser, 1972) and also contains quartz veins with beryl, topaz and aquamarine in some areas across the region (Jell, 2013). In addition to these prevalent minerals, the Elizabeth Creek Granite also contains trace amounts of zircons, and as such has been dated at ~318-322Ma (Murgulov, 2006). This unit has a more dramatic topography with steeply dipping ridges throughout, and intrudes through the Kalunga Granodiorite (Fraser, 1972).

The Elizabeth Creek Granite plays host to a large amount of economic mineralisation in the Herberton region (Black and Richards, 1972). Within the Baal Gammon region, the Elizabeth Creek Granite has a spatio-temporal relationship to the main source of mineralisation: the UNA Porphyry.

METAMORPHIC GRADE

While information is scarce about the metamorphic grade at Baal Gammon, regional metamorphism in the wider Herberton area is said to have reached middle-to-upper amphibolite facies (Chang et al, 2017). Geological mapping shows areas close to the mine have reached the greenschist facies (Fraser,1972).

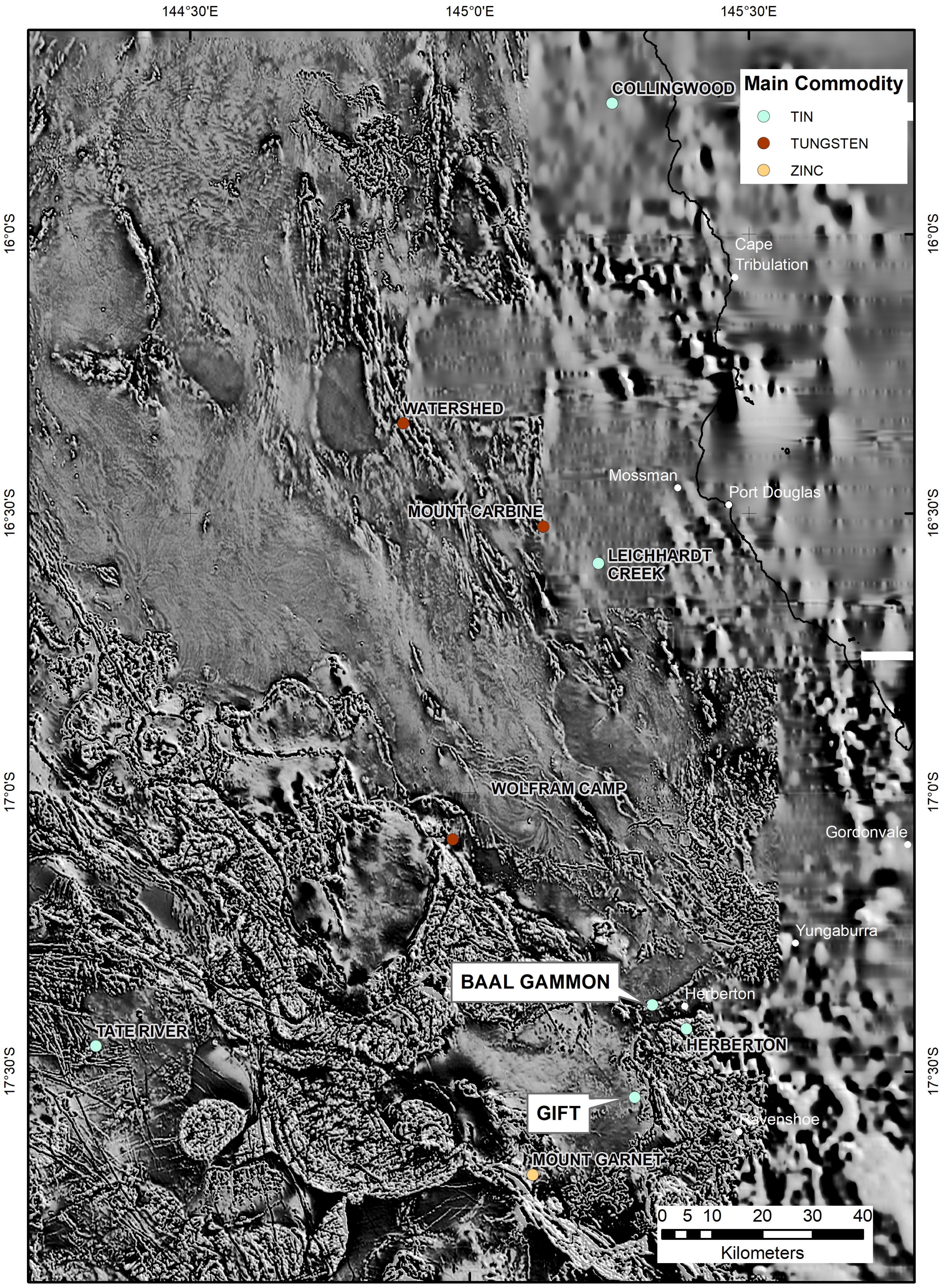

Figure 4.3: Location of the Baal Gammon and Gift tin deposits in the Hodgkinson Province in NE Queensland, shown on a map of total magnetic intensity (1VD).

STRUCTURAL CHARACTERISTICS

Structural Setting

Both the Baal Gammon and Gift deposits are hosted within the NNW trending, Siluro- Devonian Hodgkinson Formation (Hill, 1960).

The Baal Gammon orebody occurs within the West-dipping UNA Porphyry and temporally associated Elizabeth Creek Granite (Fraser, 1972; Anon, 2014). These rocks are part of the Palmer – Barron Subprovince of the Hodgkinson Province, which in turn is part of the Mossman Orogen (Jell, 2013).

The ore bodies are bounded above and below by the Hodgkinson Formation, for which the bedding dip and direction is highly variable and not always reflective of the regional deformation history (Norum, 2016). The intrusive UNA porphyry dips shallowly through the Hodgkinson Formation, with younger, less mineralised volcanic units (i.e. Slaughteryard Creek Volcanics) steeply cross-cutting both units.

Hodgkinson Formation: The Siluro-Devonian Hodgkinson Formation sediments have undergone a multiphase deformation history spanning the Devonian to Permian. Deposition was terminated and the orogen was comprehensively tectonised by crustal shortening in the Late Devonian, broadly correlated with the Tabberabberan Orogeny of the Lachlan Orogen. Much of the Hodgkinson Province was later shortened by the late Paleozoic–Triassic Hunter-Bowen Orogeny (Davis et al., 2002; Withnall and Henderson, 2012). The first two deformations, D1 and D2, were coaxial and co-planar, producing tight to isoclinal, upright, approximately north-south trending folds with a steep axial planar S1 slaty cleavage and co-planar S2 crenulation cleavage (Davis et al, 2002). For details of the D1 to D4 defromation history refer to the section on Structural History in Chapter 1: Wolfram Camp.

Major Structural Styles

The structural history of the Baal Gammon area

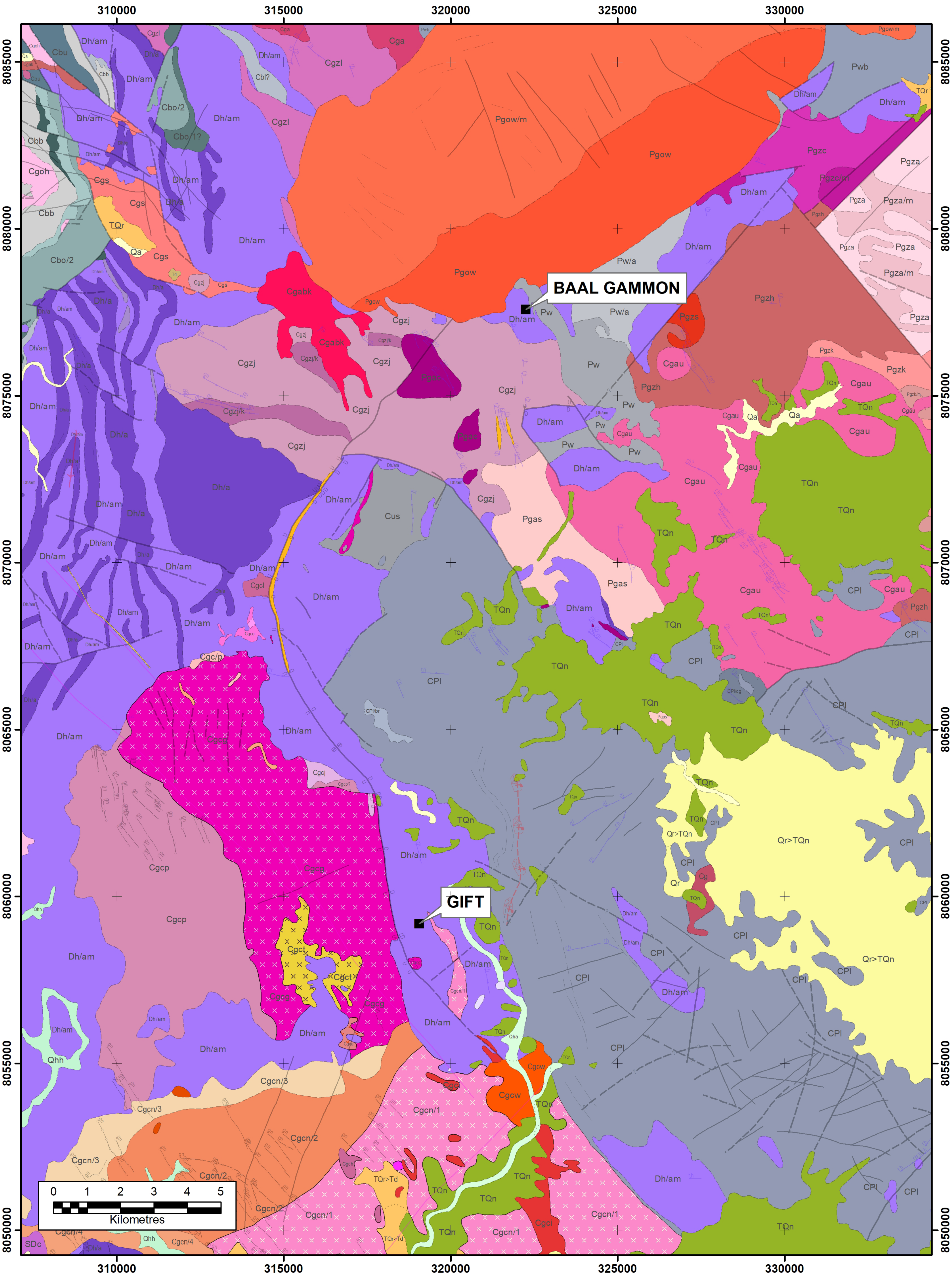

Figure 4.4 Location of the Baal Gammon and Gift deposits in the context of the regional geology (above), and geological legend (overleaf).


Legend
Quaternary
Atherton Basalt
Qa-QLD
Qha-QLD
Qhh-QLD
Qr-QLD
Qr-QLD>Atherton Basalt
TQf-QLD
TQr-QLD
TQr-QLD>Td-QLD
Td-QLD
Permian
Silver Pot Granodiorite
Pgy-7963
Clotten Granodiorite
Cherry Tree Granite
Cattle Camp Granite
CPir-Kennedy Province
Kauri Granite
Slaughter Yard Creek Volcanics
Specimen Hill Granite
Walsh Bluff Volcanics
Watsonville Granite
Late Carboniferous – Early Permian
Wild Granite
Whelan Creek Granite
Silver Valley Conglomerate
Shady Microgranite
Percy Granophyre
Bluewater Rhyolite
Cg-7962
Cgc/g-7963
Cgc/p-7963
Cgt/a-Kennedy Province
Deadman Granite
Devon Microgranite
Eureka Creek Rhyolite
Parker Microgranite
Halpin Granite
Top Nettle Microgranite
Glen Gordon Volcanics
Go Sam Granite
Hales Siding Granite
Kalunga Granodiorite
Junction Microgranite
Jumna Granite
Late Carboniferous – Early Permian
Orient Rhyolite
Oaky Granite
No Hays Minas Granite
Nettle Granite
Lime Granite
Lass O'Gowrie Granite
Herberton Hill Granite
Stinking Cornishman Microgranite
Bedlog Rhyolite
Carboniferous
Atlanta Granite
Bakerville Granodiorite
Bock Granodiorite
Silurian - Devonian
Chillagoe Formation
Hodgkinson Formation

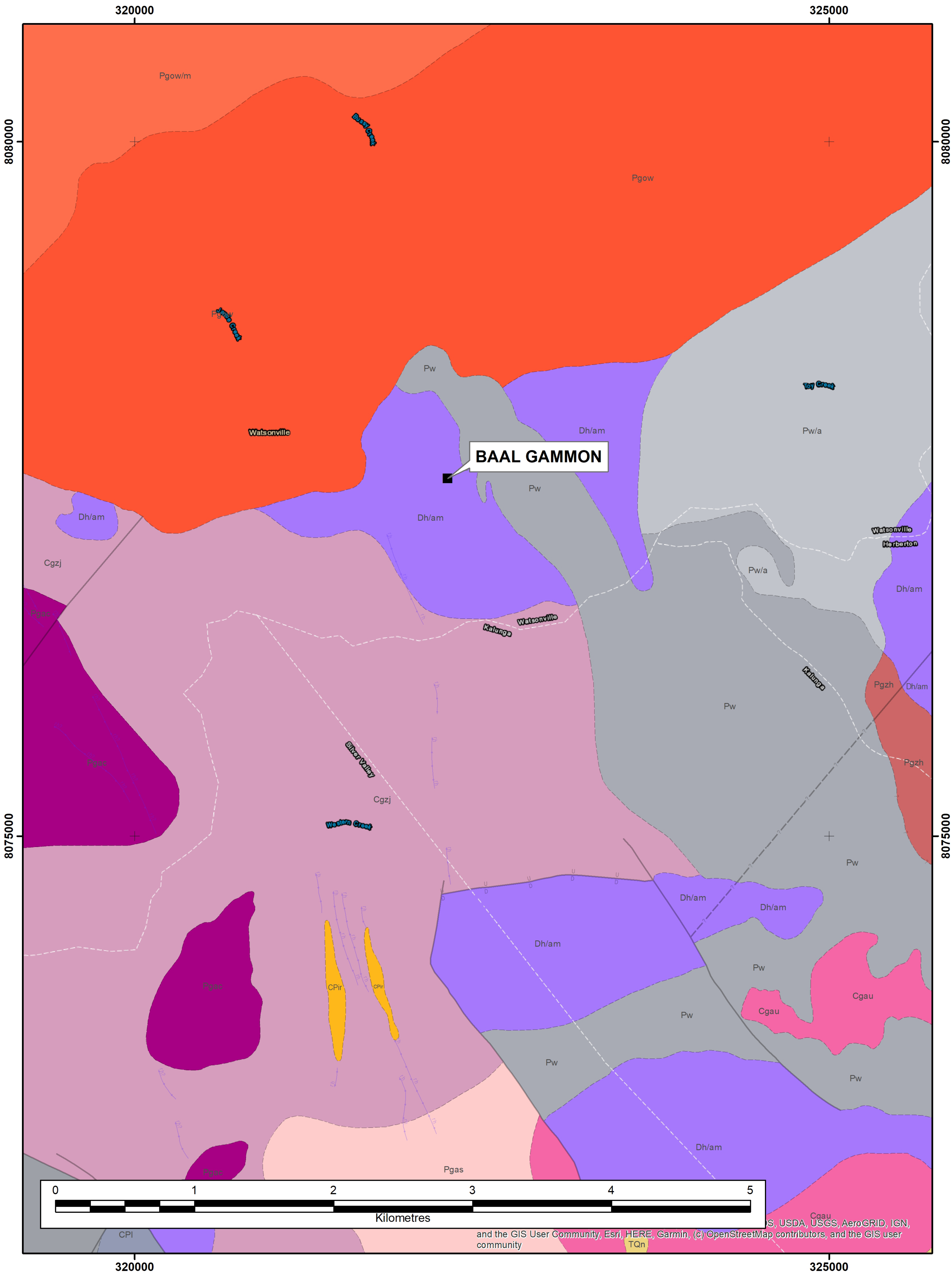

Figure 4.5 Geology of the Baal Gammon deposit. Refer to Figure 4.4 for the legend.

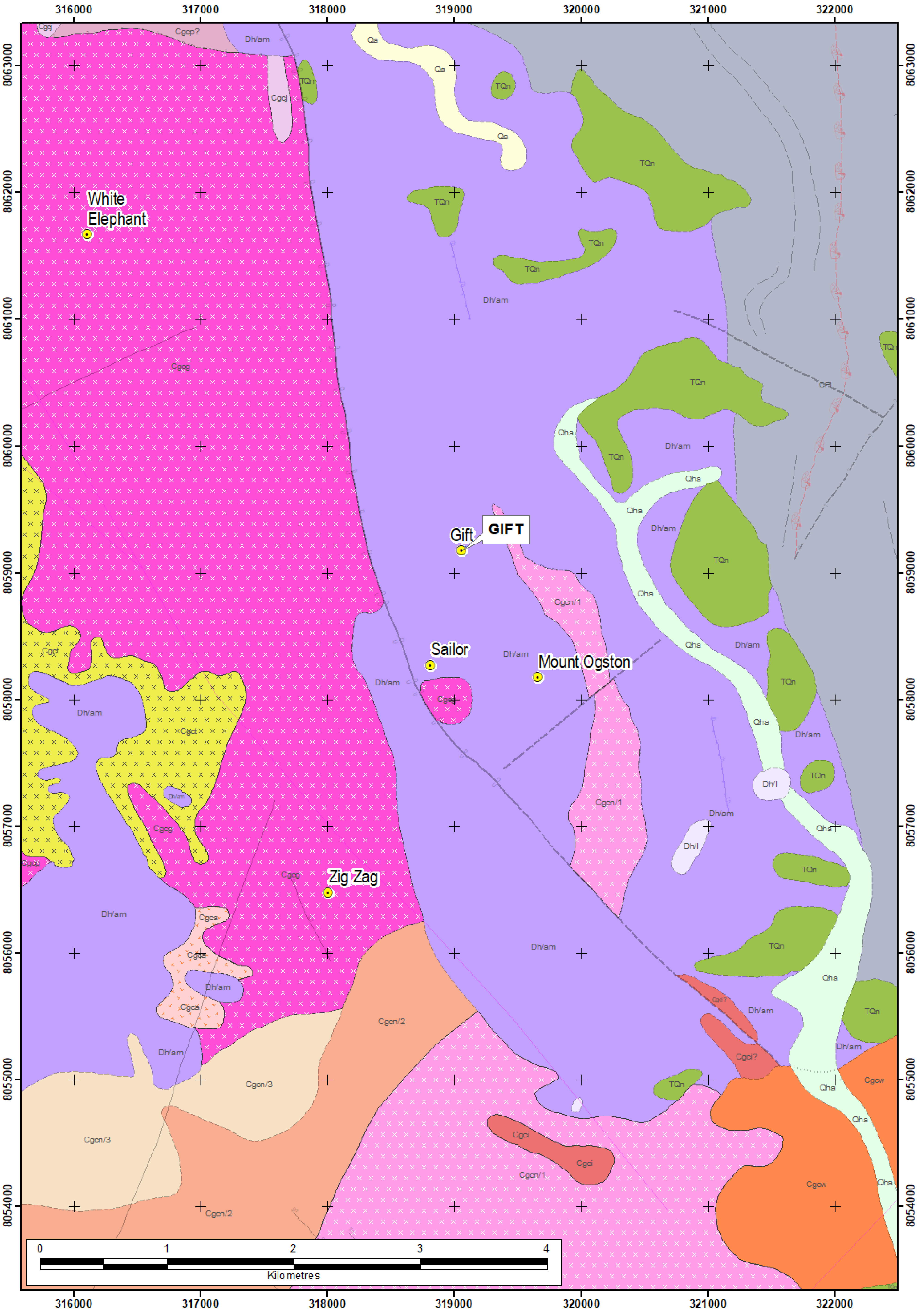

Figure 4.6 Location of the Gift and other deposits of the Silver Valley Tin Field. Refer to Figure 4.4 for the legend.

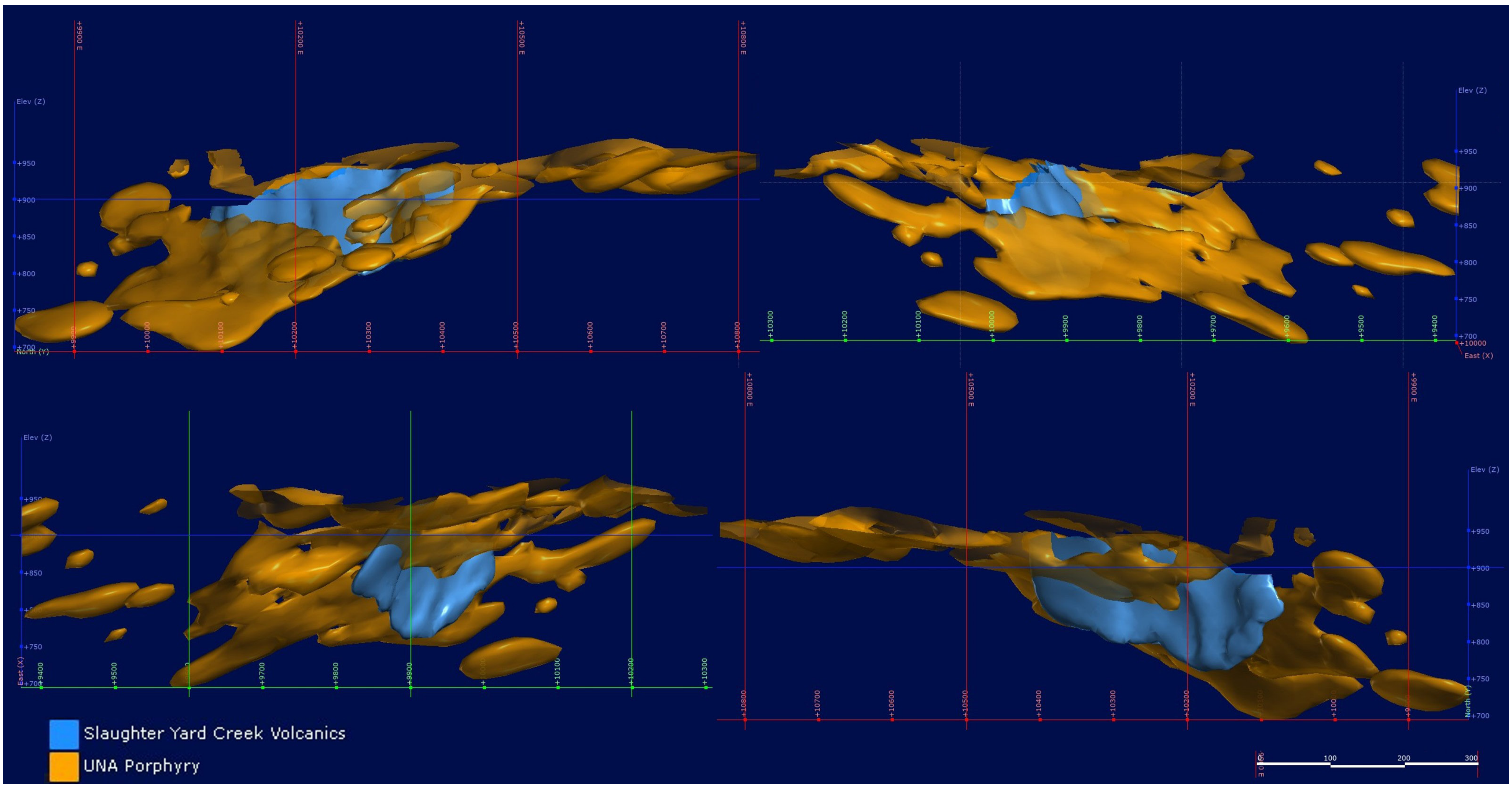

Figure 4.7 . Extent of the UNA Porphyry (orange) at the Baal Gammon deposit with the younger Slaughter Yard Creek Volcanics (blue) shown cutting steeply through the deposit . The geology surfaces are available in the accompanying 3D Atlas.

is difficult to discern, due to the large number of intrusive units that the region contains (Fraser, 1972) and significant amounts of slumping exhibited in the folded sediments (Norum, 2016). The intrusive units are found within the Hodgkinson Formation sediments and are the host rocks for the mineralization in the region (Norum. 2016). The Hodgkinson Formation is part of the northern extent of the Tasmanides (Coney, 1990). The late-Silurian to early Carboniferous Hodgkinson Formation comprises a series of interbedded sandstones, siltstones and shales. These sediments are deemed to have been deposited in a shallow marine environment (Fraser, 1972; Blake, 1968) The sedimentary sequences were intensely folded and faulted during a period in the early Carboniferous when the region was significantly uplifted, during the orogeny that created the Tasmanides (Norum, 2016).

The uplift of the Hodgkinson Formation was shortly followed by a period of volcanism in the region, which caused a series of granitic intrusive bodies, then felsic volcanic-related bodies to intrude through the Hodgkinson Formation. This activity led to the formation of the late-Carboniferous Elizabeth Creek Granite and spatially related UNA Porphyry, followed by the formation of the lower Permian Slaughter Yard Creek Volcanics and Watsonville Granite. These younger volcanic rocks contain little to no signs of mineralization in the Baal Gammon region (Fraser, 1972).

Throughout the region around Baal Gammon, the sedimentary rocks of the Hodgkinson Formation exhibit highly variable dips and large amounts of slumping. As a result, the structural history of the area surrounding Baal Gammon has remained largely uncertain (Norum, 2016; Murray, 1986; Fraser, 1972).

Nature and Orientation of Controlling Structure

Througout the region, there are two main fault trends: A northwest trend, and a less pronounced northeast trend (Norum, 2016). These two trends are both dominated by steep normal faults, which typically dip at between 60° and 90°.

The main controlling structure in the case of both Baal Gammon and Gift is the contact between the mineralised granitic bodies and overlying sedimentary rocks of the Hodgkinson Formation. Norum (2016) states that it is possible that pre-existing faults and fault zones within the Hodgkinson Formation controlled the flow of mineralising fluids during the greisenisation process. Alignment of tin mines and prospects along NE – SW trends has been noticed by other workers (Norum, 2012).

Post Mineralisation Structure

The timing of NW – SE trending (323°) normal faults and orthogonal NE – SW faults (approx. 233°) is interpreted by Norum (2012) to be post granite emplacement and presumably formation of the tin bearing greisen mineralisation. It is possible, however, that these NE – SW faults were already present in the overlying Hodgkinson Formation sediments prior to the intrusion of the granites.

MINERALISATION

Mineralisation at Baal Gammon domonstrates the region's typical style of mineralisation. Here, the Elizabeth Creek I-type granite exhibits both greisenisation and stockwork veining type mineralisation. Regionally, such I-type granites have been suggested as the largest source of mineralisation (Chang et al, 2017; Jell, 2013). Younger igneous units in the area, such as the Slaughter Yard Creek volcanics (Figure 4.7), have not yielded evidence of mineralisation, despite being relatively close in age (Fraser, 1972; Blake, 1968). The primary ore minerals present in the Baal Gammon region are cassiterite, wolframite, chalcopyrite, sphalerite and galena (Fox et al, 2017).

WALL ROCK ALTERATION

The mineralisation at the Baal Gammon mine is hosted in igneous igneous bodies that have intruded a roof pendent of Hodgkinson Formation sediments (Douglas, 2014). Several of the major lithologies surrounding the Baal Gammon area are felsic, with compositions varying from rhyolitic to that of an adamellite.

BAAL GAMMON MINERAL RESOURCE

Classification	Tonnage (Mt)	Copper (%)	Tin (%)	Silver (g/t)	Indium (g/t)
INDICATED	2.769	1	0.2	40	38
INFERRED	0.031	0.6	0.1	18	63
TOTAL	**2.800**	**0.966**	**0.199**	**18**	**39**

Table 4.1a . Mineral Resource from the Baal Gammon deposit - 0.2% Cu cut-off.

BAAL GAMMON HIGH GRADE ZONE MINERAL RESOURCE

Classification	Tonnage (Mt)	Copper (%)	Tin (%)	Silver (g/t)	Indium (g/t)
INDICATED	0.826	2.5	0.4	96	96
INFERRED	0.004	2.7	0.4	94	146
TOTAL	**0.829**	**2.5**	**0.4**	**96**	**96**

Table 4.1b . Baal Gammon Mineral Resource from the high grade zone detected by Monto Minerals .

Fraser (1972) characterized the alteration through the UNA Porphyry at neighboring Two Treys ore body into 6 zones (Figure 4.8). The zoning system highlights the progressive changes in alteration mineralogy in drill corewith depth through the porphyry towards its basal contact with Hodgkinson Formation rocks. The six zones as described by Fraser 1972) are:

Zone 1

a) Rock still resembles the original porphyry

b) Small amounts of plagioclase has been altered to sericite. No other alterations in the rock recorded.

c) Drusy cavities contain biotite (sometimes altered to sericite), pyrite, chalcopyrite, garnet and cassiterite

Zone 2

a) Plagioclase feldspar is now completely replaced by sericite and quartz. Other areas are being replaced with muscovite, and sericite has a radiating fibrous appearance.

b) There is no clear boundary between zones 1 and 2

Zone 3

a) None of the original alkali feldspar remains, with sericite-quartz intergrowths, secondary green biotite and garnets now replacing all of the plagioclase seen in zones 1 and 2.

b) As a result of the breakdown of plagioclase, there is a sharp decrease in K and Na

c) There is a sharp contact between zones 2 and 3, made visible due to the change to sericite-quartz dominated mineralogy in the feldspar phenocrysts

Zone 4

a) Primarily a zone of sericite alteration with no major mineralogical changes

b) Massive sulphide zones present

c) Gangue minerals include: amorphous silica, hydrated calcium silicates, siderite and fluorite

d) Gangue mineral veins crosscut massive sulphide zones

e) Depletion of K and Al, enrichment of Ca (in gangue minerals)

Zone 5

a) Topaz present, fluorite absent

b) Similar characteristics to Zone 3

c) Depleted in Ca and Si, enrichment in Ti, Mn, Al and Mg

Zone 6

a) Base of porphyry consisting primarily of altered sediments from the Hodgkinson Formation

b) Unaltered porphyryblasts of plagioclase and alkali feldspar present

c) Enrichment in Ba and Sr

GEOCHEMICAL EXPRESSION

Stream Sampling

Of the available stream sediment data from the regional GSQ database (Figures 4.9 to 4.13) very little of the data falls within 5km of Baal Gammon mine.

Arsenic (Figure 4.9) concentrations in stream sediment samples reach between 10-25ppm approximately 5km to the North of Baal Gammon. Slightly further North still, a single reading of between 25-50ppm is recorded approximately 8km Northwest of Baal Gammon. There is no nearby data available in other directions from the mine.

Copper concentrations in stream sediment samples (Figure 4.10) reach between 0-25ppm approximately 5km to the north of Baal Gammon. Higher Cu values are recorded in stream sediments approximately 15-20km south of Baal Gammon.

Lead (Figure 4.11) concentrations are not recorded in the immediate vicinity to Baal Gammon. However, there are readings from 10ppm to >100ppm approximately 15km south of Baal Gammon, near (around 5km east of Gift).

Tin (Figure 4.12) concentrations are typically around 0-50ppm in the stream sediments to the north of Baal Gammon, with higher values in that range being found further north, and lower values occurring closer to Baal Gammon. No data is available elsewhere around the mine site.

Soil Sampling

There is no publically available data on soil chemistry in the area surrounding Baal Gammon. This being said, a Monto Minerals report from 2014 indicates that there was soil sampling carried out between 2012 and 2013 (Anon, 2014). Such data was not found in the historic mining activity files stored with the Queensland Department of Resources.

GEOPHYSICAL EXPRESSION

Aeromagnetic Data

The aeromagnetic dataset (Figure 4.15 - RTP-1VD) is visually dominated by the highly textured signature of the Tertiary Atherton Basalts (TQn) and the Late Carboniferous Glen Gordon Volcanics (CPl), which are dominated by rholitic to rhyodacitic ignimbrites. In the simple reduced to pole data, however, the Glen Gordon Volcanics display a distinct low intensity, perhaps indicative of a component of remanent magnetisation.

In contrast, the granites typically display textureless signatures with the very common obltae shapes characteristic of the Kennedy Igneous Association granites. Examples inclue the Go Sam (Cgcg), Watsonville (Pgow) and Nettle (Cgcn) Granites. The intermediate composition plutons display a higher more textured aeromagnetic signature (e.g. the late Carboniferous Bakerville Granodiorite - Cgabk).

The greywacke-dominated Hodgkinson Forma-

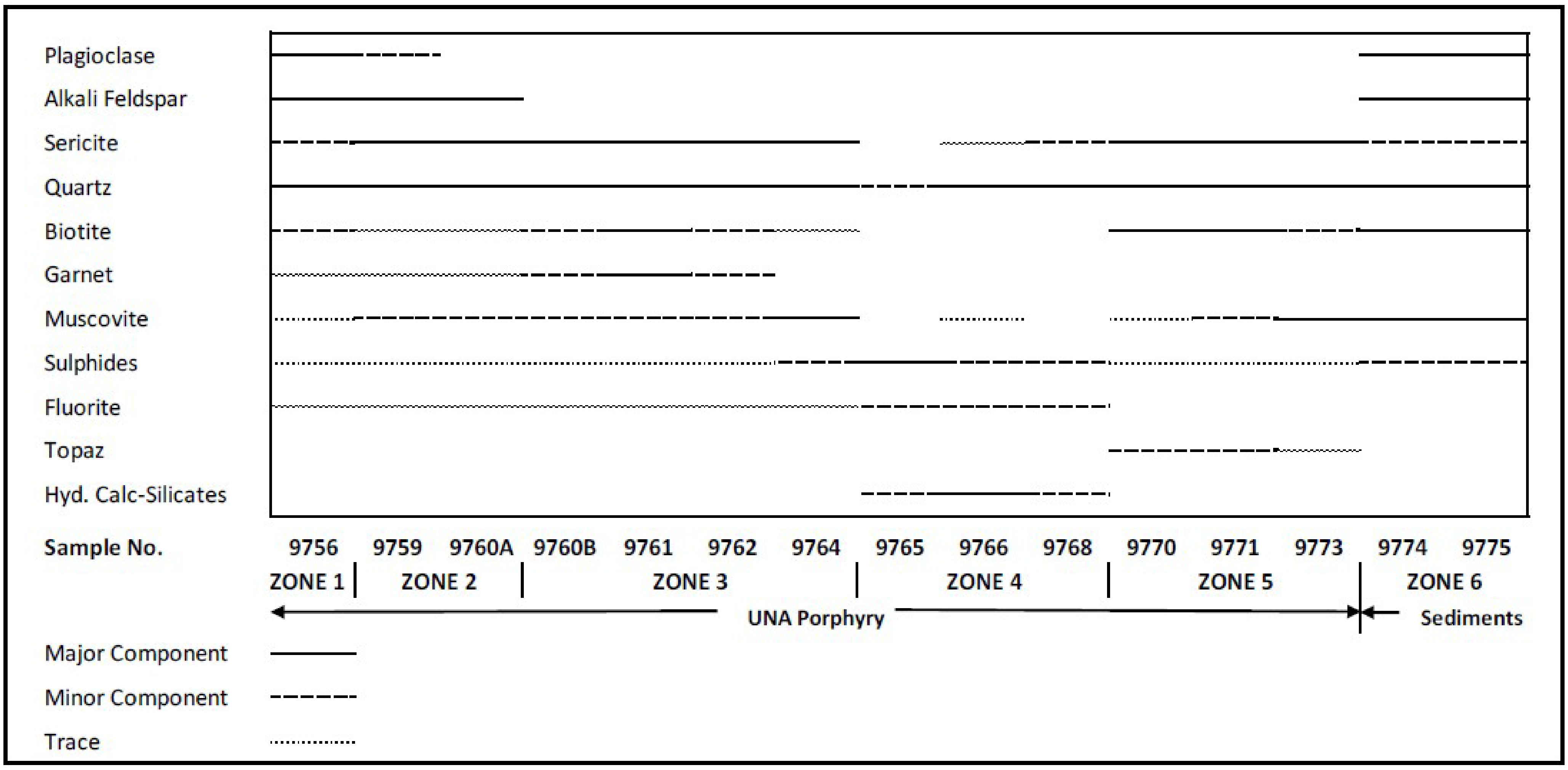

Figure 4.8: (Fraser, 1972) UNA Porphyry Mineralogy from samples taken near Baal Gammon mine in the Two Treys Mine, showing variation of mineralogy defining the 6 zones described by the author.

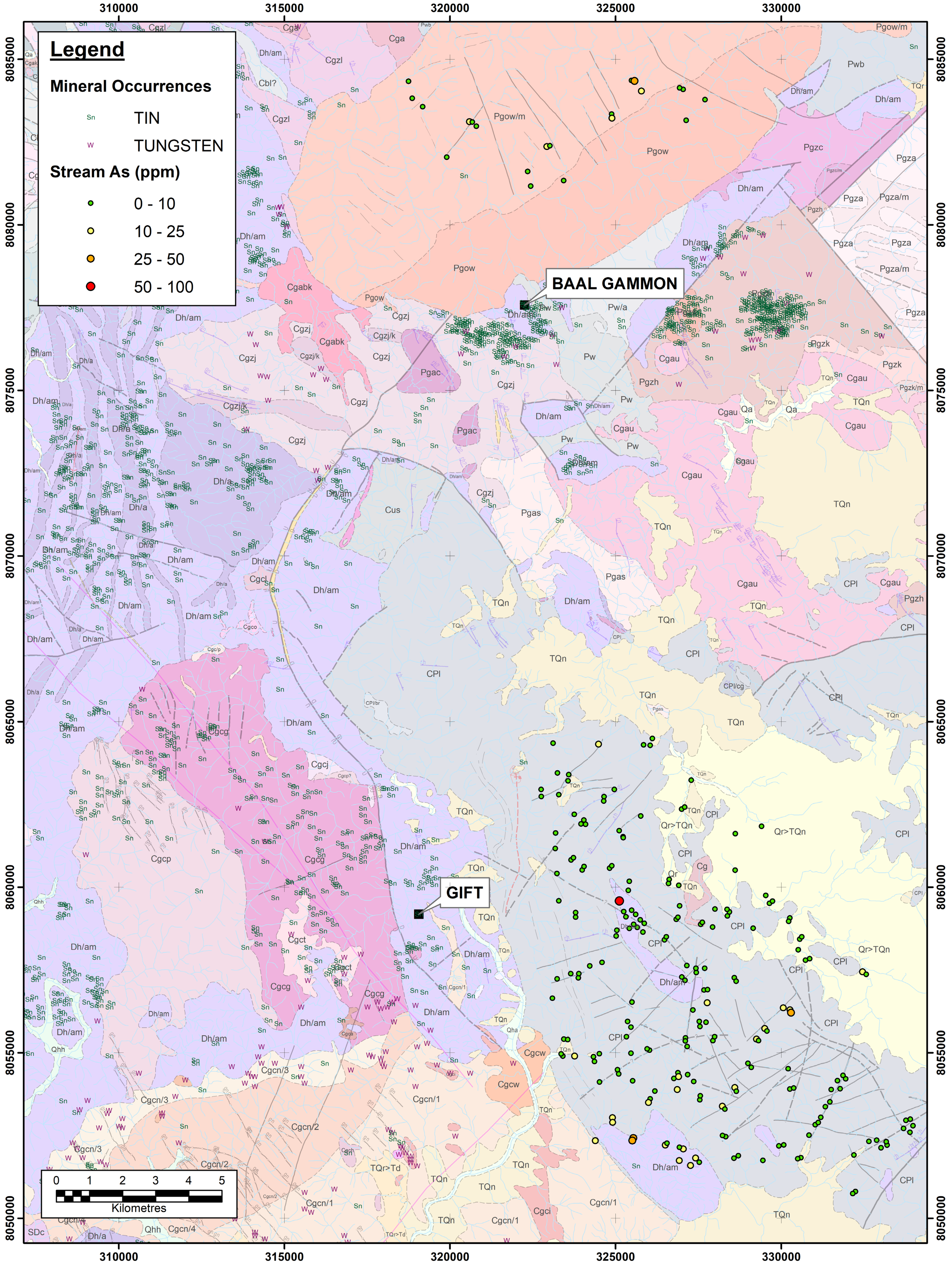

Figure 4.9. Regional stream sediment data: Arsenic. Data from GSQ NEQ Stream sediment database.

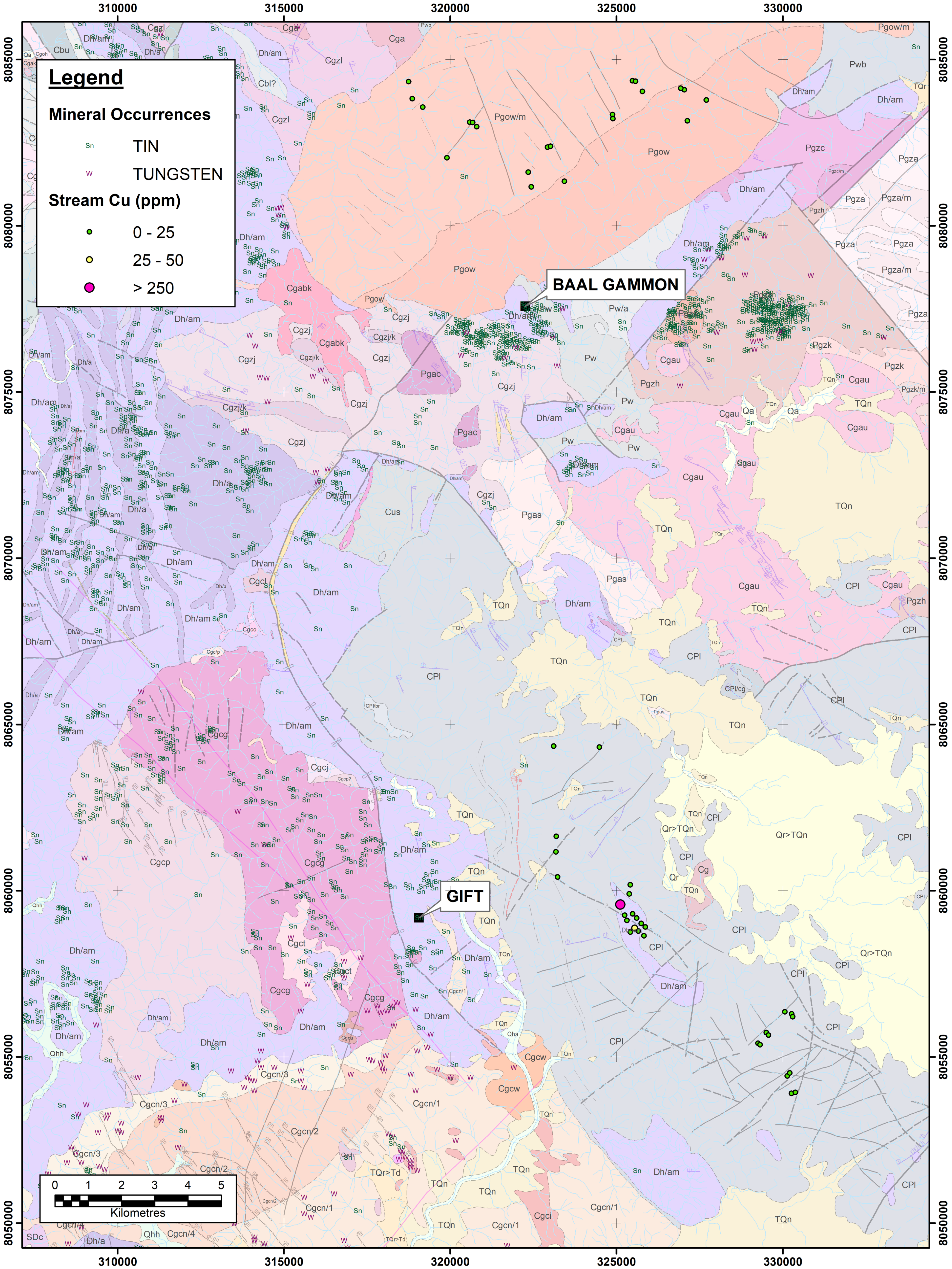

Figure 4.10: Regional stream sediment data: Copper. Data from GSQ NEQ Stream sediment database.

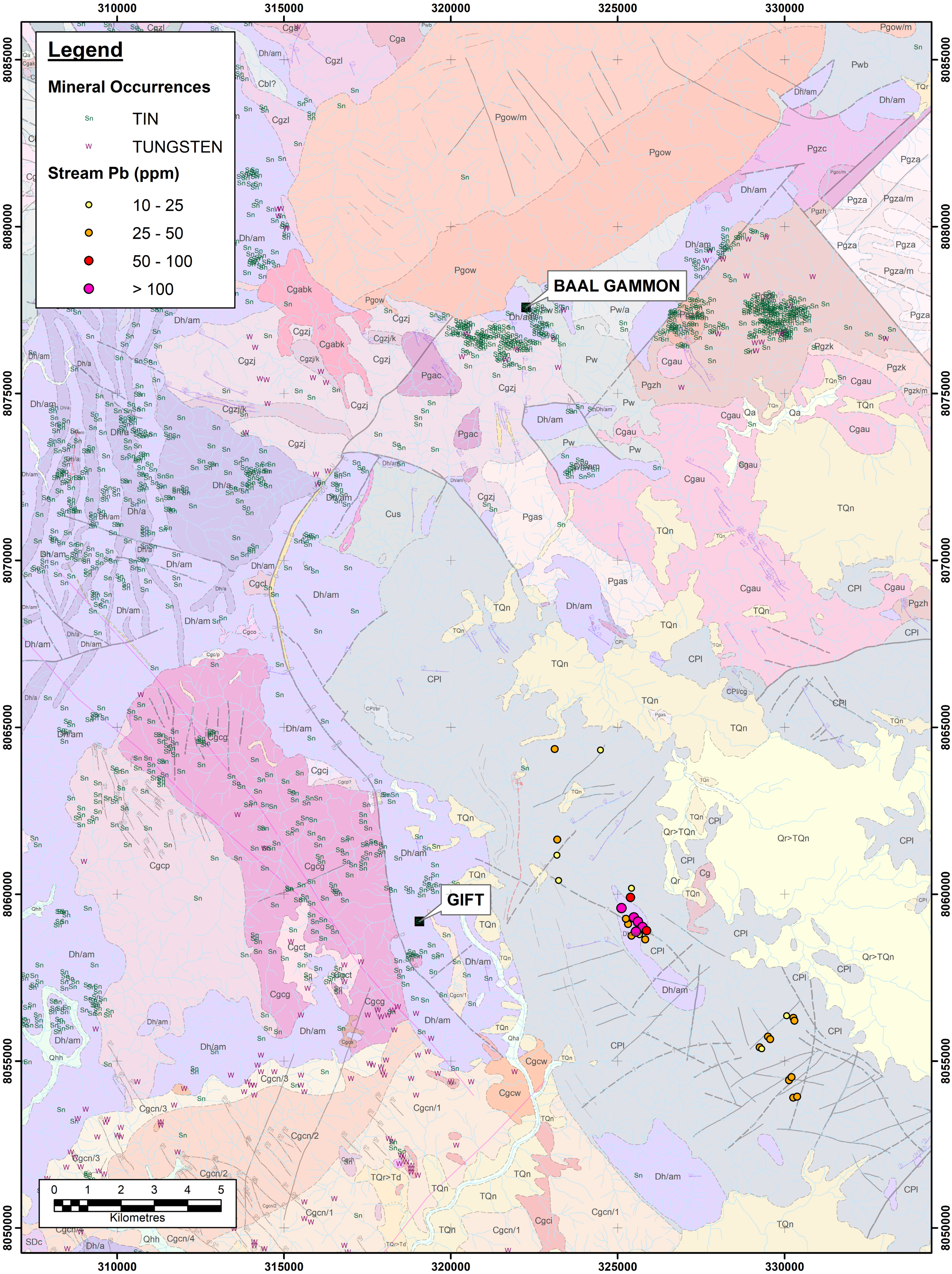

Figure 4.11: Regional stream sediment data: Lead. Data from GSQ NEQ Stream sediment database.

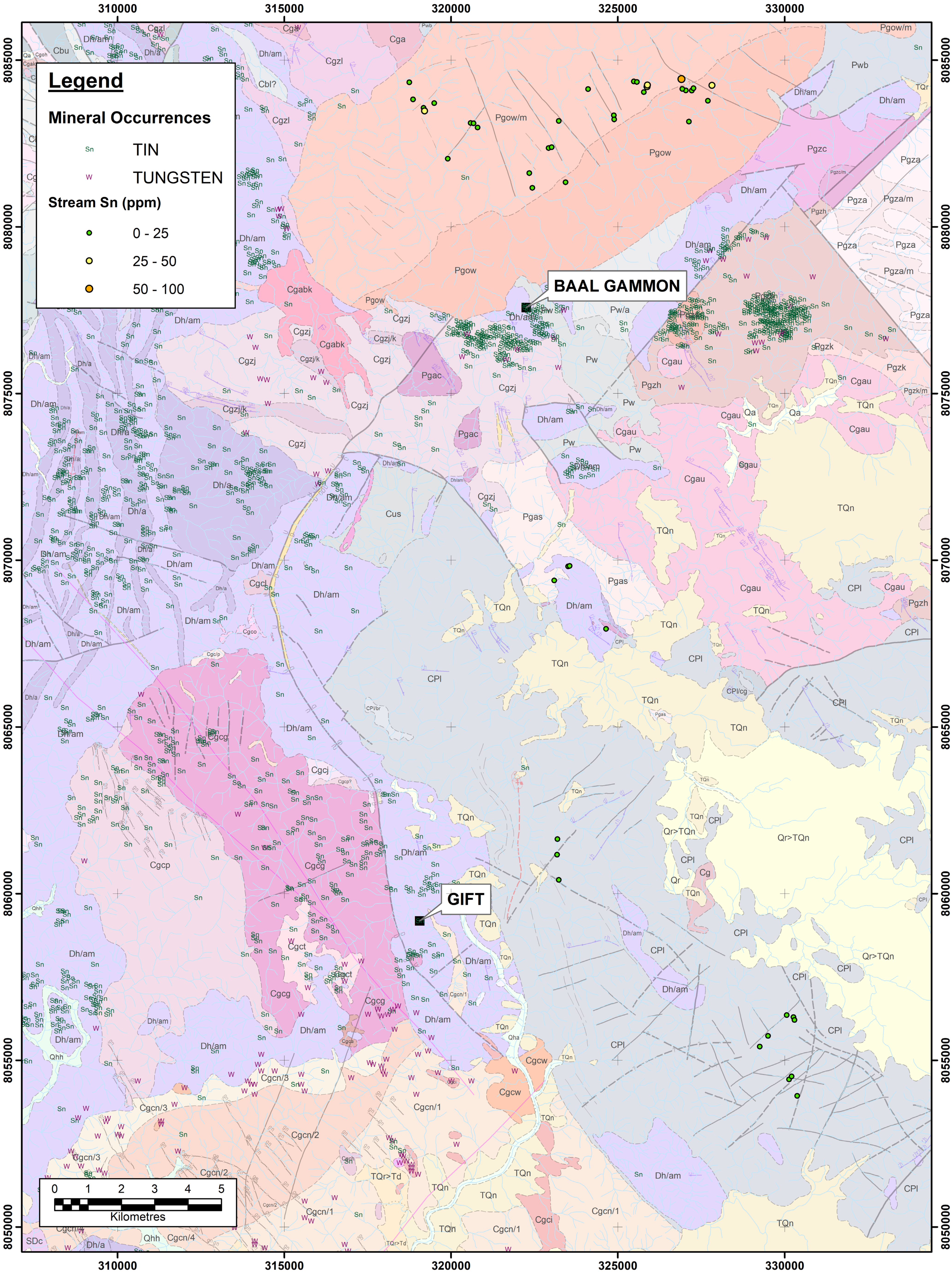

Figure 4.12 . Regional stream sediment data: Tin. Data from GSQ NEQ Stream sediment database.

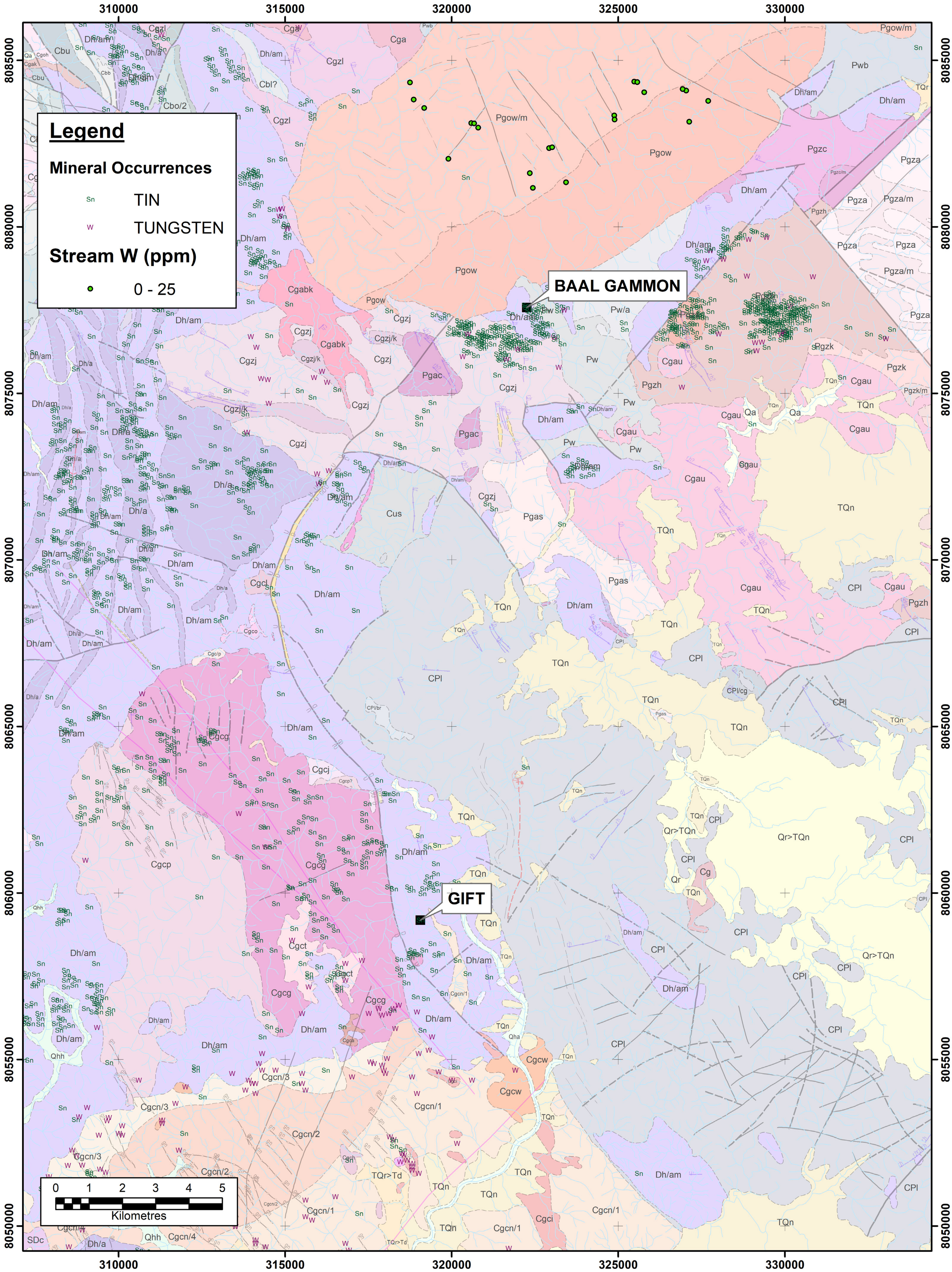

Figure 4.13 Regional stream sediment data: Tungsten. Data from GSQ NEQ Stream sediment database.

tion (Dh) typically also displays a low magnetic intensity signature, except where obvious hornfels rocks on the margins of the ganites produce magnetite-enriched higer signatures.

The Baal Gammon deposit itself is located on a subtle discrete maganetic anomaly on the southern edge of the Watsonville Granite (Pgow).

Airborne Radiometric Data

The airborne radiometric data (Figure 4.16-4.18) displays an almost inverse relationship to the aeromagentci data, in that in all channels the Tertiary Atherton Basalt is least enriched, the Late Carboniferous Glen Gordon Volcanics are moderately enriched and the various granite bodies are highly enriched.The thorium and uranium channels are notably very strongly correlated.

The Baal Gammon deposit itsef appears as a subtle low readiometric zone, but not an obvious anomaly on a district scale.

TIMING OF MINERALISATION

Relative Timing

Mineralisation at Baal Gammon is interpreted by Fraser (1972) to be associated with stockwork veining within the UNA Porphyry. Mineralisation is interpreted to be slightly younger, but broadly synchronous with the intrusion of the Elizabeth Creek Granite and UNA Porphyry. This is mainly due to the fact that while neither of the units are seen to intrude the other, the tin phase of mineralization (at least) can be seen in veins cutting through both units (Fraser, 1972).

Absolute age

No isotopic dating has been carried out in the local region. However, elsewhere in the Elizabeth Creek Granite, zircons have produced ages of around 318-322 Ma (Murgulov, 2006).

GENETIC MODEL

Baal Gammon is interpreted to be formed as the result of concentration, during the late-Carboniferous intrusion of shallow granitic bodies such as the Elizabeth Creek Volcanics. The UNA Porphyry was derived from the Elizabeth Creek Granite at the time that the plutonic body intruded to shallow depths where it is seen today. The base metal-rich volatile phase of the magma separated, forming the rhyolitic-porphyry, with disseminated sulphides forming primarily in veins (Fraser, 1972).

POST FORMATION MODIFICATION

The deposit has not undergone significant post-formation modification.

DISCOVERY

Alluvial tin was discovered in the Herberton district in 1874 and the first major lode was discovered at the Great Northern Mine, Herberton in 1880 (Blake, 1972).

The Baal Gammon deposit was discovered in 1892 (Mineral Occurrence Data Sheet, 2019), although limited information is available about the mine's early life.

GIFT (SILVER VALLEY TIN FIELD)

HOST ROCKS

Mine Stratigraphy

Stratigraphy in the Silver Valley area comprises Hodgkinson Formation sediments intruded by the Late Carboniferous Go Sam Granite, and a later phase, the Top Nettle Granite. The Go Sam Granite is also intruded to the west by the Parker Granite. The Hodgkinson Formation sediments have undergone contact metamorphism and partial silicification at the Go Sam Granite contact. This produced local patches of marble and skarn. The Atherton Basalt occurs, in individual outcrops, along the eastern edge of the Hodgkinson Formation sediments abutting the Glen Gordon Volcanics. Greisenisation of granite is reported to be widespread within the tenement (Norum, 2012; Figure 4.6).

INTRUSIVE UNITS

The granites of the Silver Valley region are all part of the O'Briens Creek Supersuite (of the Kennedy Igneous Association) and are dated as Middle to Late Carboniferous (Norum, 2012; Pollard et al., 1983; Figure 4.6)

Go Sam Granite (Cgcg): The Go Sam Granite, is described as a pink to yellow, medium grained, porphyritic biotite granite with associated tin mineralisation (Johnstone and Black, 1986). Bain and Draper (1997) describe the Go Sam Granite as an I-type. Niton analysis on drill core shows that Rb/Sr ratios are of the order of 1 to 100 and above indicating it is well fractionated. The granitic stocks in the Sailor Prospect area are leucocratic, fine-to-medium-grained and moderately to strongly altered. A fine-grained aplitic phase is also present. (Norum, 2012).

Top Nettle Granite (Cgct): The Go Sam Granite is intruded by the later phase, possibly co-magmatic, Top Nettle Granite, which is a fine to medium-grained porphyritic biotite microgranite (Pollard et al., 1983).

Parker Micro-Granite (Cgca): The Go Sam Granite is also intruded by the Parker Micro-granite, which is a fine grained topaz bearing granite to the west (Norum, 2012).

Nettle Granite (Cgcn): The Nettle Granite, described as moderately to richly porphyrytic biotite granite, appears to intrude the Go Sam granite and the Hodgkinson Formation just east of the Gift mine (Figure 4.6) within the Silver Valley tin field.

METAMORPHIC GRADE

In the Silver Valley region, the regional metamorphic grade of the Hodgkinson Formation sediments is greenschist facies. Thermal metamorphism associated with intrusion of the Go Sam granite has resulted in the recrystallization of quartz grains and formation of silicified hornfels of the sediments on the contact.

STRUCTURAL CHARACTERISTICS

Major Structural Styles

The Silver Valley Tin Field (Gift and related deposits) is situated where the Hodgkinson Formation is in contact with the late Carboniferous Go Sam, porphyritic biotite granite (Johnston and Black, 1986) on the west and the Permo-Carboniferous Glen Gordon felsic volcanics and intrusive ricks on the east (Figure 4.6; de Keyser, 1965).

A NNW to SSE trending, normal fault runs along the east contact between the Go Sam granite and the Hodgkinson Formation sediments, then at the Sailor mine it turns NW - SE trending (323°) and transects the Hodgkinson Fm. sediments (Figure 4.4). This NNW to NW trending normal fault is interpreted to have the eastern block down movement (GSQ online Data portal). Mapping at the Dingo and White Elephant mines shows extensive shearing in the same 323° direction (dipping east at 85°) and the Dingo structure is interpreted as a highly fractured zone in the Go Sam Granite and probably an extension of the major SSE trending structure seen in the aeromagnetics image (Figure YY). A structure parallel to the Dingo structure, to the north of the Gift mine, can be identified in the aeromagnetic and radiometric data (Norum, 2012), and NE trending, sub-vertical faults, which are orthogonal to the NW – SE trending faults described above.

Nature and Orientation of Controlling Structure

Througout the region, there are two main fault trends: A northwest trend, and a less pronounced northeast trend (Norum, 2016). These two trends are both dominated by steep normal faults, which typically dip at between 60° and 90°.

The main controlling structure in the case of both Baal Gammon and Gift is the contact between the mineralised granitic bodies and overlying sedimentary rocks of the Hodgkinson Formation. Norum (2016) states that it is possible that pre-existing faults and fault zones within the Hodgkinson Formation controlled the flow of mineralising fluids during the greisenisation process. Alignment of tin mines and prospects along NE – SW trends has been noticed by other workers (Norum, 2012).

MINERALISATION

Style of Mineralisation

Two types of greisen were mapped at the Sailor leases; pyritic greisen which hosts most of the tin mineralisation, and 'non-mineralised', saccharoidal, siliceous greisen. The greisens comprise dark grey sericitic, sub-horizontal lenses with variable pyrite. Less common, dark green, chloritic variants are also present (Figure 4.14A). Tin assays range from 500 to 3000 ppm Sn with higher values over widths of greater than a few metres are rare (Figure 4.14B). Cassiterite is generally within 0.05 to 0.5mm size range. There are <1% chalcopyrite (chalcocite or covellite) and marmatite and trace amounts of galena, bismuth and bismuthinite (Cochrane and French, 1981).

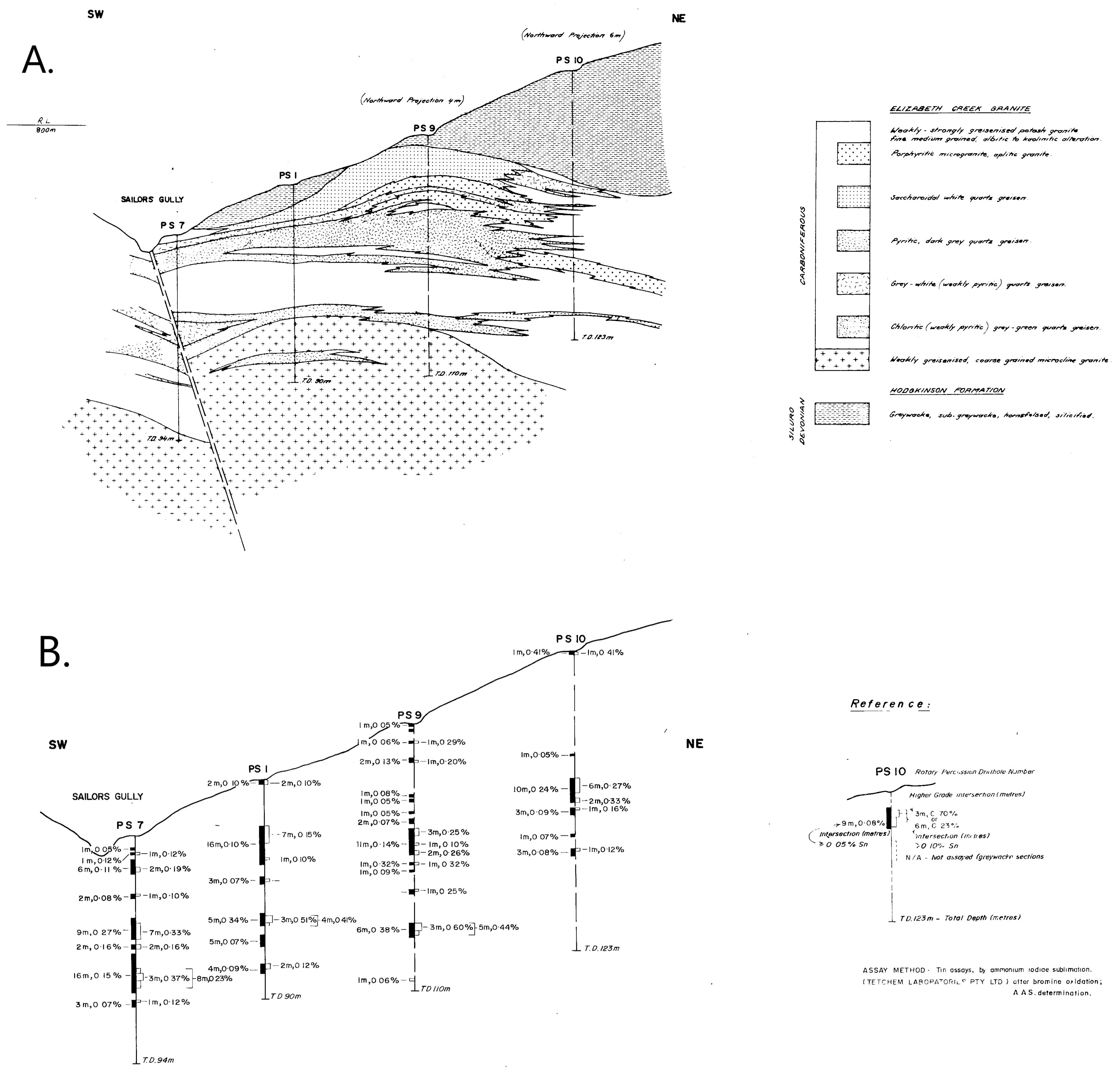

Figure 4.14. SW to NE drill section at the Sailor tin deposit with; A) down-hole geological interpretation; B) tin (%) assays, the mineralised interval and drill hole depth (Plan Q80-34 from Cochrane and French, 1981)

WALL ROCK ALTERATION

Alteration at the Gift and other Silver Valley tin deposits is associated with greisens developed in the upper cusp of the Go Sam Granite in contact with the hornfelsed Hodgkinson Formation sediments (Norum, 2012). At the Sailor Mine mineralised greisens comprise sericite –pyrite -cassiterite, whereas non-mineralised greisens comprise sercite – quartz with saccharoidal texture. There are also lessor amounts of sericite – chlorite greisens (Cochrane and French, 1981). No detailed petrological study of the rocks has been carried out but it is believed that alteration includes development of microcline, albitisation and kaolinisation. Alteration is most intense adjacent to greisen lenses (Norum, 2012).

GEOPHYSICAL EXPRESSION

Aeromagnetic Data

A discusison of the magnetic signatures of the regional rock types is provided above in the discussion of the Baal Gammon geophysical expression.

A detailed 100m line-spacing aeromagentci survey was completed over the Silver Valley tin field in 2007 by North Queensland Metals Limited (survey ID 1185 - Herberton Project) but the data was never submitted to the GSQ. However, an image was provided in company reporting and is presented in Figure 4.19. It indicates that the Gift and Sailor tin deposits do not display appreciable magnetic anomalis, but interestingly the Zig Zag targets hosts a discrete magnetic high anomaly. The reason for this is unknown.

GEOCHEMICAL EXPRESSION

Stream Sampling

Although prospectors panned the creeks for alluvial cassiterite (Cochrane and French, 1981), there are no -80# or bulk stream sediment sample results present in the GSQ stream sediment database in the immediate tin field environs (https://geoscience.data.qld.gov.au/geochemistry/whole-of-queensland-geochemistry-databases).

Soil Sampling

Western Mining (WMC) conducted 100m x 200m spaced soil sampling (50m x 100m infill) at Zig Zag, with the aim of examining a hydrothermal breccia for primarily gold mineralisation. The samples comprised -200µm material, which was analysed for Au, As, Cu, Pb, Zn, Ag, Mo and Sn. Assay results defined a 50m x 300m zone of >500ppm Sn which coincided with the breccia. Follow-up sampling did not reproduce the high anomaly with a peak of 496ppm Sn. The result was attributed to sporadic quartz veinlets within the breccia. WMC completed a traverse of ten bulk rockchip samples, which returned assays results with a poor spatial correlation to the soil sample assay results (Norum, 2012).

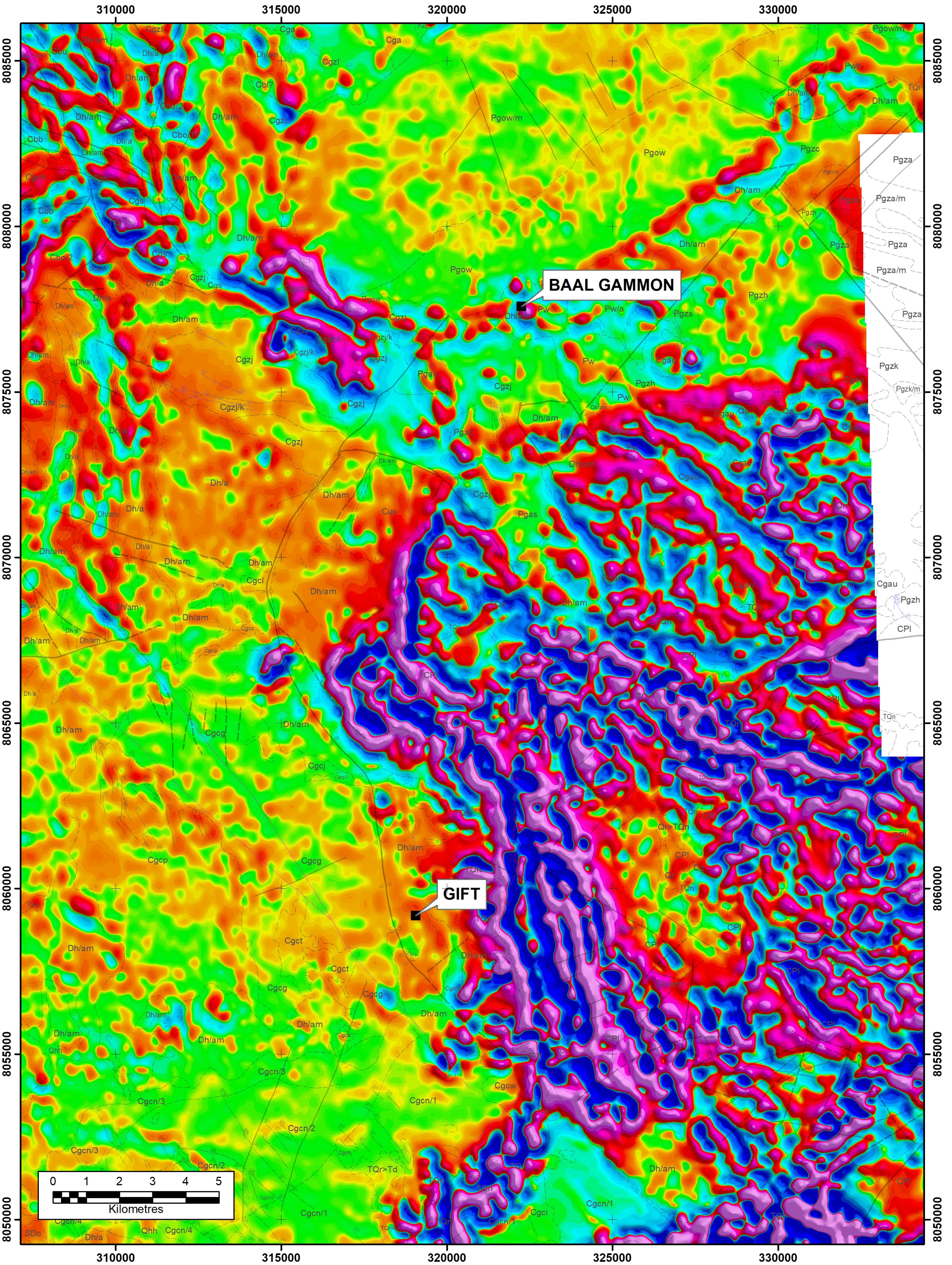

Figure 4.15 Image of Aeromagnetic survey data (reduced to pole with first vertical derivative processing - RTP-1VD) for the Baal Gammon and Gift district (GSQ Hodgkinson - Georgetown Block B, Survey ID 1092).

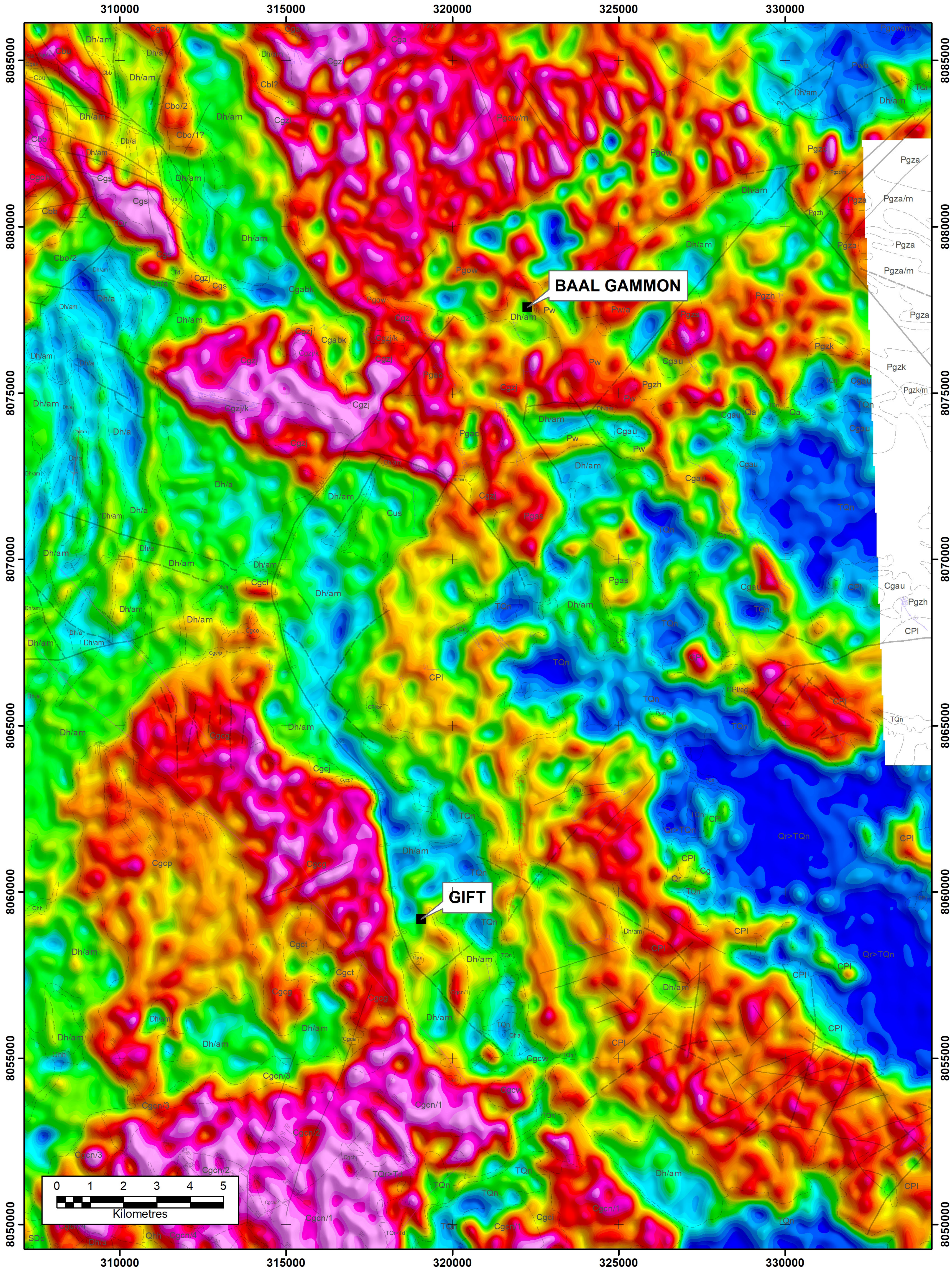

Figure 4.16 Image of airborne radiometric survey data (potassium channel) for the Baal Gammon and Gift district (GSQ Hodgkinson - Georgetown Block B, Survey ID 1092).

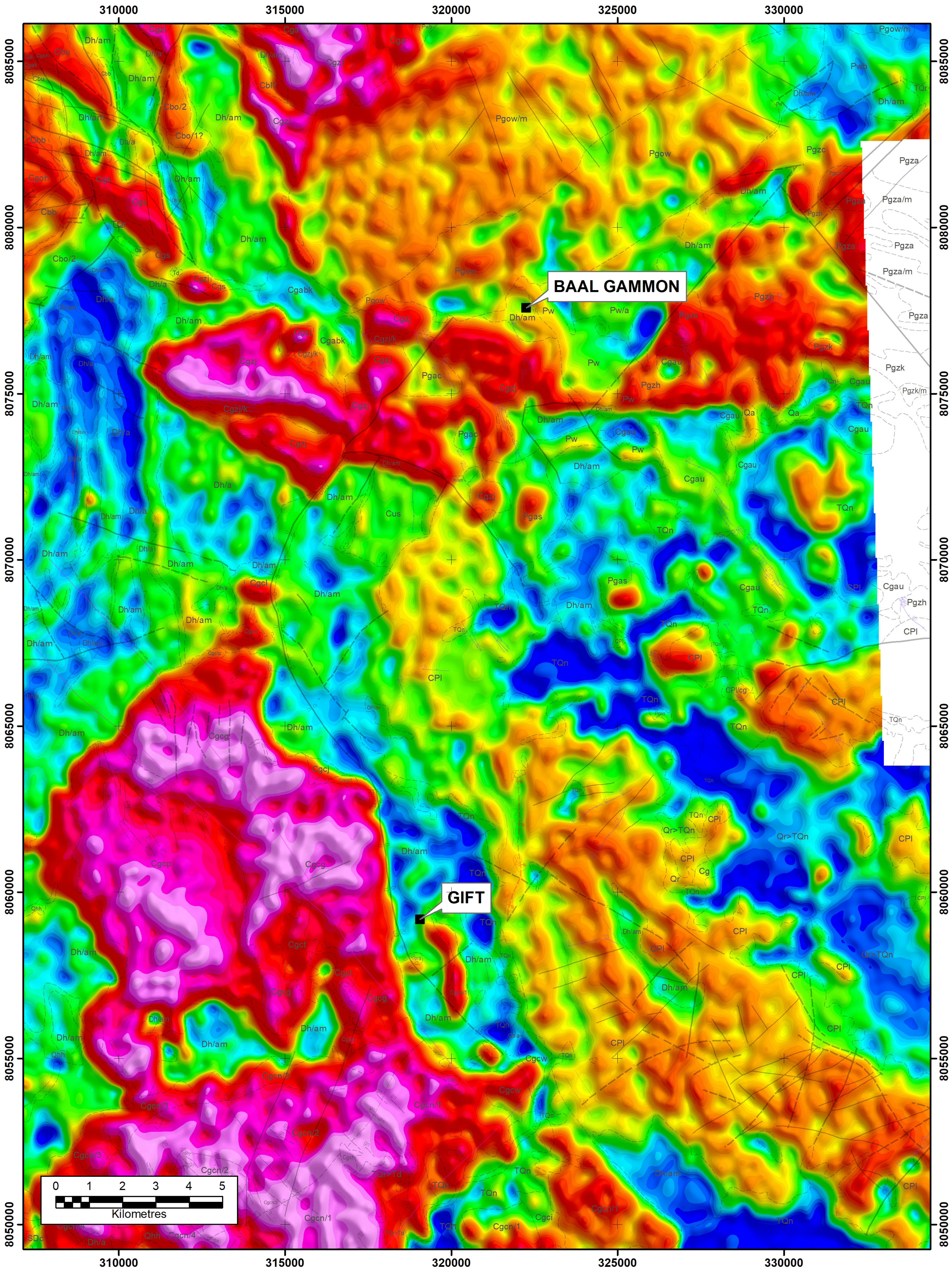

Figure 4.17 Image of airborne radiometric survey data (thorium channel) for the Baal Gammon and Gift district (GSQ Hodgkinson - Georgetown Block B, Survey ID 1092)

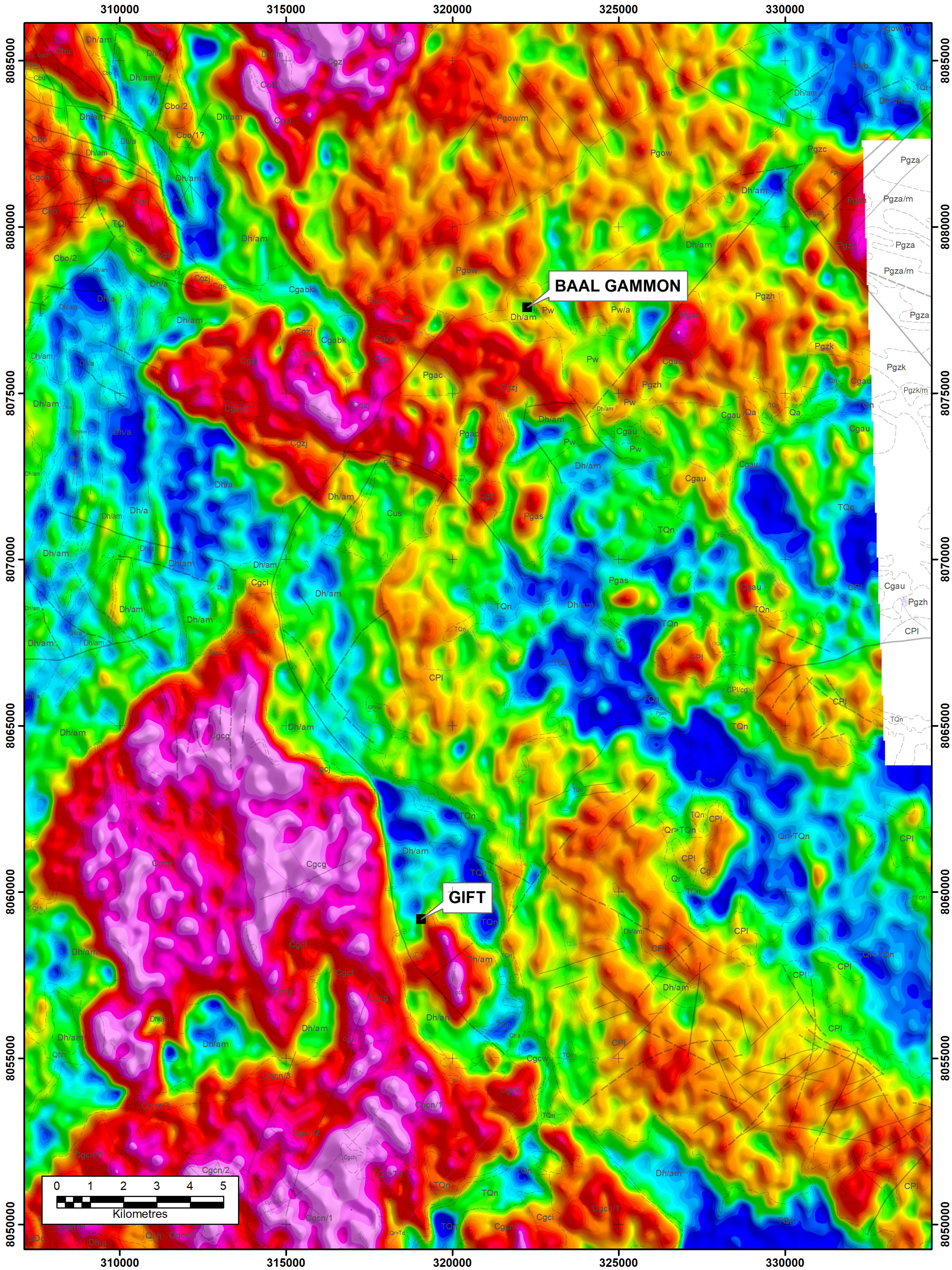

Figure 4.18 Image of airborne radiometric survey data (uranium channel) for the Baal Gammon and Gift district (GSQ Hodgkinson - Georgetown Block B, Survey ID 1092)

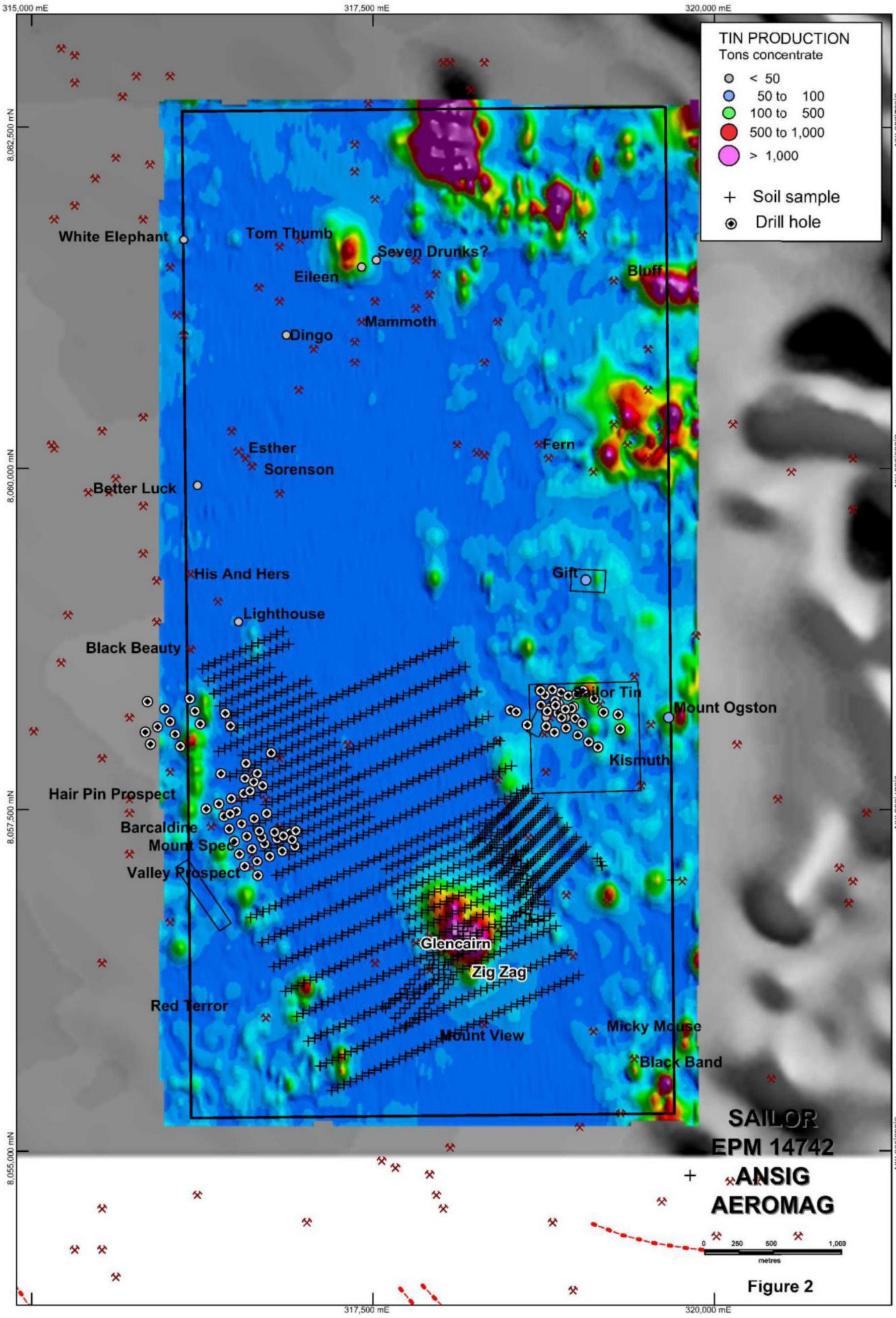

Figure 4: EPM 14742 Prospect Areas, Tin Production, Soil Sampling and Drilling on Aeromag

12

Figure 4.19. Image of aeromagnetic data (Analytic Signal) from the 2007 100m line-spacing survey (survey ID 1185), also showing tin mines and prospects for the Silver Valley mining field (Fig. 2 from Norum, 2012).

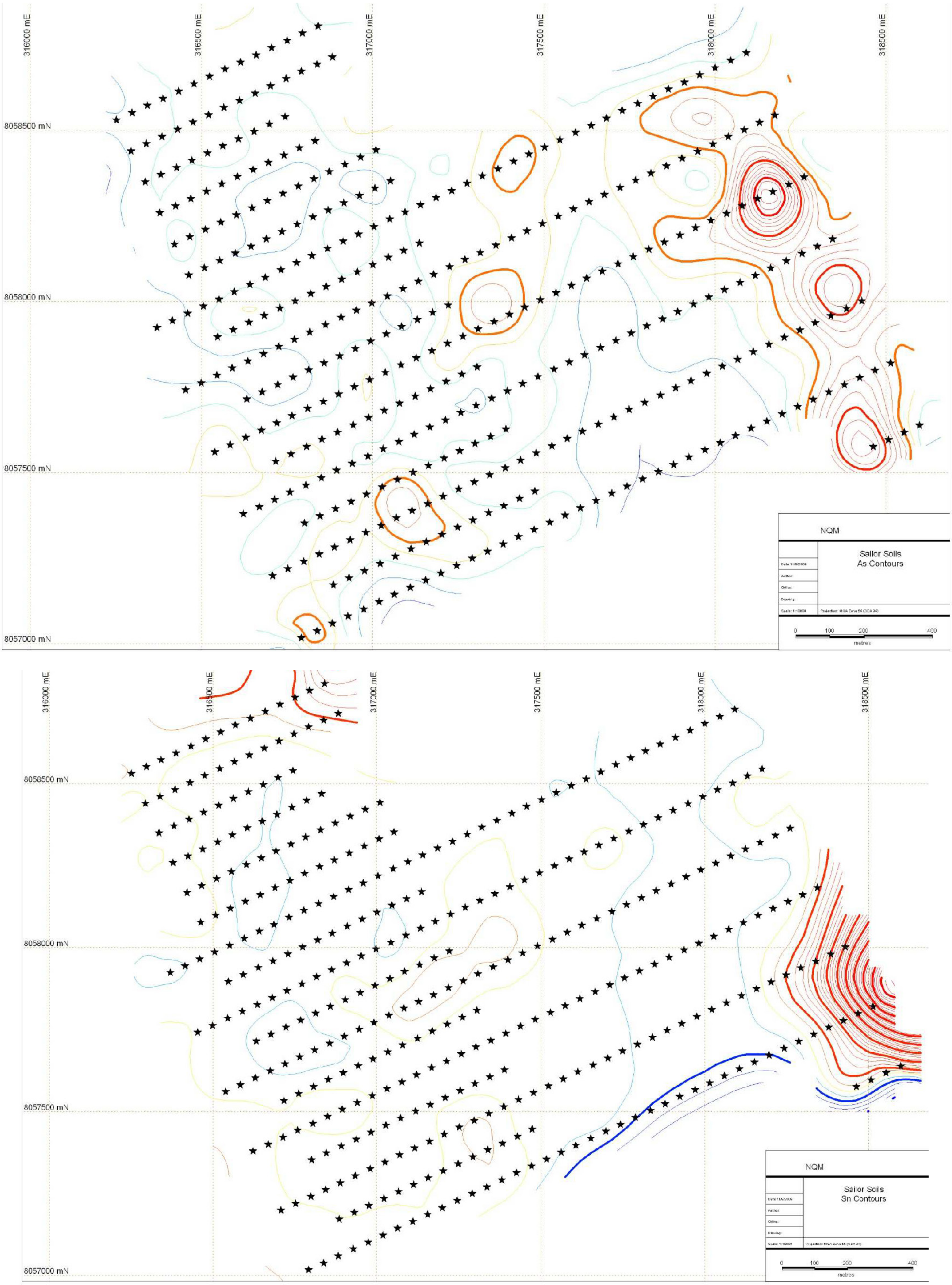

Figure 4.20. Sailor Prospect soil grid; Top – Contoured As results; Bottom – Contoured Sn results (Dale, 2010)

North Queensland Metals (NQM) conducted soil sampling at the Zig Zag and Sailor prospects exploring primarily for gold (Dale, 2010; Norum, 2012). Sampling was conducted at 50m x 200m with infill of 50m x 100m spacings to identify major displacement faults affecting Sailor and Zig Zag and the location of extensive regional structures which appear to have a controlling relationship with mineralisation at Zig Zag. The samples comprised 0.5 to 1kg of -1.6mm soil. The Zig Zag soils were analysed at ALS for Sn, Ag, As, Cu, Pb, Zn by ME-ICP61, In by ME-MS62s and Au by Au-AA21, whereas soils from the Sailor prospect were analysed by a hand-held Niton portable XRF machine. Data was collected for 34 elements including Mo, Au, Bi, As, Zn, W, Cu, Ni, Co, Fe, S, K, Sb, Sn, Ag and Pd. At the Zig Zag prospect a 300m x 300m coincident Sn, Pb and As anomaly was defined (Dale, 2010). The location and extent of the anomaly are topographically controlled and spatially it is coincident with the occurrence of Hodgkinson Formation sediments. The anomaly also appears to be constrained by the transition from Go Sam Granite (west) to the Hodgkinson Formation sediments. At Sailor a 300 x 500m Sn anomaly was defined in the south-east corner of the grid, which is coincident with As and partially coincident with Cu, Pb and Zn (Figure 4.20; Dale, 2010).

TIMING OF MINERALISATION

Relative Age

The Go Sam Granite, which is dated as Late Carboniferous is interpreted as the source of the mineralising fluids which led to the formation of the Gift tin deposit (Johnstone and Black, 1986).

Absolute Age

No absolute age is known for the tin deposits of the Silver Valley tin field.

GENETIC MODEL

The mines within the Silver Valley tin field occur in the greisenized roof of the Go Sam Granite, which is a post orogenic, fractionated, I-type granite, within the Sn and W mineral field of the Kennedy Igneous Province (Figure 4.6; Jell, 2013; Bain and Draper, 1997). The Gift mine is hosted within the Hodgkinson Formation sedimentary rocks, presumably above a stock of the Go Sam granite (Norum, 2012). A description by Launay et al (2019) of the greisenization process in Sn – W granites and the enhanced permeability created by the alteration of feldspars and biotite is a good analogy for the formation of the Silver Valley tin deposit; Greisenization is a common hydrothermal alteration associated with Sn-W and rare metal deposits that are usually spatially and genetically associated with fractionated crustal granitic intrusions. This post-crystallization alteration, marked by the breakdown of feldspars and biotite, occurs generally on the cupolas of intrusions during the cooling stage of the granitic intrusions and the first stages of hydrothermal activity. Numerous studies have established that greisenization results from strong interactions between granitic rocks and acidic fluids at temperatures ranging from 250°C to 450°C. These intense fluid-rock interactions lead to complete mineralogical transformation of the granitic rocks by coupled dissolution-precipitation (CDP) reactions. (Launay et al, 2019). Refer to Figure 4.21for an illustration and description of the greisenization process.

POST-FORMATION MODIFICATION

The Neogene to Pleistocene Atherton basalt, which unconformably overlies the Hodgkinson Formation sediments, outcrops within Silver Valley (Figures 4.4 and 4.6) and is described as dark grey to black, fine-grained vesicular to massive olivine basalt, with minor scoria, basaltic tuff (Hill, 1960).

DISCOVERY

The Sailor Mine was discovered by panning alluvial tin in creeks draining the deposit, and this was followed-up with detailed 1:5000 scale mapping, rockchip sampling of the greisen outcrops and then percussion drilling. In 1978 an I.P. geophysical survey was also used to define the pyrite associated with the tin mineralisation (Cochrane and French, 1981). The discovery method at Gift is unknown, however, it is assumed that the Gift tin deposit was found by early prospectors panning the creeks, as for other mines and prospects within the Silver Valley tin field.

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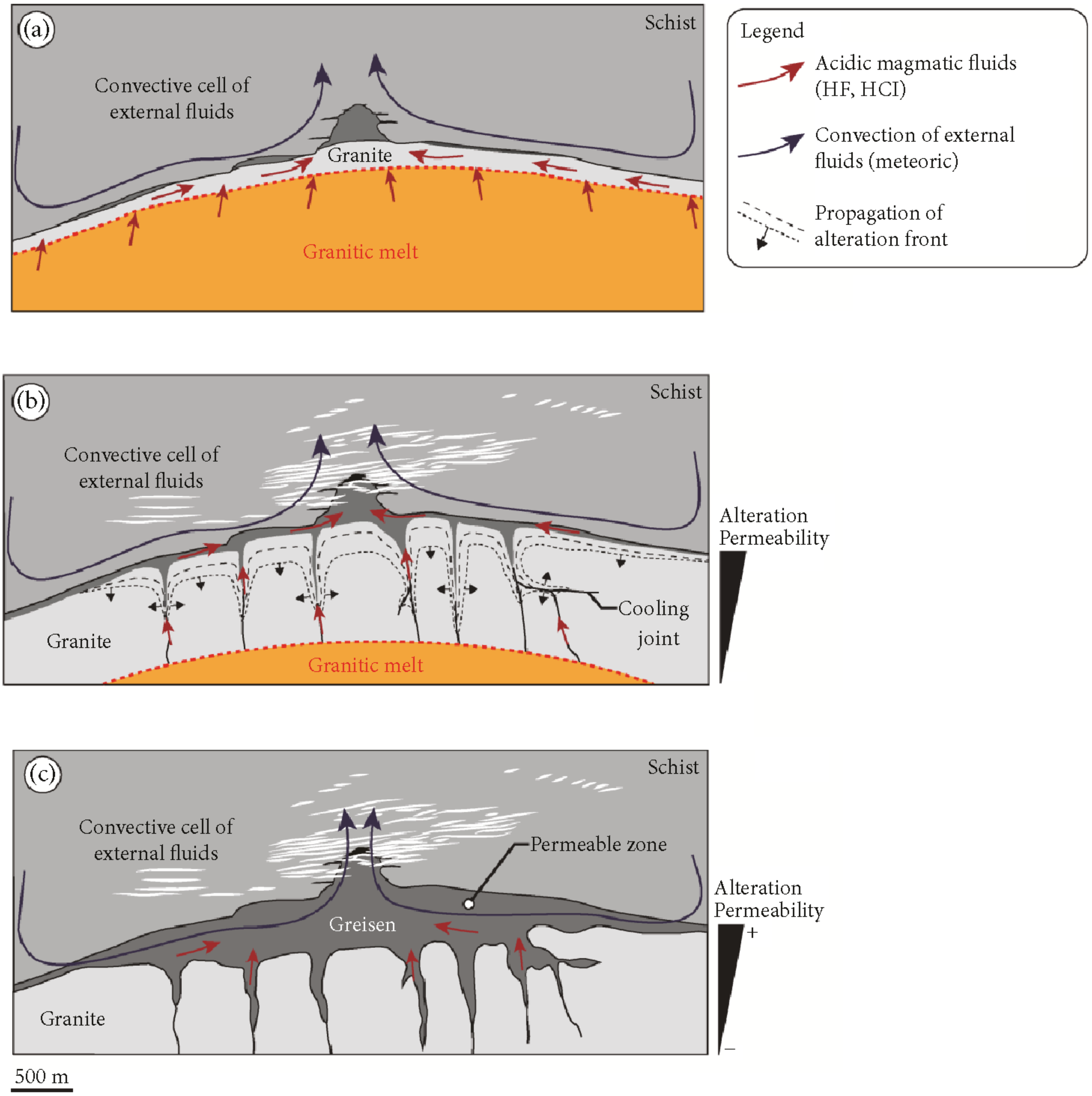

Figure 4.21: Greisenization of the Panasqueira granite, modified from Launay et al, 2019 as an example of possible mineralising processes that operated in the Silver Valley Tin Field (Gift and other deposits) . (a) Initiation of granite cooling and fluid flow, which trigger the greisenization of the granite along the granite-schist contact (permeable interface). (b) Alteration of the granite leading to the progressive replacement of feldspars and biotite by muscovite. This mineralogical transformation is accompanied by the generation of porosity resulting from the decrease in molar volume associated with the replacement reactions. A positive feedback between greisen alteration and permeability is assumed here to explain the propagation of the greisenization front and the development of massive greisen. (c) The porosity generated by the greisen alteration enhances permeability and creates a potential permeable zone that can enhance fluid flow and metal transport. The presence of metal bearing-minerals (cassiterite and sulfides) in the newly formed greisen's porosity seems to confirm the role of massive greisen as a drain for mineralizing fluids and to explain the formation of this type of deposit.

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