Magnesium Minerals Pty Ltd
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Annual Technical Report

EL 4639

For the period 7 January 2011 – 6 January 2012

Tenure holder | Magnesium Minerals Pty Ltd Tenement operator | Magnesium Minerals Pty Ltd
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Summary

During the period, Magnesium Minerals Pty Ltd conducted geological mapping and assessment of Hymap hyperspectral thermal imagery to characterise and define the significance of the effects of folding and structure on the thickness and potential economics of developing the sedimentary Magnesite ($MgCO_3$) beds hosted in the Skillogalee Dolomite within EL 4639.

Keywords

- EL 4639
- Magnesite
- Magnesium
- Skillogalee Dolomite
- Burra Group
- Hymap

Table of Contents

Page

List of Figures

List of Tables

List of Appendices

1. Introduction

Collaby Hill is located 200 km north of Adelaide and lies within the Skillogalee Dolomite of the Neoproterozoic Burra Group. The Skillogalee Dolomite is host to a major sedimentary magnesite deposit in the Willouran Ranges and magnesite is known to exist throughout the formation.

Following up on the work completed by Magnesium International Ltd during 2002-2003, the Collaby Hill area was selected by Magnesium Minerals for magnesite exploration and potential development of mining operations, due to its close proximity to transport and processing infrastructure, existing mining activity in the area (*benefit of possible shared utilities*) and being less environmentally sensitive than other parts of the southern Flinders Ranges.

The Skillogalee Dolomite consists of shallow water, intraclastic dolomites and magnesite with interbeds of siltstone and sandstone (Preiss, Belperio, Cowley and Rankin 1993). Collaby Hill is situated on the western limb of a large north-south striking syncline. The apparent thickness of the Skillogalee Dolomite is much greater on the western limb than that of the eastern limb.

Geological mapping and assessment of previously flown Hymap data during the reporting period was aimed to consider the effect of localised structures on the magnesite beds.

Mapping has shown that several parasitic Z-folds are present resulting in structural thickening and repetition of dolomite beds within the Skillogalee Dolomite. The structural repetition of magnesite beds by localised folding increases the potential for an economic deposit due to the greater volume of magnesite at, or near, the surface, especially along the axis of these small parasitic folds.

2. Tenure

Collaby Hill is located approximately 200 km north of Adelaide, South Australia as shown in Figure 1. Mapping is based on the Australian Geodetic Datum 1984 (AGD84) as used in the 1:50,000 topographic map of the area. The mapping area in the Universal Transverse Mercator (UTM) zone 54 lies between 236,500 east 6,317,500 north, 239,000 east 6,322,500 north.

Access to the area is via Collaby Hill Road which connects to Highway One approximately 100 m north of the Laura turn off. Collaby Hill Road extends around the southern and eastern perimeter of the mapping area. Within the mapping area itself, access is restricted to 4WD farm tracks with most other areas accessible by foot.

Tenement details for EL 4639 are detailed below in **Table 1**

EL	Name	Tenure holder	Tenement operator	Area (km^2)	Grant Date	Expiry Date
4639	Collaby Hill	Magnesium Minierals Pty Ltd	Magnesium Minierals Pty Ltd	405	7 January 2011	6 January 2012

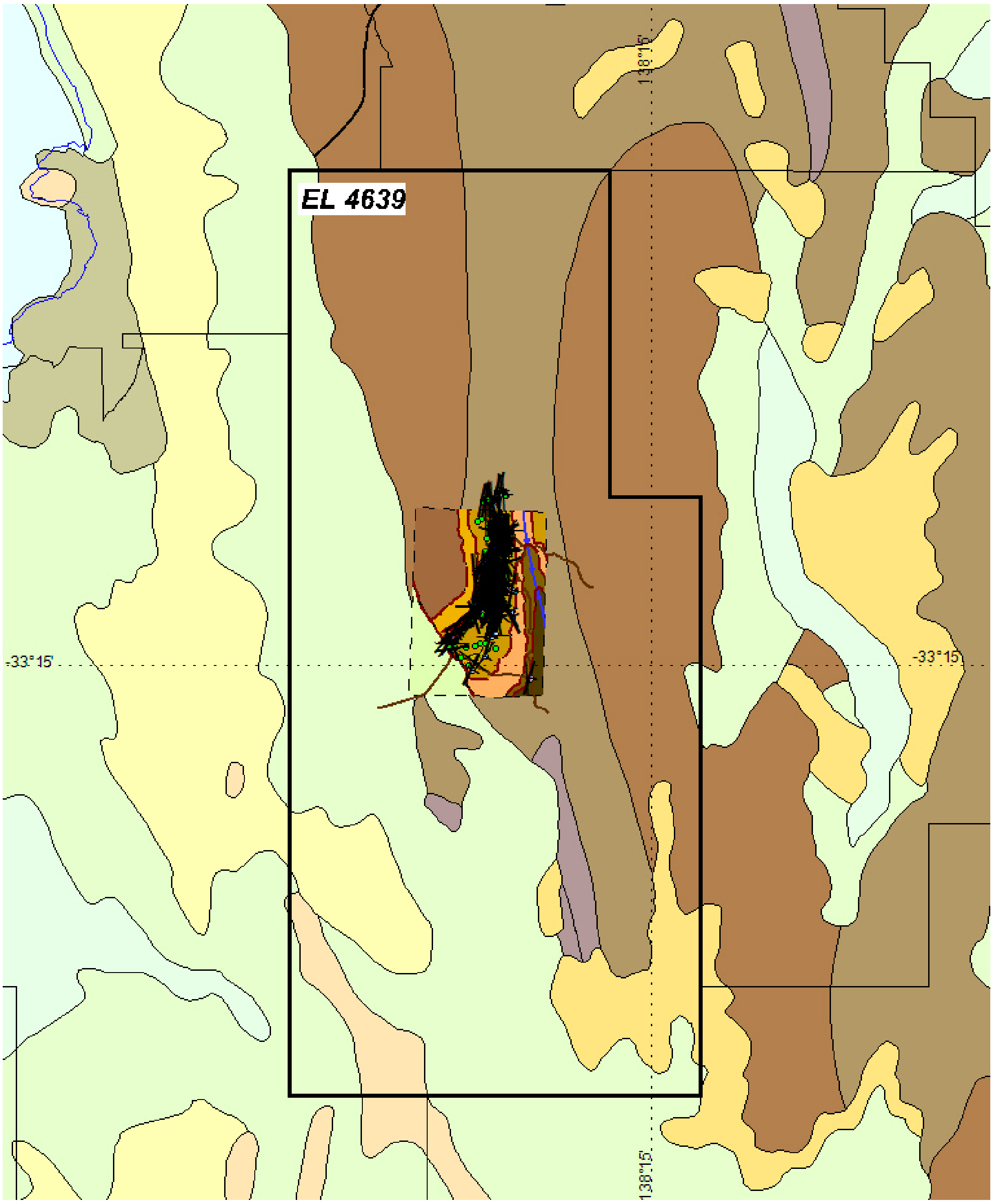


Figure1 Tenement Location

3. Geology

Ages[1] (Ma)					
	Sturtian	***Umberatana Group***			
710	**Sturtian**	**Warrina Supergroup**	**Burra Group**	**Belair Subgroup**	Kadlunga Slate
					Gilbert Range Quartzite
720					Mintaro Shale
730	**Torrensian**			**Bungarider Subgroup**	Saddleworth Formation
740					Undalya Quartzite
750					Woolshed Flat Shale
				Mundallio Subgroup	Skillogalee Dolomite Upper member
					Skillogalee Dolomite Lower Member
760				**Emeroo Subgroup**	Bungaree Quartzite
770					River Wakefield Formation
					Blyth Dolomite
780					Rhynie Sandstone
	Willouran		***Callanna Group***		

Table 2: The Burra Group as seen in the southern Flinders Ranges adapted from (Preiss 1987, p. 78; Preiss and Cowley 1999, p. 32).

[1] Ages are interpolated from Preiss (2000, p. 40)

The southern Flinders Ranges are composed of a thick sedimentary sequence that was deposited during the Neoproterozoic to Middle Cambrian in a large subsiding rift basin complex, known as the Adelaide Geosyncline. These sediments were folded and exposed during the Late Cambrian-Ordovician Delamerian Orogeny to form the Adelaide or Delamerian Fold Belt. The Adelaide Geosyncline stretches approximately 750 km from Kangaroo Island through the Mount Lofty and Flinders Ranges, the Willouran Ranges and onto the Peake and Denison Ranges, the full extent is shown in Figure 2.

The host formation of the magnesite is the Skillogalee Dolomite, a member of the Mundallio Subgroup of the Burra Group. The Burra Group is of Torrensian to early Sturtian age and represents a major sedimentary cycle.

Burra Group stratigraphy

The Burra Group along with the underlying Callanna Group make up the Warrina Supergroup and represent the first stages of deposition of the Adelaide Geosyncline (Preiss 1987). The Burra Group was first named by Mirams and Forbes (1964) and included the formations mapped by Wilson (1952), in the Clare–Riverton area. The Base of the Rhynie Sandstone and its equivalents are considered to be the base of the group. The contact between this and the underlying Callanna Group is unclear with most contacts being unconformable or faulted (Preiss 1987, p. 73). When first proposed, the top of the Burra Group corresponded with the Torrensian time interval as proposed by Mawson and Sprigg (1950) who identified the Belair group as possibly glacial. However mapping by Binks (1968), and work by Forbes (1967) and Coats (1967) identified an unconformity between the Belair Subgroup and the Sturt Tillite. Further to this Coats (1967) suggested that the Belair group had more lithological similarity to the Burra Group and that the group be relocated. This information ultimately led to the Belair Subgroup being included within the Burra Group. The boundary between the Torrensian and Sturtian however was not changed and remains at the base of the Belair Subgroup, so that the Burra Group now covers the Torrensian and part of Sturtian time (Preiss 1987, p. 74).

Mundallio Subgroup

The Mundallio Subgroup conformably overlies the Emeroo Subgroup. The subgroup was defined by Uppill (1979) to include the carbonate dominated sequences of the Burra Group that represented a time of very shallow water deposition, with smaller cycles of transgressive-regressive cycles. The subgroup as described by Uppill (1979) is shown in Table 2 and although included here in full, not all of the formations proposed have become generally accepted.

<table>
<tr><th></th><th colspan="2">Mt Lofty Ranges</th><th>Southern Flinders Ranges</th><th colspan="2">Northern Flinders Ranges</th></tr>
<tr><td rowspan="2">Mundallio Subgroup</td><td>Montacute Dolomite</td><td rowspan="2">Skillogalee Dolomite</td><td>Yadlamalka Formation</td><td>Yadlamalka Formation</td><td>Mirra Formation</td></tr>
<tr><td>Castambul Formation</td><td>Nathaltee Formation</td><td>Nankabunyana Formation</td><td>Tilterana Sandstone
Camel Flat Shale</td></tr>
</table>

Table 3: Mundallio Subgroup as proposed by Uppill (1979, p. 26)

The Castambul and Montacute Dolomites of the Mount Lofty Ranges were first named by Mawson and Sprigg (1950) and applied to two dolomite horizons that outcropped in the Torrens Gorge area. The Castambul dolomite was promoted to the Castambul Formation by Uppill (1979) to include the silts, phyllites and quartzites that lie above and below the unit as identified by Mawson and Sprigg (1950) in the Torrens Gorge area.

In the Riverton-Clare region, Wilson (1952) named the Skillogalee Dolomite and correlated a lower member with the then Castambul Dolomite and an upper member with the Montacute Dolomite. This correlation was supported by Mirams and Forbes (1964) who also extended the name to other similar units in the Flinders and Willouran Ranges.

In the southern and northern Flinders Ranges Uppill (1979) proposed splitting the Skillogalee Dolomite into new formation names as shown in Table 2. These revisions were not accepted by Preiss (1987) due to problems with mapability and facies variations throughout the formation. Preiss instead proposed that the informal classification of a lower and upper member be maintained. However Preiss does acknowledge the usefulness of Uppill's reference sections for the Skillogalee Dolomite in the Flinders Ranges.

Skillogalee Dolomite

In the type area around Riverton and Clare, Wilson (1952) describes the Skillogalee Dolomite as approximately 330 m of cream coloured fine to medium grain dense dolomites with occasional interbedded dolomitic shales, with only meagre blue grey dolomites near the top of the formation. Also noticeable in Wilson's type section was the lack of any magnesite within the formation in this area. Preiss (1987, p. 99) describes the Skillogalee Dolomite as generally consisting of a lower unit of pale commonly recrystallised dolomite and an upper unit of dark grey dolomites with sedimentary magnesite and black chert, which can be recognised in many areas.

In the type section 30 km northeast of Port Augusta Uppill (1979) describes her lower unit of the Skillogalee Dolomite (Nathaltee Formation) as three distinct units. The base unit (Unit 1) is described as two thirds carbonate facies and one third terrigenous facies. The carbonate facies consist of primarily grey and dark grey laminated dolomicrites with pale grey to black chert nodules. The presence of mud cracks and small scale soft sediment structures within these rocks are indicative of original mudstones. Sandstones and siltstones form the terrigenous clastics, the sandstones consist of moderately sorted fine to coarse grain size sandstones that are either quartzose or dolomitic cemented and sub-arkosic in composition. Planar bedding and lamination dominate the sedimentary structures. The interbedded siltstones are partly dolomitic planar and wavy laminated and occur as thin beds within the dolomites or thicker beds up to 6 m thick.

In the Port Germein-Beetaloo Valley area Uppill (1979) assigned the lower unit of the Skillogalee Dolomite to the upper two units of her Nathaltee Formation. Uppill describes the transition from the underlying quartzite to the Nathaltee Formation as siltstones interbedded with quartzites and dolomites. Overlying this is a sequence similar to unit two of the Nathaltee Formation consisting of interbedded green siltstones, buff stromatolitic dolomites and laminated dolomicrites. This is followed by a unit similar to unit three consisting of poorly laminated shale overlain by trough cross bedded quartzites.

The upper unit of the Skillogalee Dolomite is represented by Uppill's (1979) Yadlamalka Formation with a type section 50 km north of Port Augusta. The formation consists of predominantly carbonate facies that are dominated throughout the unit by a dark grey laminated dolomicrite that forms fissile and more massive outcrops. Structures include planar to slightly wavy lamination, silty and sandy laminae and occasional graded laminae that are indicative of carbonate muds being deposited from suspension with minor silt and sand introduced by current activity. Stromatolites, most abundant in the middle of the formation occur in biostromes and bioherms of dark grey dolomicrite. Magnesite forms approximately 11% of the type section and most commonly consists of an intraformational conglomerate particularly in the lower and uppermost sections of the formation.

Preiss and Cowley (1999) identified three facies belts within the Skillogalee Dolomite that are bounded by approximately N–S faults in the Mid-North. Their westernmost facies belt along the Torrens Hinge Zone is most relevant here since it covers the project area. This area is described as being dominated by sandy facies, which are commonly coarse grained, feldspathic and dolomite cemented. They have proposed the name Marola Sandstone Member for this unit which interfingers the unnamed lower and upper members of the Skillogalee Dolomite.

A detailed petrographic study was performed by Forbes (1960) on what is now known as the upper member of the Skillogalee Dolomite. Forbes (1960, pp 3-6) describes the composition and textures of the magnesite, dolomite, dolomite-quartz and cherts. The magnesite rocks as described by Forbes contain magnesite, talc, dolomite, authigenic albite, carbon and detrital quartz and feldspar with most rocks containing between 5 and 10% acid insoluble material. The magnesite conglomerates consist of rounded magnesite pebbles up to about 12 cm diameter in a matrix of mainly magnesite and dolomite. The magnesite pebbles show no internal structure and most lie in a preferred orientation. Massive magnesite often occurs at the base of conglomerates and is the same composition as the pebbles.

The dark grey laminated dolomicrite from Uppill (1979) above is described by Forbes (1960, p. 5) as consisting of chiefly lath shaped fragments with long axis parallel to bedding, the colour variations between medium and dark grey depends largely on carbon content. Individual dolomite crystals are about 0.004 mm diameter.

Uppill (1979, p. 36) describes interbedded sandstones consisting of fine to medium grain size, moderately sorted with a dolomite cement throughout the formation but most common near the base and top of the formation. These sandstones are called dolomite arkose by Forbes (1960, p. 5) consisting of up to 50 % (more commonly between 20 to 40 %) dolomite, quartz and feldspar. Lamination is sometimes shown by alteration of fine and coarse layers. Most grains are irregular in shape apart from larger quartz and feldspar grains which tend to be more rounded. According to Forbes this irregularity is due in part to recrystallisation and reaction with the carbonate matrix. Heavy minerals such as zircon and tourmaline and tiny cubes of pyrite are also present. Variations in the type and amount of feldspar and heavy mineral content are seen in different areas. In the Port Germein Gorge area the feldspar tends to be microcline of between 37 and 47 % with pink zircon and tourmaline as the heavy mineral (Forbes 1960).

Black chert nodules form lenses throughout the formation. These are formed by secondary silicification prior to and during lithification and compaction (Uppill 1979). Forbes (1960, p. 6) describes two types of chert, one, that forms beds that may extend several kilometres and the other, small nodule lenses, as described by Uppill (1979). The bedded cherts show a relic conglomerate or arenite fabric and consist of fine grained quartz and medium grained dolomite with a very fine material that is possibly carbon. The nodular cherts examined by Forbes showed outlines of small elongate and rounded fragments whilst one sample showed lamination parallel to the enclosing dolomite.

The Yadlamalka Formation occurs throughout the Flinders Ranges with characteristic facies as described in the type section, however thickness is variable with a maximum of 3000 m in the Willouran Ranges and 258 m in the type section (Uppill 1979). In the Port Germein–Beetaloo Valley area Forbes (1960, p. 6) describes a higher terrigenous content and only minor magnesite.

4. Exploration Rationale

The aims of the exploration programs during the period were to:

- Map the general geology of the area, with a focus on the stratigraphic relations and structural controls on the Skillogalee Dolomite.
- Map the exact locations of the magnesite beds, including the lateral extent, thickness and number of beds
- Investigate the effect of geologic structures on these beds.

5. Previous Work

5.1 Previous Mining

From 1915 to 1984 almost 44,000 tonnes of magnesite was mined in South Australia. Of this amount 36,449 tonnes were sedimentary deposits from the Skillogalee Dolomite, 6,382 tonnes were residual magnesite that had been derived from magnesium rich rocks and 660 tonnes were from metasomatic replacement magnesite (Crettenden 1985). Table 4 lists a summary of the main locations and the amount of magnesite recovered. Slight variations in these figures where published in the Mineral Industry Quarterly South Australia (South Australian Department of Mines and Energy 1984), the main discrepancy being from Myrtle Springs where a total figure of only 6770 tonnes is listed however this was from 1947 to 1983 rather than 1984 as listed by Crettenden (1985). Further to this McCallum (1990) lists a total production of magnesite in South Australia as 69,000 tonnes to the end of 1988 with 30,000 tonnes produced from the Myrtle Springs site by Commercial Minerals Ltd. Considering the publication date of this paper it is considered the more accurate figure for total magnesite production in the state.

Location	Amount (tonnes)	Type	Dates
Myrtle Springs	19,625	Sedimentary	1947-84
Robertstown	8,198	Residual	1916-53 and 1980-1984
Copley	6,031	Sedimentary	1918-55
Witchelina	2,778	Sedimentary	1964-74
Mundallio	2,554	Sedimentary	1940-53
Port Germein	1,466	Sedimentary	1947-50

Table 4: Major sources of magnesite in South Australia from 1915 to 1984, adapted from (Crettenden 1985, p. 1)

The Port Germein deposit is the most significant with respect to this project located approximately 25 km north of the mapping area. The deposit was worked by Broken Hill Proprietary Co. (BHP) who first pegged the area in 1944. Small scale production occurred during 1947, 1949 and 1950 totalling 1,277 tonnes. Prior to this in the 1920's 189 tonnes had been extracted by Hooper and Franke. Magnesite was recovered from shallow open cuts and an adit 47.2 m long with an adjoining decline shaft (King 1956; Crettenden 1985). The site was surveyed in detail by King (1956, p. 101) who described the main worked deposit as a magnesite bed about 1 m thick above a 0.5 m thick bed that are separated by a narrow bed of impure magnesite and chert. The ore grade average was 47% MgO and was expected to be continuous throughout the bed.

In Beetaloo Valley a small open cut produced 50 tonnes of magnesite, 38 tonnes by BHP in 1916 and 12 tonnes by Bairstow in 1966. The magnesite was extracted from 5 beds up to 0.7 m thick (Crettenden 1985). The location of this activity is significant due to its close proximity to the mapping area (within 5 km) and that it is on the eastern limb of a major syncline structure, with the western limb the one being mapped.

5.2 PREVIOUS EXPLORATION

A majority of the significant previous exploration work within the tenement has been conducted by Magnesium International Ltd (MIL) as part of their SAMAG magnesium metal Project feasibility work.

In 2002, MIL identified magnesite beds within the Skillogalee Dolomite, interpreted to outcrop or be shallowly buried (<5m) over a 75km strike length in the Southern Flinders Ranges. These beds were regionally sampled at 8 locations over this strike length. Table 5(a) below provides the average partial leach analysis of 16 primary magnesite outcrop samples.

Table 5(a). Average Partial Leach Analyses of 16 Primary Magnesite Outcrops.

Mg %	Ca %	Fe ppm	Mn ppm	Si ppm	S ppm	B ppm	Sr ppm	Insol %	Total %
24.9	2.1	3381	107	2097	440	95	100	6.2	99.2

At least 9 magnesite beds, with a maximum width of 1.5m have been identified near Beetaloo (15km SE of the proposed SAMAG plant site) and at Germein Gorge (15km NE of the proposed SAMAG plant site). The sum of bed thickness for the section at Beetaloo is approximately 8m over 25m, which is equivalent to an approximate ore to waste ratio of 1:3.

In March 1998 Primary Industries and Resources of South Australia (PIRSA) undertook a trial hyper-spectral airborne imaging spectrometer survey (HyMap™) along the strike of the Skillogalee Dolomite in the Willouran Ranges north of Leigh Creek (Keeling. J., & Mauger, A., 1998). Following the success of the PIRSA trial Pima Mining NL (now Magnesium International Limited) commissioned Intergrated Spectronics Pty Ltd in November 1998 to extend the trial further south along the strike towards Leigh Creek covering the Witchelina, Termination Hill, Pug Hill and Mt Playfair deposits.

The success of this trial led MDL (subsidiary of MIL) to commission a HyMap™ survey over the interpreted outcrop of the Skillogalee Dolomite in the Southern Flinders Ranges near Port Pirie. The survey included all the interpreted outcrop area within EL's 2828 and 2944.

In March 2002, Hymap™ data was acquired covering 11 image strips over the Southern Flinders Ranges east of Port Pirie (Figure 4). Weather conditions for acquisition of the data were perfect with no cloud and visibility exceeding 100 km's (Cocks, P., 2002). Hymap™ swathes 4 and 5 of the acquired data covered the Collaby Hill area in the southwestern part of EL 2828 and the data was processed for analyses and interpretation.

In 2003, MIL took a total of 94 outcrop samples were collected from the Collaby Hill area. Detailed outcrop sample assays are listed in Table 5(b) below gives the average assays of magnesite samples collected from geological Traverses 1-5.

Table 5(b) Average Assays of Magnesite Samples from Geological Traverses 1-5, Collaby Hill

Traverse No	No of Samples	Strike	Dip	No of Beds	Total Width	Mg %	MgO %	Ca %	CaO %	Fe ppm	Mn ppm	Al ppm	Si ppm	S Ppm	B ppm	Sr ppm	Insol %	Total %
1	17	350	55	?	?	26.85	44.53	1.80	2.51	668	17	508	1862	75	14	144	0.79	99.14
2	12	355	65	4	4.5	26.82	44.50	1.62	2.27	579	18	496	1544	52	15	181	0.93	98.70
3	12	350	45	7	5.8	25.02	41.46	2.34	3.28	6942	167	692	4915	116	90	123	4.19	99.20
4	26	25	40	6	8.5	25.93	43.00	2.53	3.54	3088	93	377	33072	133	53	141	2.48	100.24
5	10	70	35	5	5.3	24.49	40.62	3.33	4.67	2720	101	421	3251	203	93	182	5.09	99.87
ALL	77					25.94	43.02	2.30	3.22	2716	79	483	2877	114	52	151	2.45	99.55

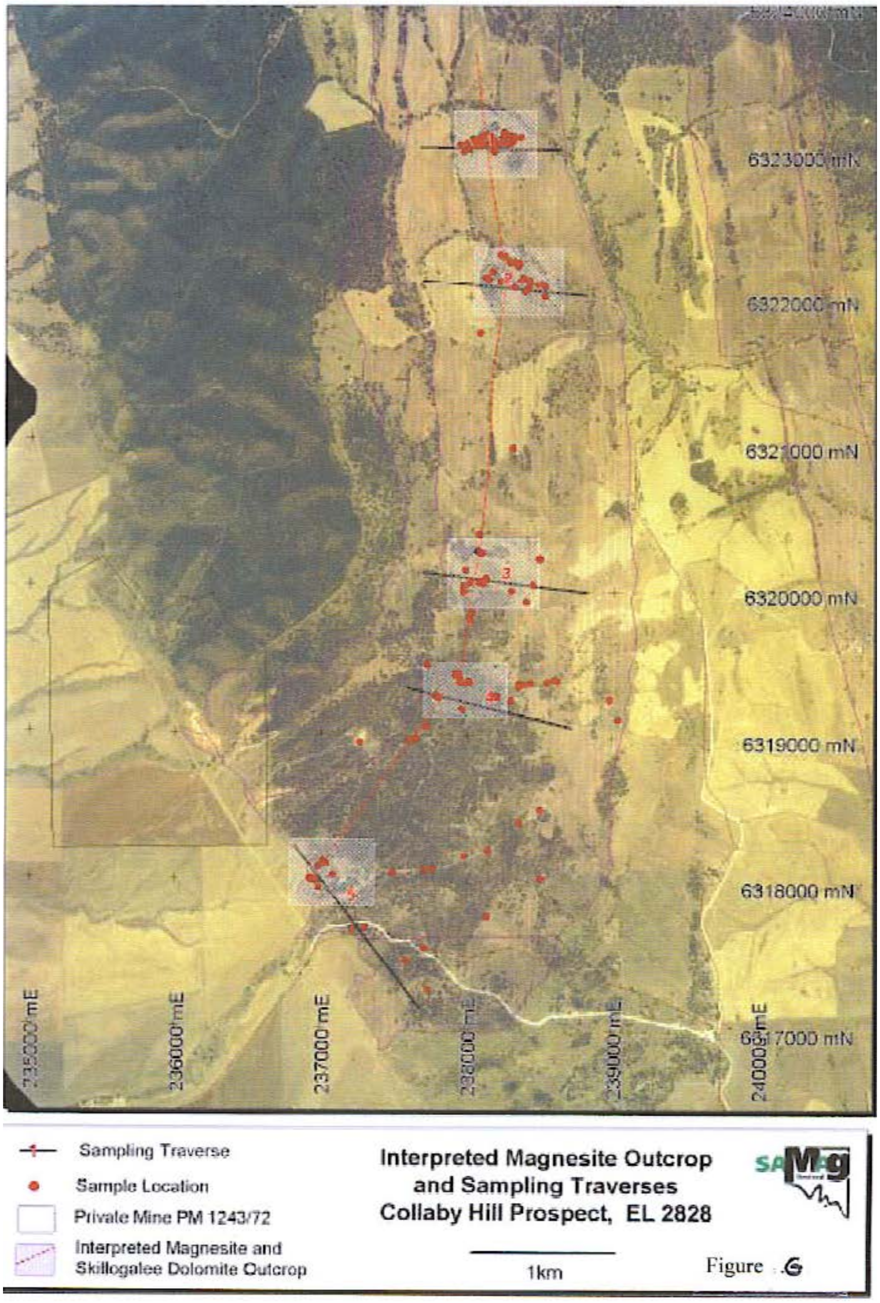


Figure 2 Interpreted magnesite outcrop and sampling traverses, Collaby Hill

6. Exploration Conducted

Geologic mapping of the area was performed by first making broad cross section traverses over the area in order to identify the major units and the general position of the magnesite beds. This was followed by the mapping of distinctive and prominent marker beds located above and below the less prominent magnesite in order to identify the approximate extent and position of the magnesite beds(Figure 2).

Direct mapping of the magnesite beds is not possible because of limited outcrop, due to the highly weatherable nature of magnesite. Fold structures identified during this early mapping were then mapped in more detail in order to provide a more complete picture of the structural complexity of the area.

Field mapping was carried out using a handheld GPS to accurately record the position of features and rock units. This data was later recorded and interpreted using computer software.

A section exposed in an old quarry in Beetaloo Valley was examined to provide an overview of the magnesite beds. Located on the western limb of the main syncline, this section provides a good representative sample of the magnesite beds in the area.

Aerial photos of the area were used as an aid to mapping, both as a base map and for further interpretation of field findings. Specific details in the aerial photos were obscured in most instances due to vegetation and soil cover.

Along with the aerial photos hyperspectral data was obtained over the area. Interpretation of this data was similarly hindered by ground cover however the position of carbonate and clastic boundaries were able to be identified (Refer Appendix 1).

Field Description

The prominent sandstone and dolomite beds that outcrop in the Collaby Hill area tend to be very consistent in thickness and composition throughout their total length with no evidence of beds lensing in or out. This is especially evident in the central region where good outcrops are visible. In this area single beds were mapped for up to 2 km before being lost beneath soil or vegetation cover. It is possible that these beds continue for several kilometres. Figure 5 illustrates the continuity of the beds, in this photograph the Marola Sandstone is running along the left edge, with a series of dolomite and sandstone beds up to the 2 m thick feldspathic sandstone in the centre. The outcropping rocks are generally the more prominent dolomite and sandstone beds. Minor outcrops of thinly interbedded dolomite, silts and clays were observed along some creeks and from small sporadic outcrops. This is indicative of what lies beneath the areas of no outcrop.

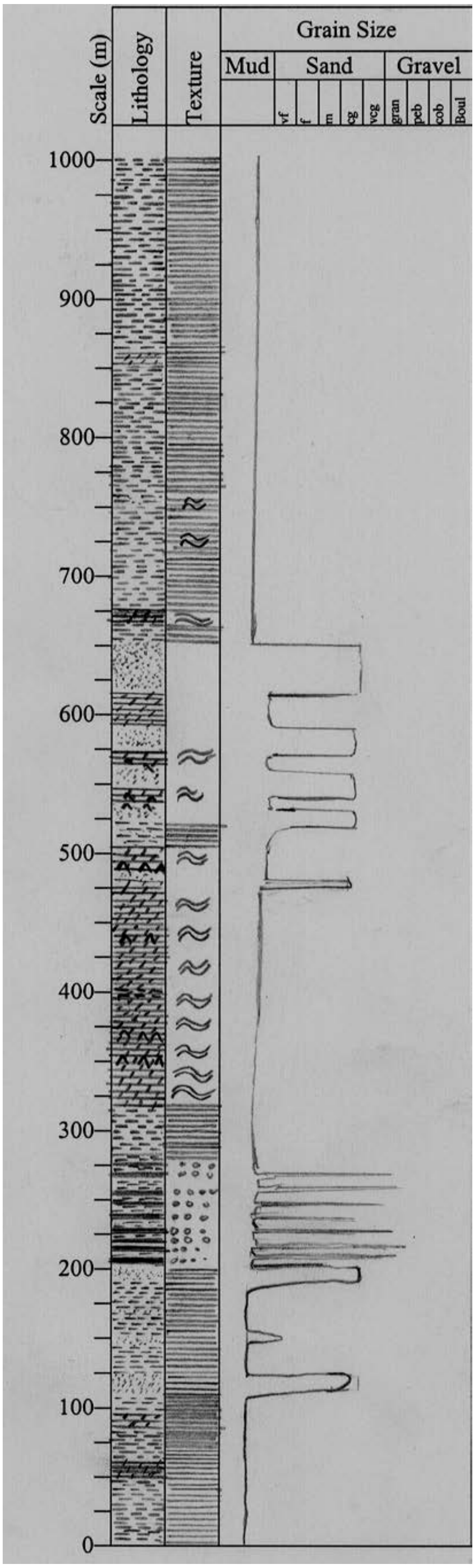


Figure 3: Stratigraphic column of the Skillogalee Dolomite in the Collaby Hill area.

Legend

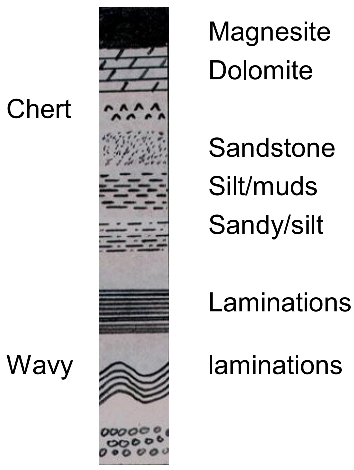


Figure 4 Legend for stratigraphic columns

Figure 4a Legend for stratigraphic columns

Comments

Unit 6

Fine silts and clays, colours include browns, reds, purple, grey and white. Beds are thinly laminated and generally planar.

Unit 5 (Marola Sandstone member)
Pinkish coloured feldspathic quartzite.

Unit 4
Dark grey wavy dolomite and feldspathic sandstones

Unit 3

Prominent dark grey dolomite beds with black chert interbeds

Unit 2
Magnesite beds with interbedded silts and dolomite.

Unit 1

Brown/grey shale with fine sandy interbeds. Occasional dolomite and feldspathic sandstone beds


Figure 5: Photograph looking south illustrating the continuous beds

The stratigraphic column in Figure 3 shows the relative position and composition of the 6 distinct units of the Skillogalee Dolomite upper member, mapped in the Collaby Hill area. Unit 1 lies directly above a coarse grained arkosic sandstone that marks the top of the lower member. Outcrops in the lower part of this unit are limited to a few dark grey dolomite beds with black chert interbeds (sample 103). In places the chert appears as beds that are up to 10 cm thick. Towards the top of the unit dark brown/grey shales dominate with thin (up to 0.5 m thick) sandstone and dolomite interbe). At the top of the unit is an approximately 1 m thick prominent, medium to coarse grain arkosic sandstone. This thinly bedded sandstone was easily followed in the field due to its reddish colour and banded weathered texture. The position of this bed directly beneath the magnesite made it a good marker bed in mapping the position of the magnesite in the central and southern areas.

Unit 2 consists of the magnesite beds that are approximately 80 m thick. The precise detail of the magnesite beds was not visible due to poor outcrop. However observations made in the area and comparisons with the section through Beetaloo Valley (see below) indicate the presence of around 10 magnesite beds of up to 1.5 m thick. These beds are interbedded with silts and dolomites. Magnesite in the field was often observed as weathered float rock. This rock has a bright (blue tint) white colour that makes it easily identifiable from a distance. The texture of the float rock is very similar to calcrete however the brightness and higher density can be used to distinguish between the two. Often the float rock also had a cracked desiccation like weathered surface. In several places float rock could be followed in narrow bands along strike indicating the presence of a magnesite bed beneath. Occasional outcrops of fresh magnesite were observed confirming the presence of magnesite. Figure 6 shows one of the better magnesite outcrops.

Unit 3 consists of an approximate 200 m thick series of dark grey thinly laminated wavy dolomites. Interbeds and smaller lenses of dark black chert are common throughout the dolomite. The majority of parasitic Z-folds mapped in the area were within this unit.

The change to unit 4 is gradual and is marked by the introduction of more clastic sediments. The unit consists of similar dark grey dolomites with chert as described above and coarse grained feldspathic sandstones. The sandstones are generally thinly bedded with planar beds or in some cases very low angle cross bedding. Figure 6 is of a typical sandstone bed and illustrates the thin planar bedding. Also visible in this photograph is small veins/tension gashes of silica and carbonates along with some small micro faults. The grains are angular in shape which along with the high feldspar content indicates a close proximity to the sediment source.

Unit 5 consists of the prominent 40 m thick, pinkish coloured, feldspathic quartzite that is observable throughout the area. It is interpreted as the Marola Sandstone Member that interfingers the Skillogalee dolomite in the region (Preiss and Cowley 1999). The quartzite is massive, coarse-grained and feldspathic. The outcrop is generally very blocky with bedding structures difficult to detect.

Figure 6: Photograph of one of the better magnesite outcrops (left) and feldspathic sandstone showing planar bedding (right).

Overlying this member is unit 6 consisting of fine silts and clays with occasional dolomite. The clays are finely laminated and of various colours including various browns, reds, purple, grey and white. Sedimentary dewatering tepee structures and some small scale slumping structures are visible within the clays. The laminations are generally planar with occasional areas of wavy laminations. Small scale faults are also present.

Section through Beetaloo Valley

In order to gain a better understanding of the magnesite beds a detailed examination was made of an exposed section in an old quarry located in Beetaloo Valley on the eastern limb of the main anticline. The precise location is between 240,049 E, 6,321,518 N and 240,102 E, 632,1553 N. The outcrop extends about 70 m and consists of reasonably fresh rock, apart from some of the softer siltier beds which showed considerable weathering in places.

The stratigraphic column for this section is shown in Figure 7. The section consists of two broad packages of magnesite beds separated by a 25 m package of silt and dolomite. The upper package is the better of the two consisting of about 10 magnesite beds up to about 1.5 m thick. Earlier assay results from SAMAG (Biggins S. 2003, pers. comm.) on this package returned average MgO values of 40% out of a maximum 47.8% for magnesite (Harben and Kuzvart 1996). The lower package consists of three magnesite beds with average MgO content of about 30%.

The magnesite beds form an almost cyclic pattern consisting of dolomite, overlain by dolomitic silts and chert, then magnesite and finally more silts. This cycle is not always complete with dolomite absent in many cases. The magnesite beds are a white colour and generally consist of a basal mud, overlain by a conglomerate consisting of aligned curled plate shaped rip up clasts of magnesite in a magnesite mud matrix which in turn is overlain by a small pebble conglomerate. Other sedimentary structures include small scale cross bedding and dewatering structures. A photograph is shown in Figure 10 of these clasts, note the small tepee structure in the top left corner. The pebbles are well rounded and pellet shaped up to 1 or 2 cm in size. Figures 8 and 9 are photographs of selected beds along the section.

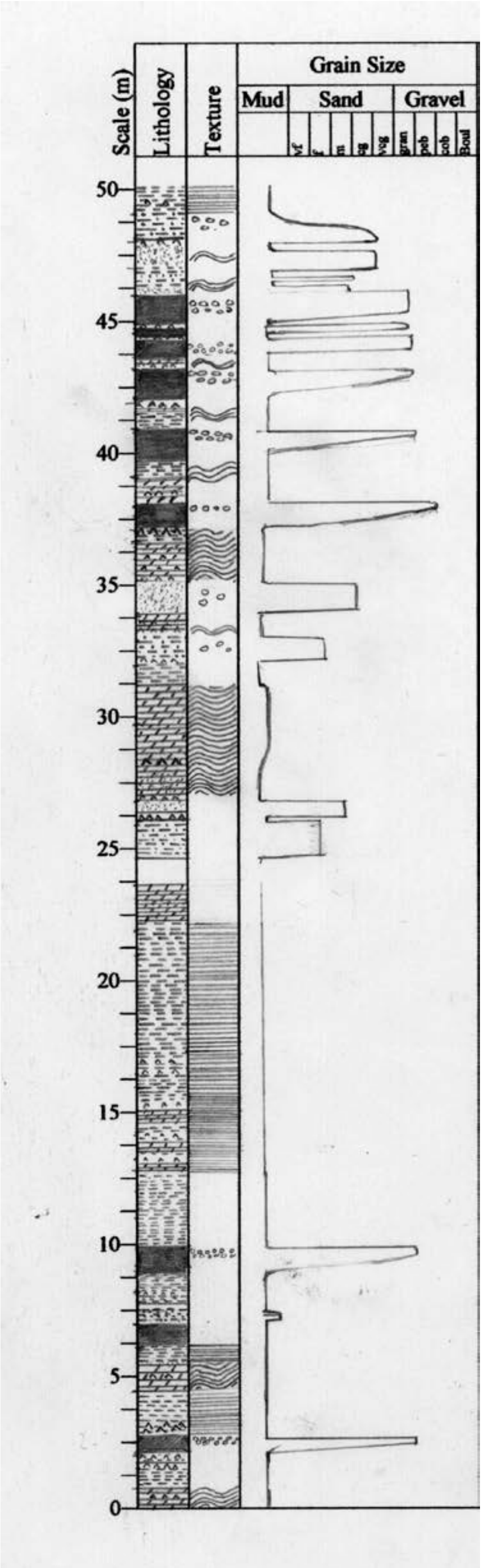


Figure 7: Stratigraphic section through Beetaloo Valley (Continued on next page)

Comments

Yellow brown silts with chert interbeds

Poorly sorted sandstone with 2cm silt clasts

Interbedded silts and sandstone

Magnesite package with thin interbeds of chert and dolomitic silts

Interbeds of dolomite and chert

Interbedded silts/dolomite and chert
Light creamy coloured feldspathic sandstone with
silt clasts to 3cm length
light grey sandstone with silt clasts to 2cm in length

No outcrop, area covered by calcrete

Finely laminated brown silts

Chert interbeds up to 10 cm thick

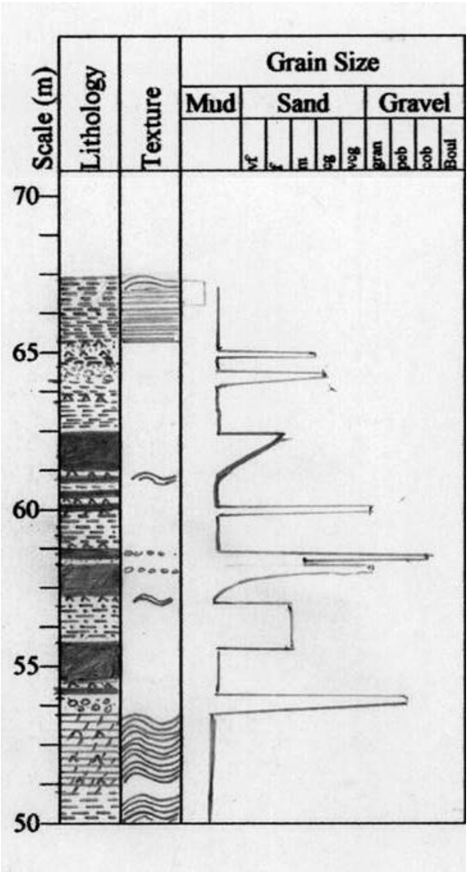
Thick set of dolomite, hard siliceous shales and chert interbeds

Very weathered brown/yellow coloured silts

Interbedded weathered silts and cherts
Quartz vein

Creamy coloured silts

Light grey silts



Comments

Yellow brown silts

Sandstone and cherts interbeds

Poorly sorted sandy silts

Very coarse conglomerate sandstone
Dolomite chert interbeds

Greenish grey silts

Figure 7 (continued): Stratigraphic section from Beetaloo valley.

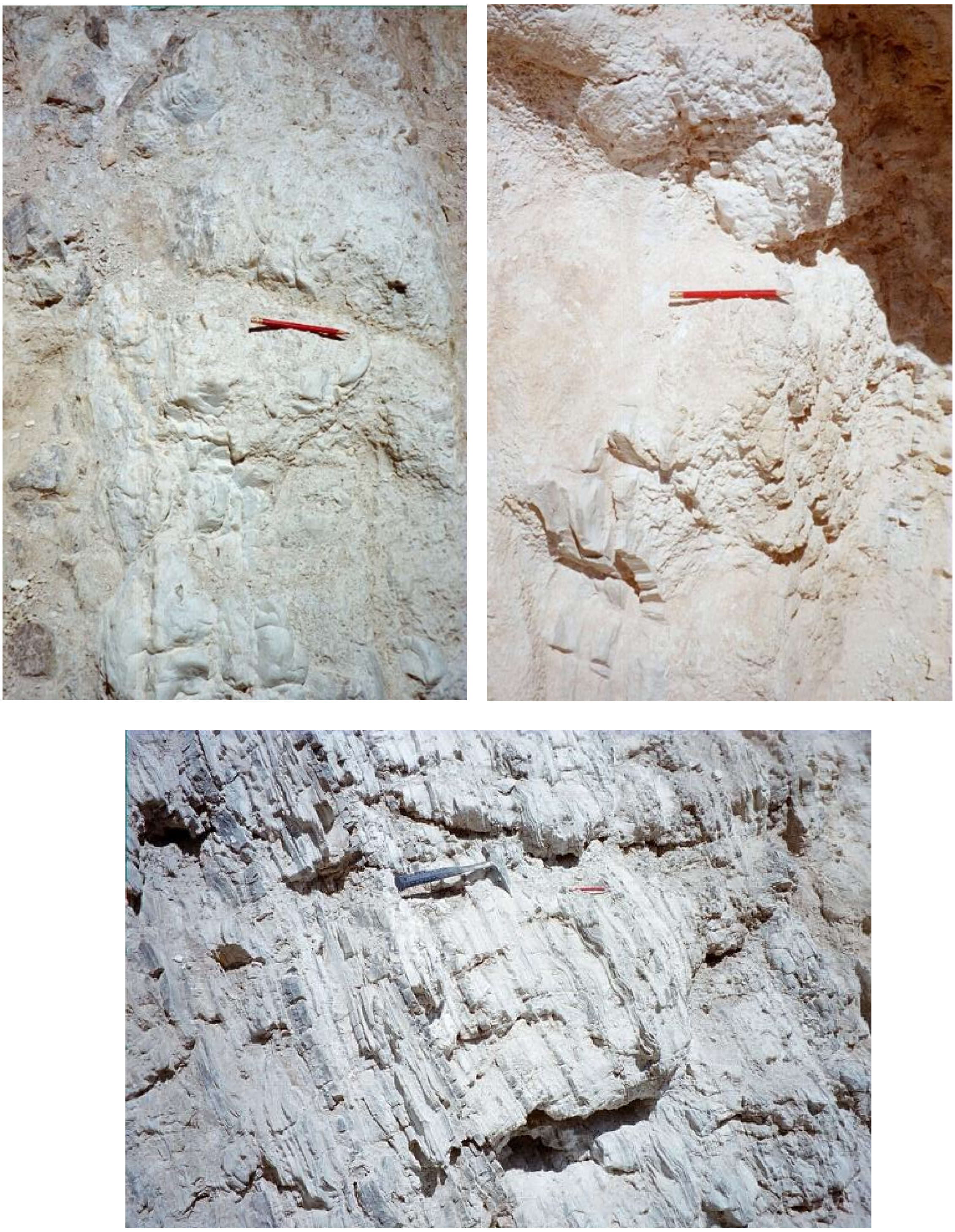


Figure 8: Photographs of two magnesite beds illustrating the blocky magnesite mud base grading into a pebble conglomerate (top) and thinly bedded chert, dolomite and silts (bottom). (Pencil is 12cm in length).

Figure 9: Photograph showing interbedded dolomite and chert, illustrating the wavy nature of the laminations. (Pencil is 12cm in length).

Figure 10: View of magnesite sample displaying rip up clasts and tepee structure (top left). (Sample is 10 cm across).

(Blue and red colours are from the scanning process).

Discussion

The observations described above for the Collaby Hill area closely match those described by Uppill (1979) and Forbes (1960). Hence there is little compositional variation throughout the Skillogalee Dolomite with only the thickness and number of beds present changing between different areas.

The planar bedding and consistency of beds through out the area suggest deposition in a flat shallow environment. A gradual subsidence or a sedimentation rate equal to relative sea level rise would have allowed for the continual deposition of sediments. The conglomerate textures observed in the magnesite support the view that magnesite has been precipitated out as a mud in an environment that has occasionally been allowed to dry out. Periodic influxes of water has reworked this sediment and allowed further precipitation creating the magnesite matrix. One such environment may be a shallow lagoon that is normally closed off from the sea and occasionally breached, possibly during storm activity. The feldspathic sandstones were most likely deposited as single events related to subsidence that allowed an influx of clastic sediment into the lagoon. The immaturity of the grains and relatively fresh feldspar indicates proximity to the source, possibly from the granites of the Gawler Craton.

The laterally extensive and consistent beds that were observed in the area help to support the idea that the magnesite beds viewed and measured on the eastern limb are representative of those beneath cover, around Collaby Hill. Hence there is no reason to believe that the magnesite beds in the Collaby Hill area are not of a similar number and quantity.

The position of the top of the Skillogalee Dolomite requires further discussion. The very distinct change in lithology above the Marola Sandstone member to clastic clays and silts leads S. Biggins (2003, pers. comm.) to believe that the Marola Sandstone marks the top of the Skillogalee Dolomite and is in fact the Undalya Quartzite with the overlying clastic sediments being part of the Saddleworth Formation. However W. Cowley (2003, pers. comm.) describes similar clastic facies within the Skillogalee Dolomite in other areas and believes the sandstone to be the Marola Sandstone Member which interfingers the Skillogalee Dolomite throughout the area (Preiss and Cowley 1999). Field observations support both points of view, however for mapping purposes I have taken the Quartzite to be the Marola Sandstone Member of the Skillogalee Dolomite since Uppill (1979), Forbes (1960) and Preiss and Cowley (1999) all describe a more clastic facies towards the top of the Skillogalee Dolomite for this area.

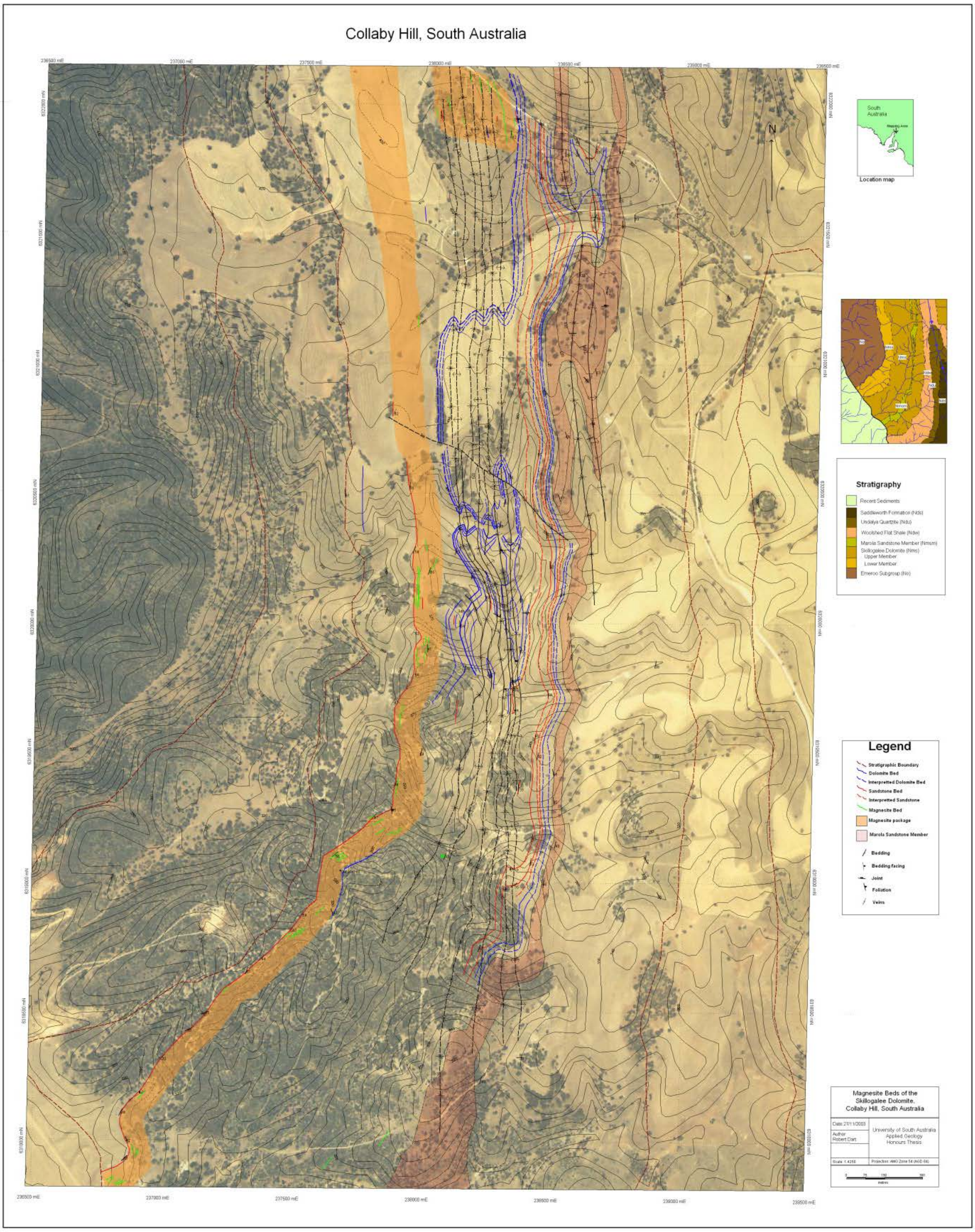


Fig 11. Detailed geological map of the magnesite beds and relevant structural geology within the Skillogalee Dolomite, EL 4639, Collaby Hill South Australia.

7. Expenditure

Expenditure for the period 7 January 2011 to 6 January 2012 is detailed in Table 6 below:

Table 6 Expenditure for EL 4639 – Collaby Hill

EL 4639 Collaby Hill

Minimum annual expenditure	70 000

Detailed annual expenditure for the period 7 January 2011 to 6 January 2012

Operations	**Total**
Advertising	
Application fees - licences	
Personnel (Geologists/Geophysicists)	35 000
Food, travel, accommodation	7 500
Vehicle	2 500
Geophysics	13 500
Software	2 200
Tenement administration	6 000
Administration	7 500
Total expenditure for the period	$74 200
+ previous expenditure	n/a
Total cumulative expenditure for the licence	$74 200

8. Conclusions

Field mapping around the Collaby Hill area has determined that magnesite is present in what appears to be a series of continuous beds that extend from the escarpment in the south through to the north of the mapping area and beyond. The magnesite package is around 80 m thick and consists of around 10 beds that are up to 1.5 m thick.

The magnesite beds are folded and structurally repeated by parasitic Z-folds evident in the more resistant dolomite and quartzite beds. These folds are tight to chevron shaped and like the main syncline, plunge gently towards the south. The amount of magnesite present at near surface levels may be triple that observed in the main package due to the effect of this folding. This is especially evident in the north of the mapping area where magnesite outcrop is up to 300 m thick. In the south of the area the shallower dip and lower elevation has also increased the amount of near surface magnesite. This is a significant factor to consider and would make further investigation of the area through the use of costeans or drilling a worthwhile exercise.

Repetition of the magnesite beds due to parasitic folding especially in the north of the area can be expected to triple the amount of near surface magnesite.. In the south of the area magnesite float was identified in areas some distance from the main package. The shallow dip of the beds in this area, parasitic folding and steep topography is possibly maintaining the magnesite nearer to the surface than in the north. This is illustrated in Figure 17 of a cross section through the southern area.

The magnesite observed in the area is a white to creamy coloured cryptocrystalline mud. The beds are commonly graded from muds at the base through to pebble conglomerates at the top. These conglomerates are almost 100% magnesite with the pebbles and matrix formed of the same microcrystalline material. The clasts in the coarser conglomerates are generally elongate and plate shaped up to 10 cm in length.

Further review and analysis of hyperspectral data was not able to differentiate the composition of individual beds, particularly magnesite from dolomite, compared with the success obtained from the northern Flinders Ranges and Willouran Ranges. The effect of increased vegetation and soil cover having a big impact on the ability to accurately determine the position of magnesite from dolomite within this area. Instead the best use of this data was in determining the position of the carbonates from the surrounding clastic sediments.

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Figures

Magnesium Minerals Pty Ltd

Annual Technical Report for EL 4639

7 January 2011 – 6 January 2012

Table of Contents – Figures

Magnesium Minierals Pty Ltd

Annual Technical Report for EL 4639

7 January 2011 – 6 January 2012

Table of Contents – Appendices

Appendix 1

Appendix 1 : Remote sensing images

Plate Number	Description
1	Approximate true colour image composed of bands 18, 14 and 2 from a subset of the raw data for strip 4. Band 18 is represented by red, band 14 by green and band 2 by blue.
2-6	Composite images formed from selected matched endmember images. These images clearly show the boundaries between the carbonate and clastic sediment lithologies.
7-9	These images were produced from strip 5 located to the south of the strip 4 images above. Plate 7 shows a matched image produced from end-members directly derived from the image. Plates 8 and 9 are matched images using the end-members from strip 4 as shown in plates 2-6

Plate 1: Approximate true colour image of raw data

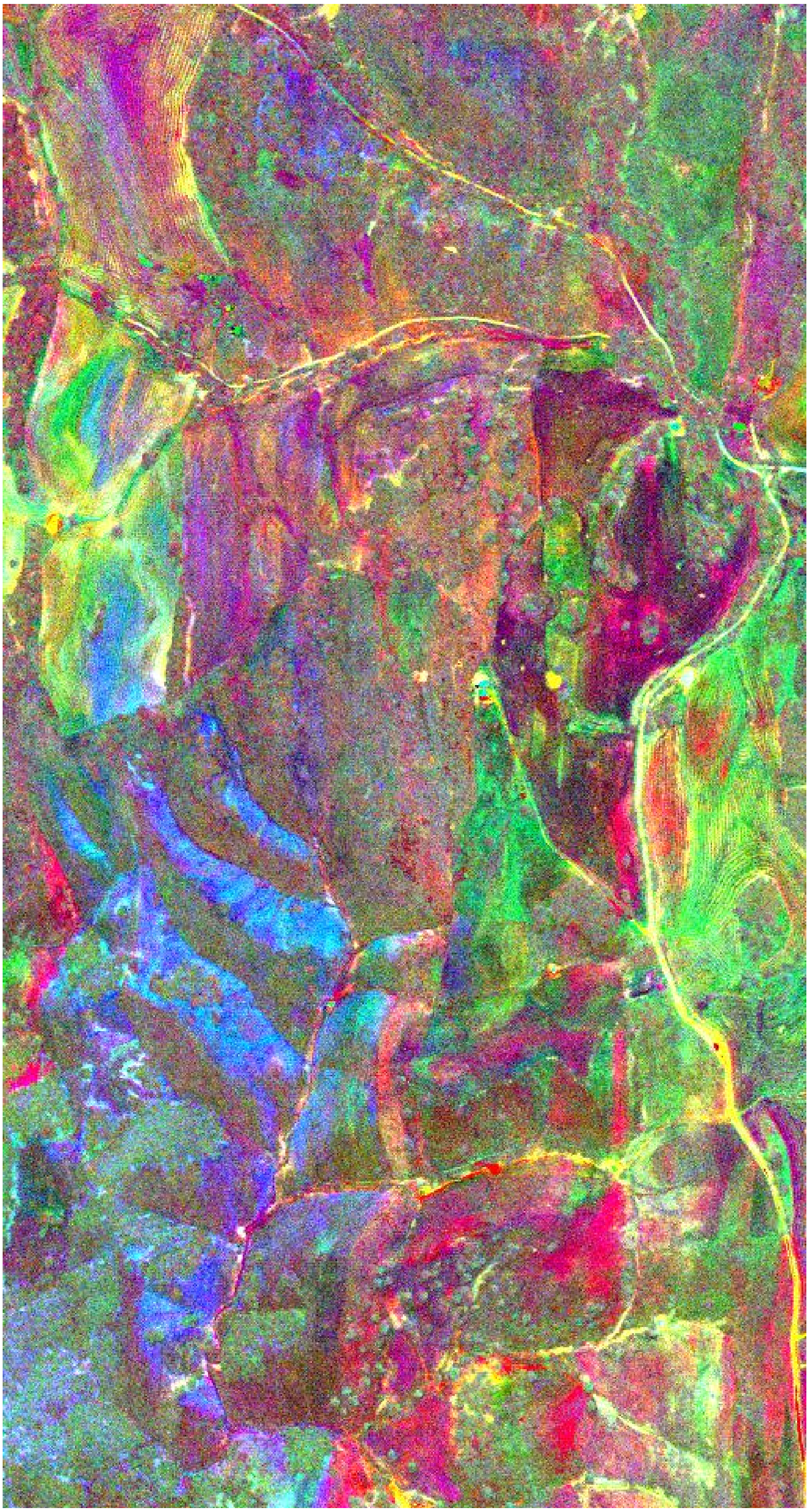

Plate 2: Colour composite matched image of endmembers 1, 2 & 4.

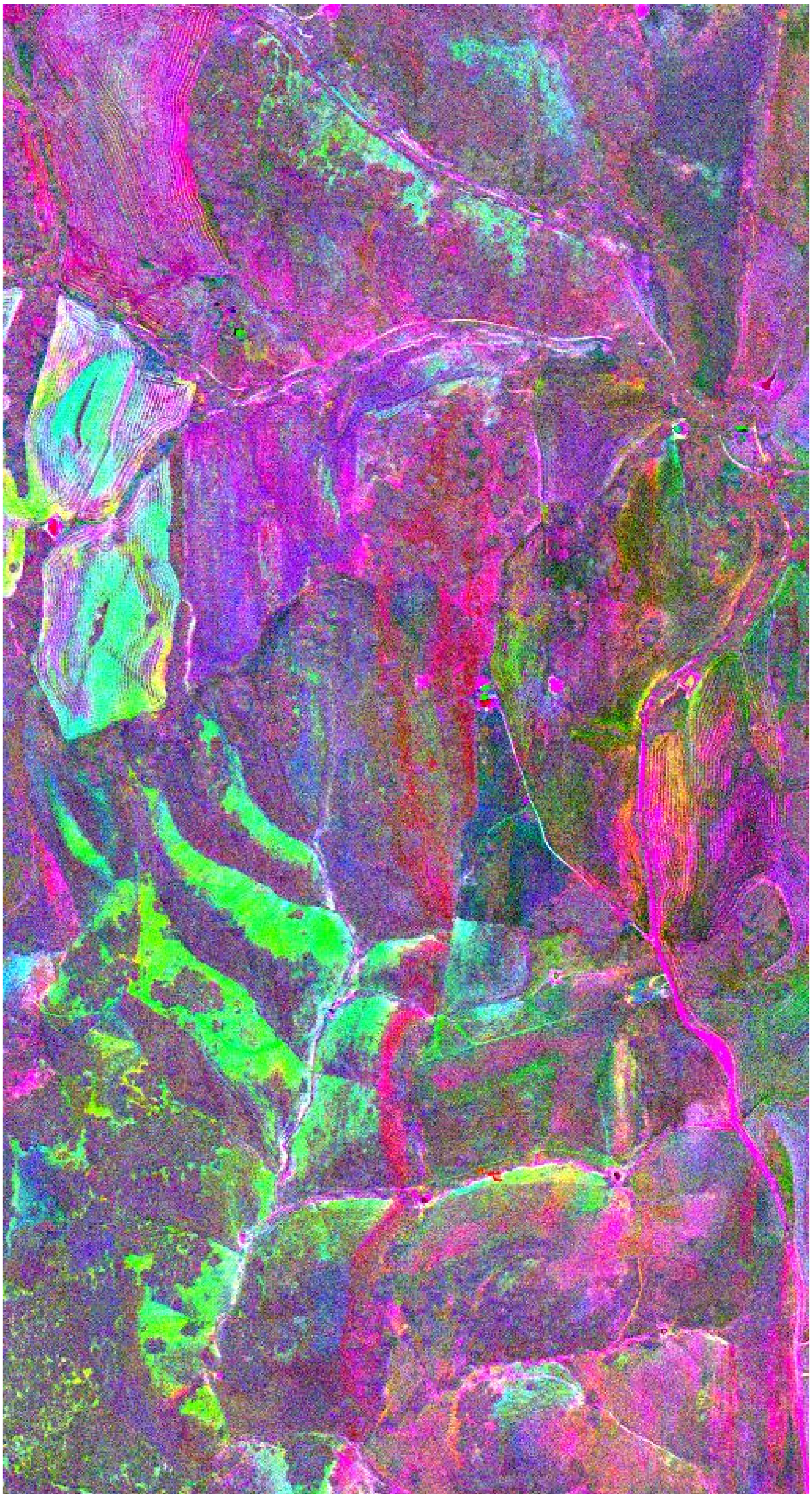

Plate 3: Colour composite matched image of endmembers 1, 5 & 6.

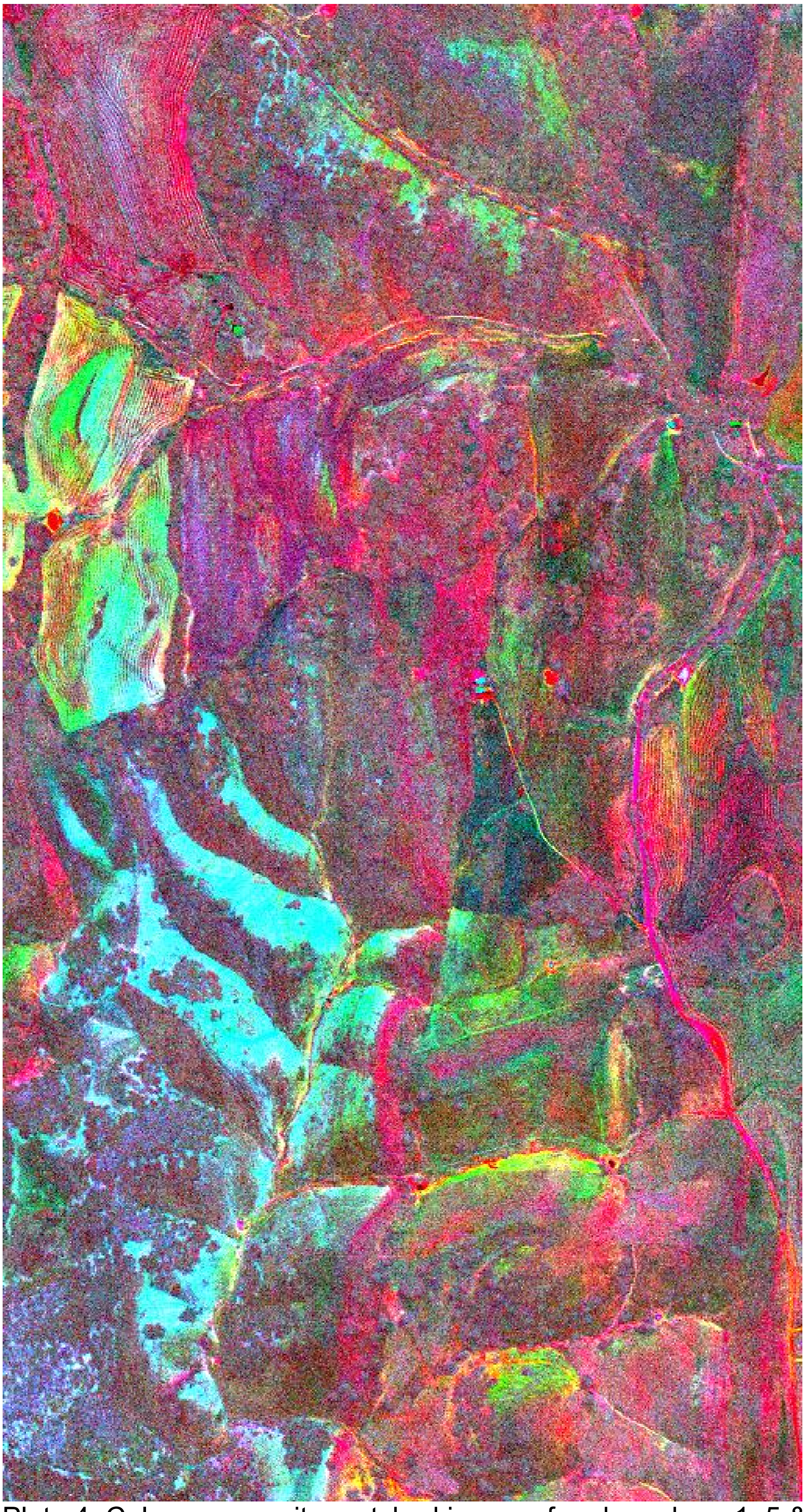

Plate 4: Colour composite matched image of endmembers 1, 5 & 4.

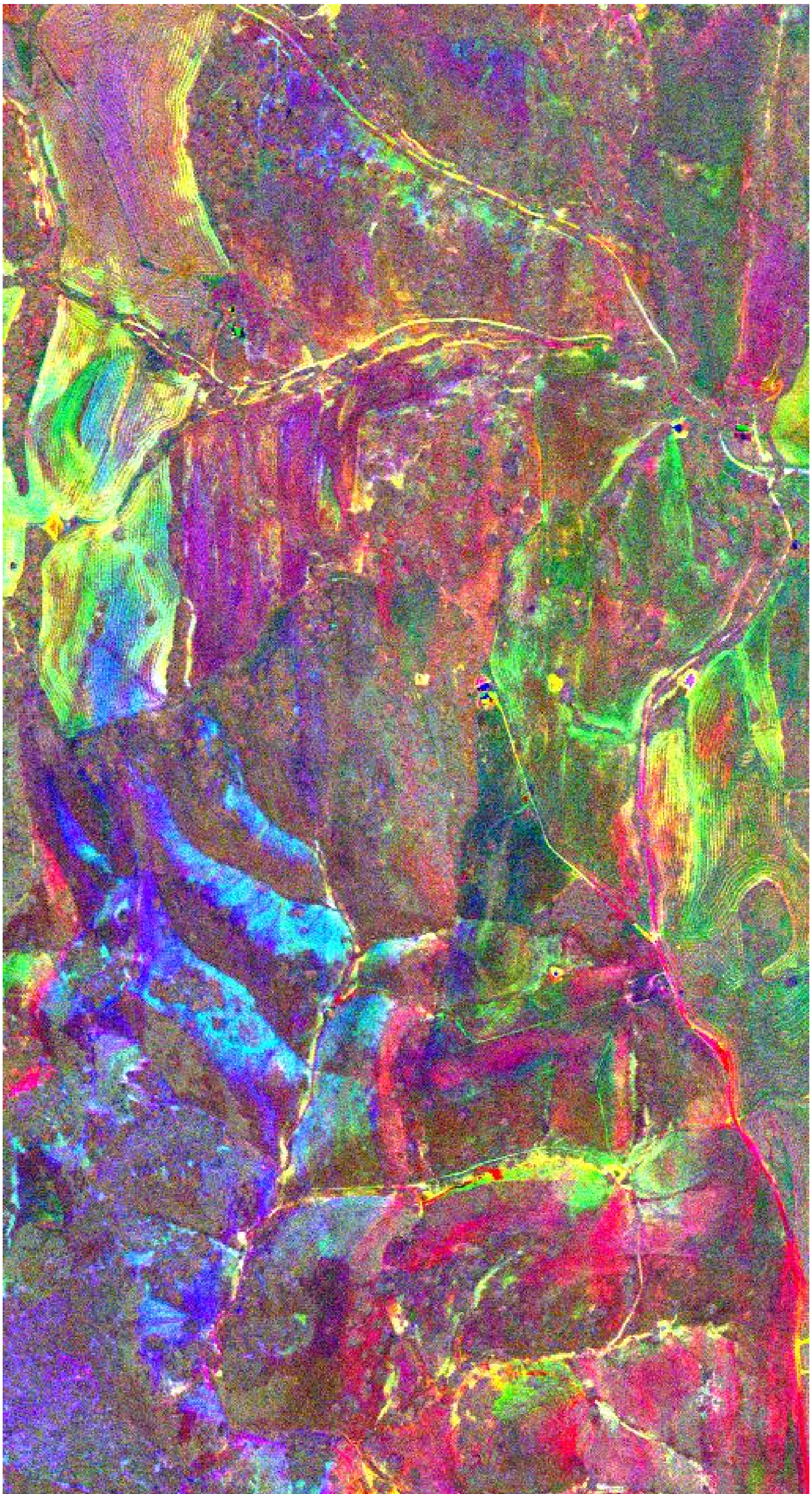
Plate 5: Colour composite matched image of endmembers 1, 3 & 4.

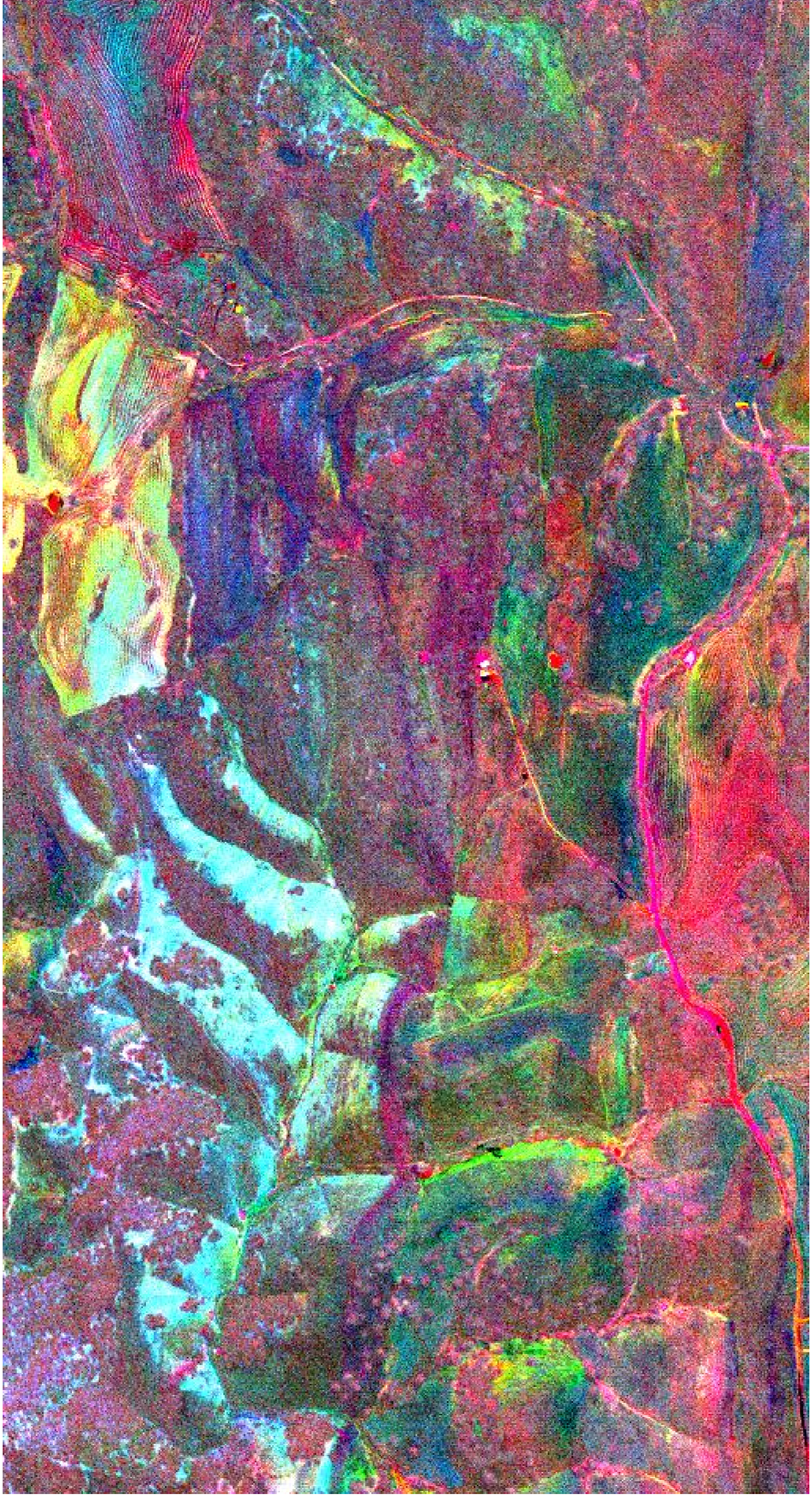

Plate 6: Colour composite matched images of endmembers 2, 5 & 4.

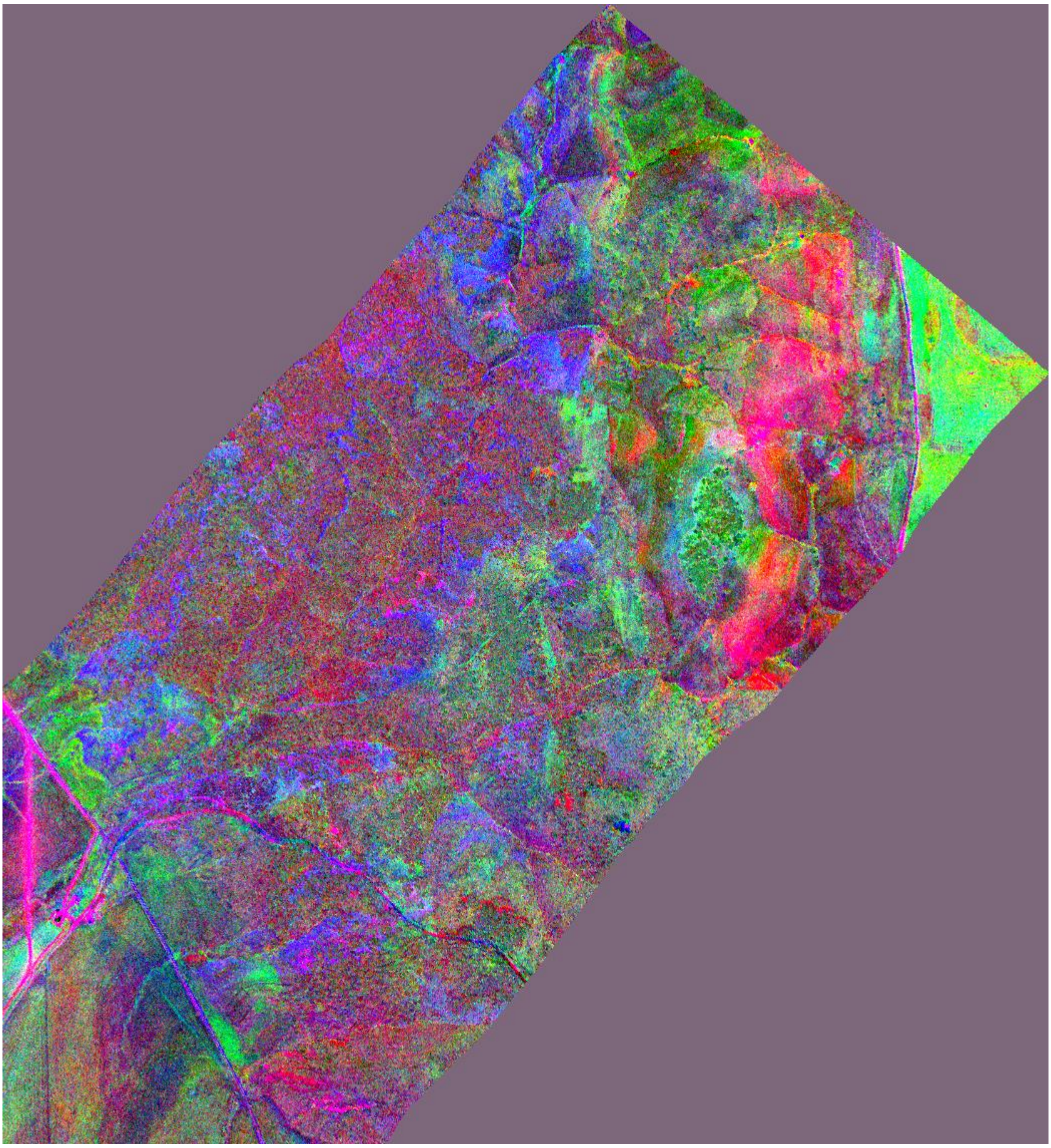

Plate 7: Colour composite matched image of selected end-members derived directly from strip 5 data.

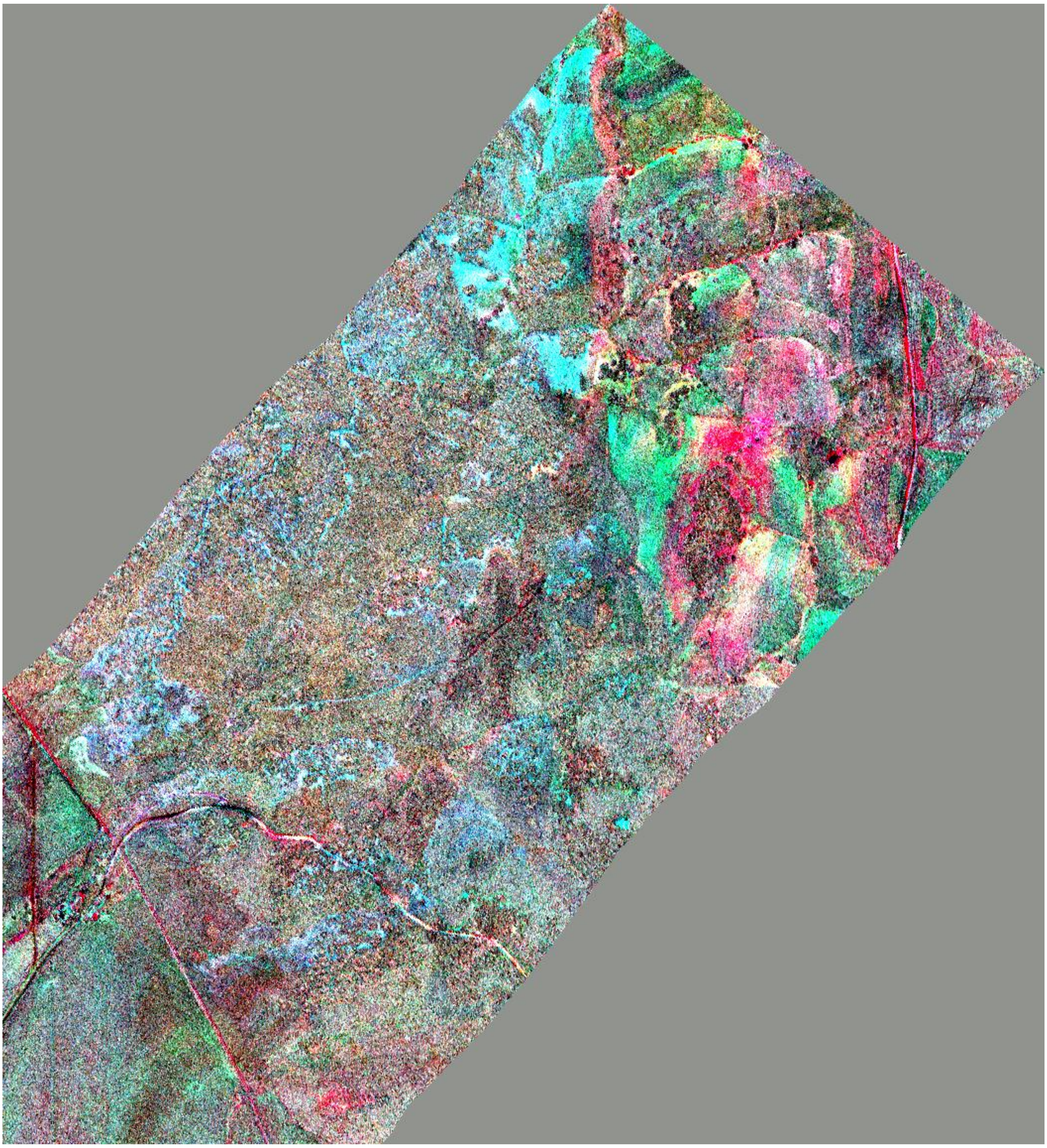

Plate 8: Colour composite matched image using end-members 1, 5 & 4 identified from strip 4 processing.

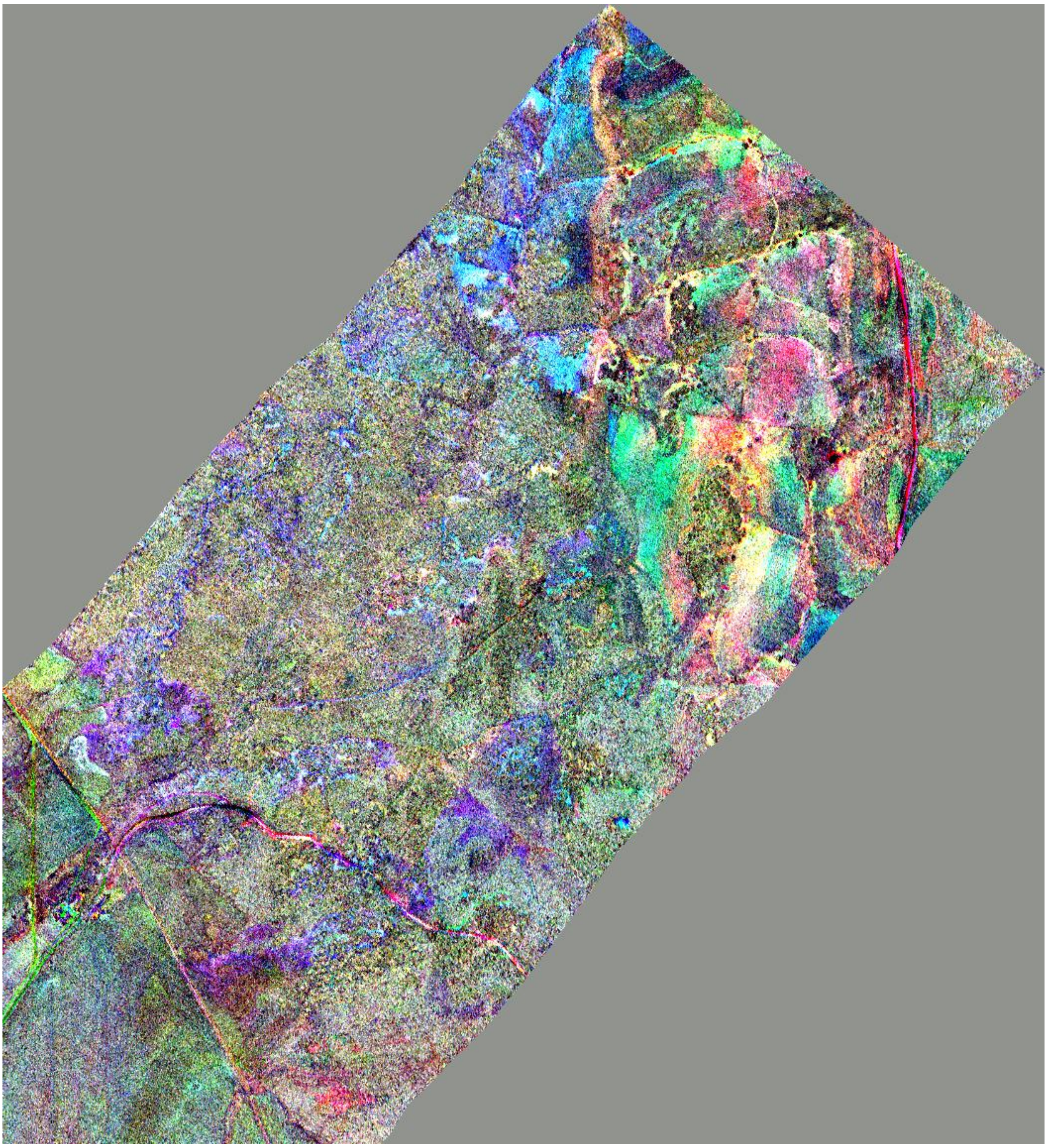

Plate 9: Colour composite matched image using end-members 1, 3 & 4 identified from strip 4 processing.

Magnesium Minerals Pty Ltd
Stephen Biggins – sbiggins@internode.on.net

Annual Technical Report

EL 4639

For the period 7 January 2012 – 6 January 2013

Tenure holder | Magnesium Minerals Pty Ltd   Tenement operator | Magnesium Minerals Pty Ltd
Author | Stephen Biggins   Report date | 12 August 2013

Distribution: Department of Manufacturing Industry and Trade (DMITRE) (digital copy)

Summary

During the period, Magnesium Minerals Pty Ltd conducted geological and structural mapping to characterise and define the significance of the effects of folding and structure on the thickness and potential economics of developing the sedimentary Magnesite ($MgCO_3$) beds hosted in the Skillogalee Dolomite within EL 4639.

Keywords

- EL 4639
- Magnesite
- Magnesium
- Skillogalee Dolomite
- Burra Group
- Hymap

Table of Contents

Page

List of Figures

List of Tables

List of Appendices

Digital file list	File size
EL4639_2013_ATR period ending 6 Jan 13.pdf	1177Kb

1. Introduction

Collaby Hill is located 200 km north of Adelaide and lies within the Skillogalee Dolomite of the Neoproterozoic Burra Group. The Skillogalee Dolomite is host to a major sedimentary magnesite deposit in the Willouran Ranges and magnesite is known to exist throughout the formation.

Following up on the work completed by Magnesium International Ltd during 2002-2003, the Collaby Hill area was selected by Magnesium Minerals for magnesite exploration and potential development of mining operations, due to its close proximity to transport and processing infrastructure, existing mining activity in the area (*benefit of possible shared utilities*) and being less environmentally sensitive than other parts of the southern Flinders Ranges.

The Skillogalee Dolomite consists of shallow water, intraclastic dolomites and magnesite with interbeds of siltstone and sandstone (Preiss, Belperio, Cowley and Rankin 1993). Collaby Hill is situated on the western limb of a large north-south striking syncline. The apparent thickness of the Skillogalee Dolomite is much greater on the western limb than that of the eastern limb.

Geological mapping and assessment of previously flown Hymap data during the reporting period was aimed to consider the effect of localised structures on the magnesite beds.

Mapping has shown that several parasitic Z-folds are present resulting in structural thickening and repetition of dolomite beds within the Skillogalee Dolomite. The structural repetition of magnesite beds by localised folding increases the potential for an economic deposit due to the greater volume of magnesite at, or near, the surface, especially along the axis of these small parasitic folds.

2. Tenure

Collaby Hill is located approximately 200 km north of Adelaide, South Australia as shown in Figure 1. Mapping is based on the Australian Geodetic Datum 1984 (AGD84) as used in the 1:50,000 topographic map of the area. The mapping area in the Universal Transverse Mercator (UTM) zone 54 lies between 236,500 east 6,317,500 north, 239,000 east 6,322,500 north.

Access to the area is via Collaby Hill Road which connects to Highway One approximately 100 m north of the Laura turn off. Collaby Hill Road extends around the southern and eastern perimeter of the mapping area. Within the mapping area itself, access is restricted to 4WD farm tracks with most other areas accessible by foot.

Tenement details for EL 4639 are detailed below in **Table 1**

EL	Name	Tenure holder	Tenement operator	Area (km^2)	Grant Date	Expiry Date
4639	Collaby Hill	Magnesium Minierals Pty Ltd	Magnesium Minierals Pty Ltd	405	7 January 2011	6 January 2013

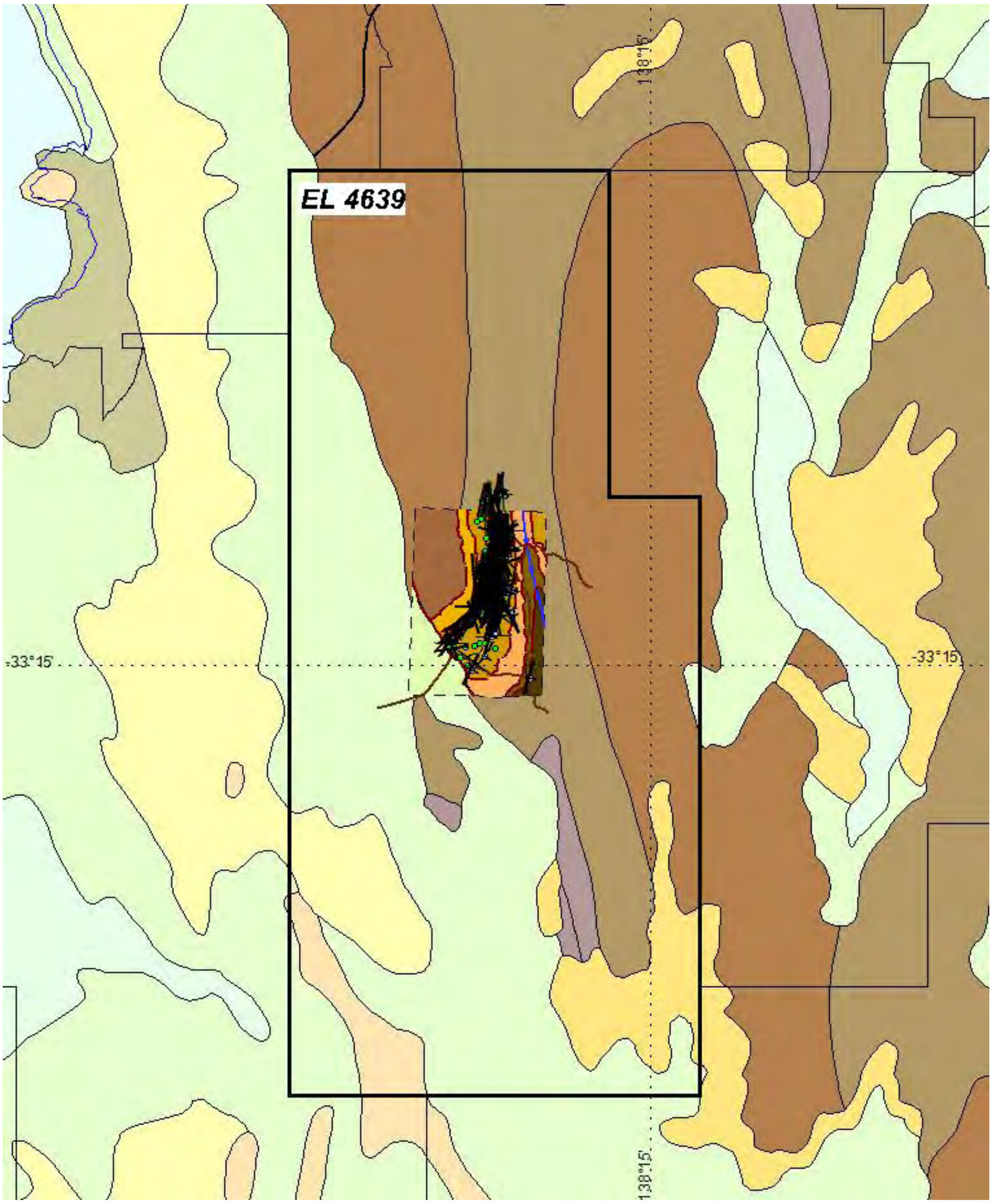

Figure1 Tenement Location

3. Geology

Ages[1] (Ma)					
		Umberatana Group			
710	**Sturtian**	**Warrina Supergroup**	**Burra Group**	**Belair Subgroup**	Kadlunga Slate
					Gilbert Range Quartzite
720					Mintaro Shale
730	**Torrensian**			**Bungarider Subgroup**	Saddleworth Formation
740					Undalya Quartzite
750					Woolshed Flat Shale
				Mundallio Subgroup	Skillogalee Dolomite Upper member
					Skillogalee Dolomite Lower Member
760				**Emeroo Subgroup**	Bungaree Quartzite
770					River Wakefield Formation
					Blyth Dolomite
780					Rhynie Sandstone
	Willouran		***Callanna Group***		

Table 2: The Burra Group as seen in the southern Flinders Ranges adapted from (Preiss 1987, p. 78; Preiss and Cowley 1999, p. 32).

[1] Ages are interpolated from Preiss (2000, p. 40)

The southern Flinders Ranges are composed of a thick sedimentary sequence that was deposited during the Neoproterozoic to Middle Cambrian in a large subsiding rift basin complex, known as the Adelaide Geosyncline. These sediments were folded and exposed during the Late Cambrian-Ordovician Delamerian Orogeny to form the Adelaide or Delamerian Fold Belt. The Adelaide Geosyncline stretches approximately 750 km from Kangaroo Island through the Mount Lofty and Flinders Ranges, the Willouran Ranges and onto the Peake and Denison Ranges, the full extent is shown in Figure 2.

The host formation of the magnesite is the Skillogalee Dolomite, a member of the Mundallio Subgroup of the Burra Group. The Burra Group is of Torrensian to early Sturtian age and represents a major sedimentary cycle.

Burra Group stratigraphy

The Burra Group along with the underlying Callanna Group make up the Warrina Supergroup and represent the first stages of deposition of the Adelaide Geosyncline (Preiss 1987). The Burra Group was first named by Mirams and Forbes (1964) and included the formations mapped by Wilson (1952), in the Clare–Riverton area. The Base of the Rhynie Sandstone and its equivalents are considered to be the base of the group. The contact between this and the underlying Callanna Group is unclear with most contacts being unconformable or faulted (Preiss 1987, p. 73). When first proposed, the top of the Burra Group corresponded with the Torrensian time interval as proposed by Mawson and Sprigg (1950) who identified the Belair group as possibly glacial. However mapping by Binks (1968), and work by Forbes (1967) and Coats (1967) identified an unconformity between the Belair Subgroup and the Sturt Tillite. Further to this Coats (1967) suggested that the Belair group had more lithological similarity to the Burra Group and that the group be relocated. This information ultimately led to the Belair Subgroup being included within the Burra Group. The boundary between the Torrensian and Sturtian however was not changed and remains at the base of the Belair Subgroup, so that the Burra Group now covers the Torrensian and part of Sturtian time (Preiss 1987, p. 74).

Mundallio Subgroup

The Mundallio Subgroup conformably overlies the Emeroo Subgroup. The subgroup was defined by Uppill (1979) to include the carbonate dominated sequences of the Burra Group that represented a time of very shallow water deposition, with smaller cycles of transgressive-regressive cycles. The subgroup as described by Uppill (1979) is shown in Table 2 and although included here in full, not all of the formations proposed have become generally accepted.

<table>
<tr><th></th><th colspan="2">Mt Lofty Ranges</th><th>Southern Flinders Ranges</th><th colspan="2">Northern Flinders Ranges</th></tr>
<tr><td rowspan="2">Mundallio Subgroup</td><td>Montacute Dolomite</td><td rowspan="2">Skillogalee Dolomite</td><td>Yadlamalka Formation</td><td>Yadlamalka Formation</td><td>Mirra Formation</td></tr>
<tr><td>Castambul Formation</td><td>Nathaltee Formation</td><td>Nankabunyana Formation</td><td>Tilterana Sandstone
Camel Flat Shale</td></tr>
</table>

Table 3: Mundallio Subgroup as proposed by Uppill (1979, p. 26)

The Castambul and Montacute Dolomites of the Mount Lofty Ranges were first named by Mawson and Sprigg (1950) and applied to two dolomite horizons that outcropped in the Torrens Gorge area. The Castambul dolomite was promoted to the Castambul Formation by Uppill (1979) to include the silts, phyllites and quartzites that lie above and below the unit as identified by Mawson and Sprigg (1950) in the Torrens Gorge area.

In the Riverton-Clare region, Wilson (1952) named the Skillogalee Dolomite and correlated a lower member with the then Castambul Dolomite and an upper member with the Montacute Dolomite. This correlation was supported by Mirams and Forbes (1964) who also extended the name to other similar units in the Flinders and Willouran Ranges.

In the southern and northern Flinders Ranges Uppill (1979) proposed splitting the Skillogalee Dolomite into new formation names as shown in Table 2. These revisions were not accepted by Preiss (1987) due to problems with mapability and facies variations throughout the formation. Preiss instead proposed that the informal classification of a lower and upper member be maintained. However Preiss does acknowledge the usefulness of Uppill’s reference sections for the Skillogalee Dolomite in the Flinders Ranges.

Skillogalee Dolomite

In the type area around Riverton and Clare, Wilson (1952) describes the Skillogalee Dolomite as approximately 330 m of cream coloured fine to medium grain dense dolomites with occasional interbedded dolomitic shales, with only meagre blue grey dolomites near the top of the formation. Also noticeable in Wilson’s type section was the lack of any magnesite within the formation in this area. Preiss (1987, p. 99) describes the Skillogalee Dolomite as generally consisting of a lower unit of pale commonly recrystallised dolomite and an upper unit of dark grey dolomites with sedimentary magnesite and black chert, which can be recognised in many areas.

In the type section 30 km northeast of Port Augusta Uppill (1979) describes her lower unit of the Skillogalee Dolomite (Nathaltee Formation) as three distinct units. The base unit (Unit 1) is described as two thirds carbonate facies and one third terrigenous facies. The carbonate facies consist of primarily grey and dark grey laminated dolomicrites with pale grey to black chert nodules. The presence of mud cracks and small scale soft sediment structures within these rocks are indicative of original mudstones. Sandstones and siltstones form the terrigenous clastics, the sandstones consist of moderately sorted fine to coarse grain size sandstones that are either quartzose or dolomitic cemented and sub-arkosic in composition. Planar bedding and lamination dominate the sedimentary structures. The interbedded siltstones are partly dolomitic planar and wavy laminated and occur as thin beds within the dolomites or thicker beds up to 6 m thick.

In the Port Germein-Beetaloo Valley area Uppill (1979) assigned the lower unit of the Skillogalee Dolomite to the upper two units of her Nathaltee Formation. Uppill describes the transition from the underlying quartzite to the Nathaltee Formation as siltstones interbedded with quartzites and dolomites. Overlying this is a sequence similar to unit two of the Nathaltee Formation consisting of interbedded green siltstones, buff stromatolitic dolomites and laminated dolomicrites. This is followed by a unit similar to unit three consisting of poorly laminated shale overlain by trough cross bedded quartzites.

The upper unit of the Skillogalee Dolomite is represented by Uppill's (1979) Yadlamalka Formation with a type section 50 km north of Port Augusta. The formation consists of predominantly carbonate facies that are dominated throughout the unit by a dark grey laminated dolomicrite that forms fissile and more massive outcrops. Structures include planar to slightly wavy lamination, silty and sandy laminae and occasional graded laminae that are indicative of carbonate muds being deposited from suspension with minor silt and sand introduced by current activity. Stromatolites, most abundant in the middle of the formation occur in biostromes and bioherms of dark grey dolomicrite. Magnesite forms approximately 11% of the type section and most commonly consists of an intraformational conglomerate particularly in the lower and uppermost sections of the formation.

Preiss and Cowley (1999) identified three facies belts within the Skillogalee Dolomite that are bounded by approximately N–S faults in the Mid-North. Their westernmost facies belt along the Torrens Hinge Zone is most relevant here since it covers the project area. This area is described as being dominated by sandy facies, which are commonly coarse grained, feldspathic and dolomite cemented. They have proposed the name Marola Sandstone Member for this unit which interfingers the unnamed lower and upper members of the Skillogalee Dolomite.

A detailed petrographic study was performed by Forbes (1960) on what is now known as the upper member of the Skillogalee Dolomite. Forbes (1960, pp 3-6) describes the composition and textures of the magnesite, dolomite, dolomite-quartz and cherts. The magnesite rocks as described by Forbes contain magnesite, talc, dolomite, authigenic albite, carbon and detrital quartz and feldspar with most rocks containing between 5 and 10% acid insoluble material. The magnesite conglomerates consist of rounded magnesite pebbles up to about 12 cm diameter in a matrix of mainly magnesite and dolomite. The magnesite pebbles show no internal structure and most lie in a preferred orientation. Massive magnesite often occurs at the base of conglomerates and is the same composition as the pebbles.

The dark grey laminated dolomicrite from Uppill (1979) above is described by Forbes (1960, p. 5) as consisting of chiefly lath shaped fragments with long axis parallel to bedding, the colour variations between medium and dark grey depends largely on carbon content. Individual dolomite crystals are about 0.004 mm diameter.

Uppill (1979, p. 36) describes interbedded sandstones consisting of fine to medium grain size, moderately sorted with a dolomite cement throughout the formation but most common near the base and top of the formation. These sandstones are called dolomite arkose by Forbes (1960, p. 5) consisting of up to 50 % (more commonly between 20 to 40 %) dolomite, quartz and feldspar. Lamination is sometimes shown by alteration of fine and coarse layers. Most grains are irregular in shape apart from larger quartz and feldspar grains which tend to be more rounded. According to Forbes this irregularity is due in part to recrystallisation and reaction with the carbonate matrix. Heavy minerals such as zircon and tourmaline and tiny cubes of pyrite are also present. Variations in the type and amount of feldspar and heavy mineral content are seen in different areas. In the Port Germein Gorge area the feldspar tends to be microcline of between 37 and 47 % with pink zircon and tourmaline as the heavy mineral (Forbes 1960).

Black chert nodules form lenses throughout the formation. These are formed by secondary silicification prior to and during lithification and compaction (Uppill 1979). Forbes (1960, p. 6) describes two types of chert, one, that forms beds that may extend several kilometres and the other, small nodule lenses, as described by Uppill (1979). The bedded cherts show a relic conglomerate or arenite fabric and consist of fine grained quartz and medium grained dolomite with a very fine material that is possibly carbon. The nodular cherts examined by Forbes showed outlines of small elongate and rounded fragments whilst one sample showed lamination parallel to the enclosing dolomite.

The Yadlamalka Formation occurs throughout the Flinders Ranges with characteristic facies as described in the type section, however thickness is variable with a maximum of 3000 m in the Willouran Ranges and 258 m in the type section (Uppill 1979). In the Port Germein–Beetaloo Valley area Forbes (1960, p. 6) describes a higher terrigenous content and only minor magnesite.

4. Exploration Rationale

The aims of the exploration programs during the period were to:

- Map the general geology of the area, with a focus on the stratigraphic relations and structural controls on the Skillogalee Dolomite.
- Map the exact locations of the magnesite beds, including the lateral extent, thickness and number of beds
- Investigate the effect of geologic structures on these beds.

5. Previous Work

5.1 Previous Mining

From 1915 to 1984 almost 44,000 tonnes of magnesite was mined in South Australia. Of this amount 36,449 tonnes were sedimentary deposits from the Skillogalee Dolomite, 6,382 tonnes were residual magnesite that had been derived from magnesium rich rocks and 660 tonnes were from metasomatic replacement magnesite (Crettenden 1985). Table 4 lists a summary of the main locations and the amount of magnesite recovered. Slight variations in these figures where published in the Mineral Industry Quarterly South Australia (South Australian Department of Mines and Energy 1984), the main discrepancy being from Myrtle Springs where a total figure of only 6770 tonnes is listed however this was from 1947 to 1983 rather than 1984 as listed by Crettenden (1985). Further to this McCallum (1990) lists a total production of magnesite in South Australia as 69,000 tonnes to the end of 1988 with 30,000 tonnes produced from the Myrtle Springs site by Commercial Minerals Ltd. Considering the publication date of this paper it is considered the more accurate figure for total magnesite production in the state.

Location	Amount (tonnes)	Type	Dates
Myrtle Springs	19,625	Sedimentary	1947-84
Robertstown	8,198	Residual	1916-53 and 1980-1984
Copley	6,031	Sedimentary	1918-55
Witchelina	2,778	Sedimentary	1964-74
Mundallio	2,554	Sedimentary	1940-53
Port Germein	1,466	Sedimentary	1947-50

Table 4: Major sources of magnesite in South Australia from 1915 to 1984, adapted from (Crettenden 1985, p. 1)

The Port Germein deposit is the most significant with respect to this project located approximately 25 km north of the mapping area. The deposit was worked by Broken Hill Proprietary Co. (BHP) who first pegged the area in 1944. Small scale production occurred during 1947, 1949 and 1950 totalling 1,277 tonnes. Prior to this in the 1920's 189 tonnes had been extracted by Hooper and Franke. Magnesite was recovered from shallow open cuts and an adit 47.2 m long with an adjoining decline shaft (King 1956; Crettenden 1985). The site was surveyed in detail by King (1956, p. 101) who described the main worked deposit as a magnesite bed about 1 m thick above a 0.5 m thick bed that are separated by a narrow bed of impure magnesite and chert. The ore grade average was 47% MgO and was expected to be continuous throughout the bed.

In Beetaloo Valley a small open cut produced 50 tonnes of magnesite, 38 tonnes by BHP in 1916 and 12 tonnes by Bairstow in 1966. The magnesite was extracted from 5 beds up to 0.7 m thick (Crettenden 1985). The location of this activity is significant due to its close proximity to the mapping area (within 5 km) and that it is on the eastern limb of a major syncline structure, with the western limb the one being mapped.

5.2 PREVIOUS EXPLORATION

A majority of the significant previous exploration work within the tenement has been conducted by Magnesium International Ltd (MIL) as part of their SAMAG magnesium metal Project feasibility work.

In 2002, MIL identified magnesite beds within the Skillogalee Dolomite, interpreted to outcrop or be shallowly buried (<5m) over a 75km strike length in the Southern Flinders Ranges. These beds were regionally sampled at 8 locations over this strike length. Table 5a below provides the average partial leach analysis of 16 primary magnesite outcrop samples.

Table 5(a). Average Partial Leach Analyses of 16 Primary Magnesite Outcrops.

Mg %	Ca %	Fe ppm	Mn ppm	Si ppm	S ppm	B ppm	Sr ppm	Insol %	Total %
24.9	2.1	3381	107	2097	440	95	100	6.2	99.2

At least 9 magnesite beds, with a maximum width of 1.5m have been identified near Beetaloo (15km SE of the proposed SAMAG plant site) and at Germein Gorge (15km NE of the proposed SAMAG plant site). The sum of bed thickness for the section at Beetaloo is approximately 8m over 25m, which is equivalent to an approximate ore to waste ratio of 1:3.

In March 1998 Primary Industries and Resources of South Australia (PIRSA) undertook a trial hyper-spectral airborne imaging spectrometer survey (HyMap™) along the strike of the Skillogalee Dolomite in the Willouran Ranges north of Leigh Creek (Keeling. J., & Mauger, A., 1998). Following the success of the PIRSA trial Pima Mining NL (now Magnesium International Limited) commissioned Intergrated Spectronics Pty Ltd in November 1998 to extend the trial further south along the strike towards Leigh Creek covering the Witchelina, Termination Hill, Pug Hill and Mt Playfair deposits.

The success of this trial led MDL (subsidiary of MIL) to commission a HyMap™ survey over the interpreted outcrop of the Skillogalee Dolomite in the Southern Flinders Ranges near Port Pirie. The survey included all the interpreted outcrop area within EL's 2828 and 2944.

In March 2002, Hymap™ data was acquired covering 11 image strips over the Southern Flinders Ranges east of Port Pirie (Figure 4). Weather conditions for acquisition of the data were perfect with no cloud and visibility exceeding 100 km's (Cocks, P., 2002). Hymap™ swathes 4 and 5 of the acquired data covered the Collaby Hill area in the southwestern part of EL 2828 and the data was processed for analyses and interpretation.

In 2003, MIL took a total of 94 outcrop samples were collected from the Collaby Hill area. Detailed outcrop sample assays are listed in Table 5(b) below gives the average assays of magnesite samples collected from geological Traverses 1-5.

Table 5(b) Average Assays of Magnesite Samples from Geological Traverses 1-5, Collaby Hill

Traverse No	No of Samples	Strike	Dip	No of Beds	Total Width	Mg %	MgO %	Ca %	CaO %	Fe ppm	Mn ppm	Al ppm	Si ppm	S Ppm	B ppm	Sr ppm	Insol %	Total %
1	17	350	55	?	?	26.85	44.53	1.80	2.51	668	17	508	1862	75	14	144	0.79	99.14
2	12	355	65	4	4.5	26.82	44.50	1.62	2.27	579	18	496	1544	52	15	181	0.93	98.70
3	12	350	45	7	5.8	25.02	41.46	2.34	3.28	6942	167	692	4915	116	90	123	4.19	99.20
4	26	25	40	6	8.5	25.93	43.00	2.53	3.54	3088	93	377	33072	133	53	141	2.48	100.24
5	10	70	35	5	5.3	24.49	40.62	3.33	4.67	2720	101	421	3251	203	93	182	5.09	99.87
ALL	77					25.94	43.02	2.30	3.22	2716	79	483	2877	114	52	151	2.45	99.55

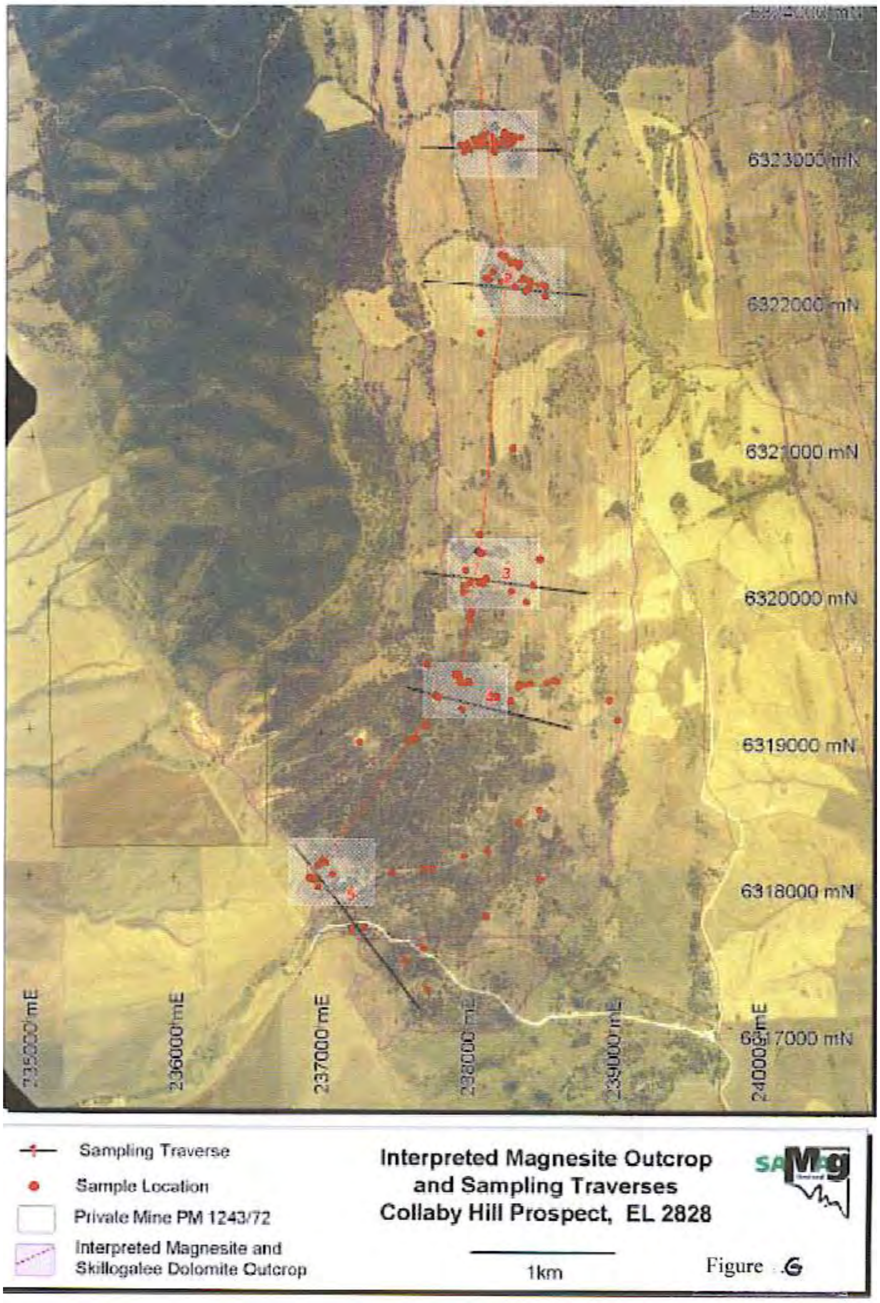

Figure 2 Interpreted magnesite outcrop and sampling traverses, Collaby Hill

6. Exploration Conducted

Geological and structural mapping of the area was completed during the reporting period.

The information gained from this and prior mapping (Dart 2002) enable the Company to predict the package of magnesite beds position and importantly geometry for potential future resource and economic evaluation.

Geological and Structural Mapping Observations

The magnesite beds located around 238,250E 6322000 N appear to be about twice the thickness as those measured in other locations. These beds were not identified in the relative position further south. They do however continue north beyond the extent of the mapping area.

There are two possible explanations for this magnesite outcrop. The first is that the magnesite beds are a separate package that lenses out to the south. Given the thickness of this package and that very few of the prominent dolomite or sandstone beds lens out, this is unlikely. The second possibility is that the observed outcrop is located within the hinges of the Z-folds observed further south within the dolomite beds.

The location of the magnesite beds to the south are consistent in their general position and strike direction until they are lost undercover at the start of the cleared paddocks. If the beds are projected along strike to the north then they clearly do not correlate with the above thick magnesite package. Along the fence line of the northern paddock around 237,750 E, 6,322,500 N, very small outcrops of magnesite were identified around the expected location that a continuation of the southern beds would pass. Hence the main northern magnesite package is not that mapped in the south unless it has been folded.

By taking into account the plunge of the folds and change in elevation this magnesite outcrop can be mapped as part of the main magnesite package that has been folded along with the dolomite. The effect of a 15° plunge over the distance of 1 km would see a change in hight of about 300 m. Hence magnesite located beneath the folds to the south would become exposed towards the north.

This information has been used in interpreting the folding of the dolomite and magnesite beds and their approximate position beneath the cleared paddocks. The full interpretation of this area is shown on the main map included with this thesis.

Figure 3 is a cross section of the northern area and illustrates the effect of the folding on the magnesite and also explains the increased thickness in this area.

Figure 4 is located approximately 1.6 km to the south of the above section and shows the effect of the plunging hinge line. In this area the folded magnesite is located approximately 200 m below the surface. The folds are clearly displayed on the surface by the overlying dolomite beds.

The cleared paddocks between the above sections prevents direct mapping of these beds. However looking towards the south from the farmhouse at 238,000 E, 6,321,500 N, a faint outline of folding is visible in these paddocks. The three prominent dolomite beds that are shown in Figure 4 are interpreted as continuing along strike and folding across these paddocks so that they remain above the folded magnesite in the north as expected. This is also illustrated on the enclosed map of the area.

At the southern end of the mapping area the dip becomes shallower as the beds move towards the hinge of the main anticline. The result of this shallow dip is the appearance of thicker beds and also the possibility that a continuation of the Z-folds would again bring more magnesite towards the surface. Evidence supporting this is the presence of four magnesite beds that were observed at the bottom of a small valley at 238,000 E, 6,319,100 N. These beds are not along strike of the main package however they are approximately in line with the outcrop near 238,250 E, 6,322,000 N described above.

Figure 5 illustrates how the shallow dip would ensure that magnesite is maintained near the surface and with the drop in elevation in this area causes it to outcrop in the bottom of some valleys. Only limited mapping was performed in this area. However patches of magnesite were located and mapped over a much wider area is this section of the map. This is supportive of the shallow dip and of folding bringing the magnesite back up to the surface.

The importance of the parasitic folding in the area is of major significance. Since the amount of magnesite at near surface levels is increased substantially. This could be the difference between an economic or non-economic resource.

Figure 6 is a combination of the three cross sections and illustrates the effect of the plunge and change in topography on the location and outcrop of the magnesite package.

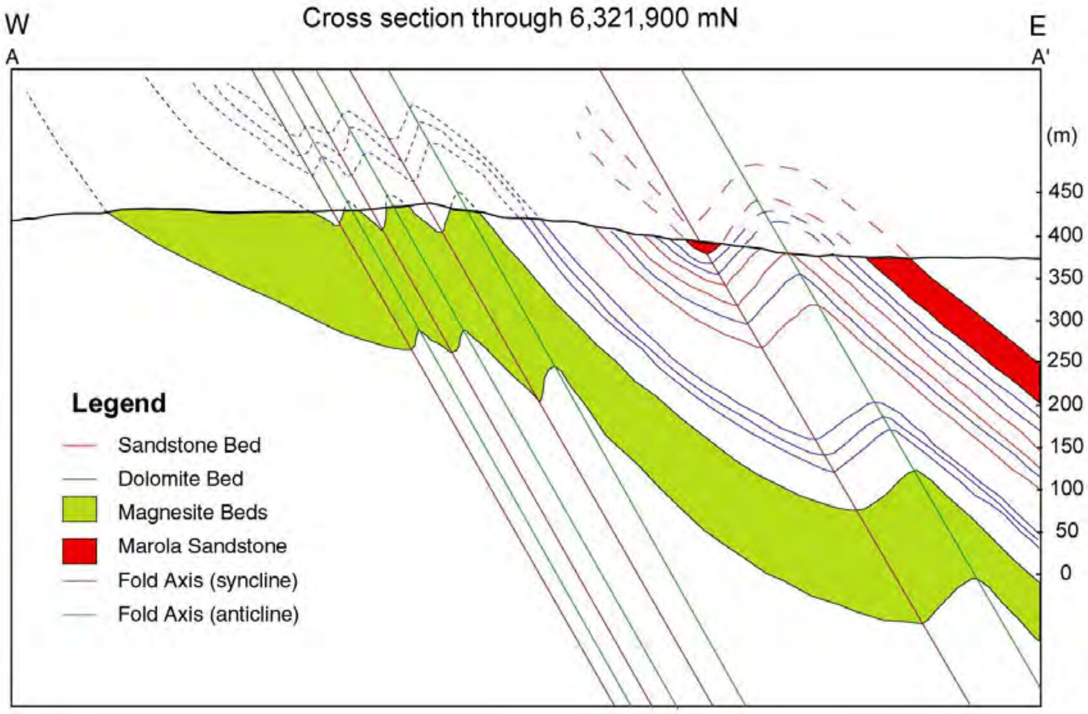

Figure 3. Northern area cross section

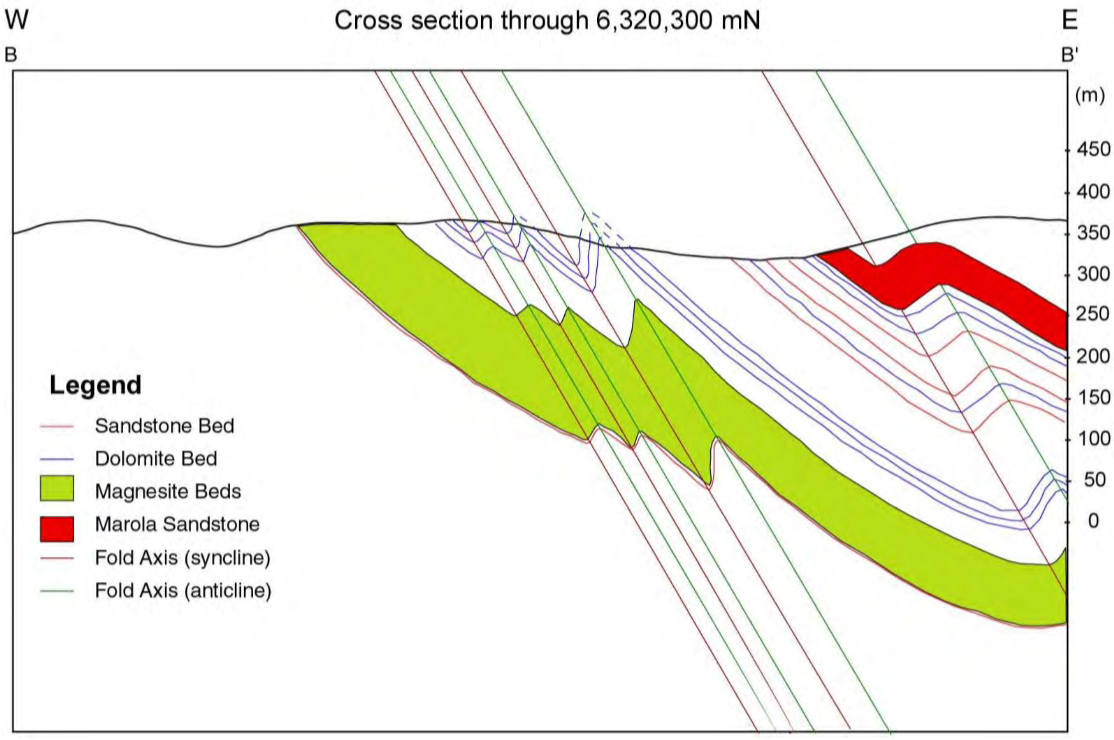

Figure 4: Central area cross section

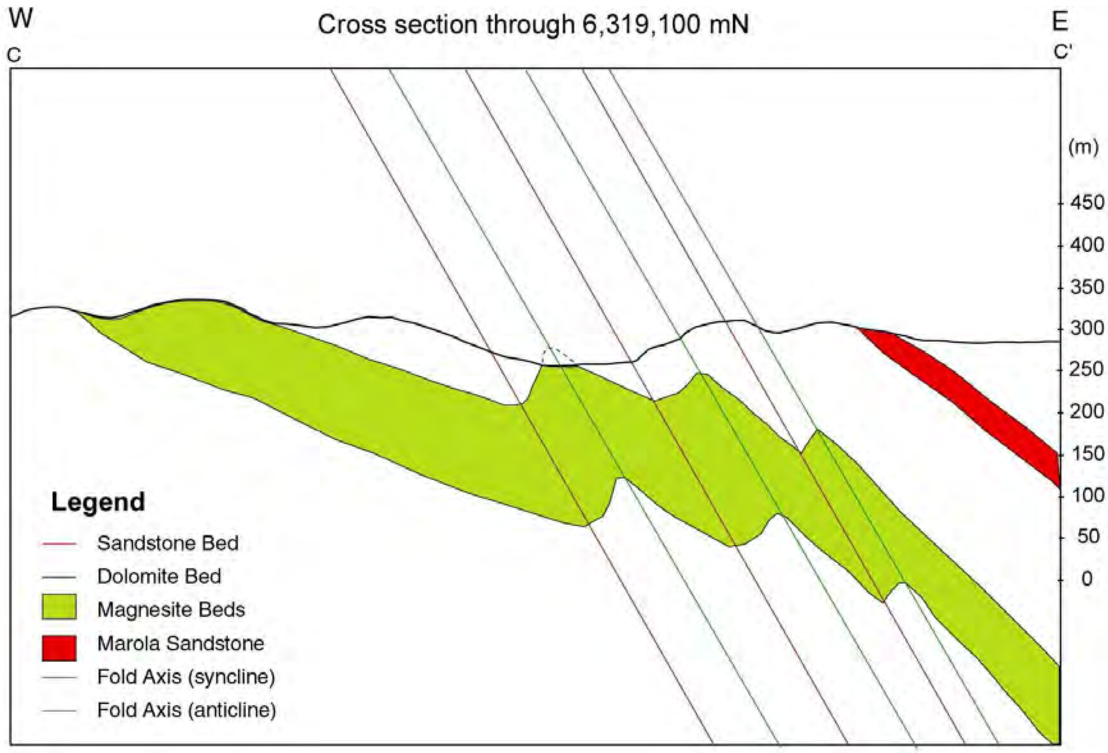

Figure 5: Southern area Cross section

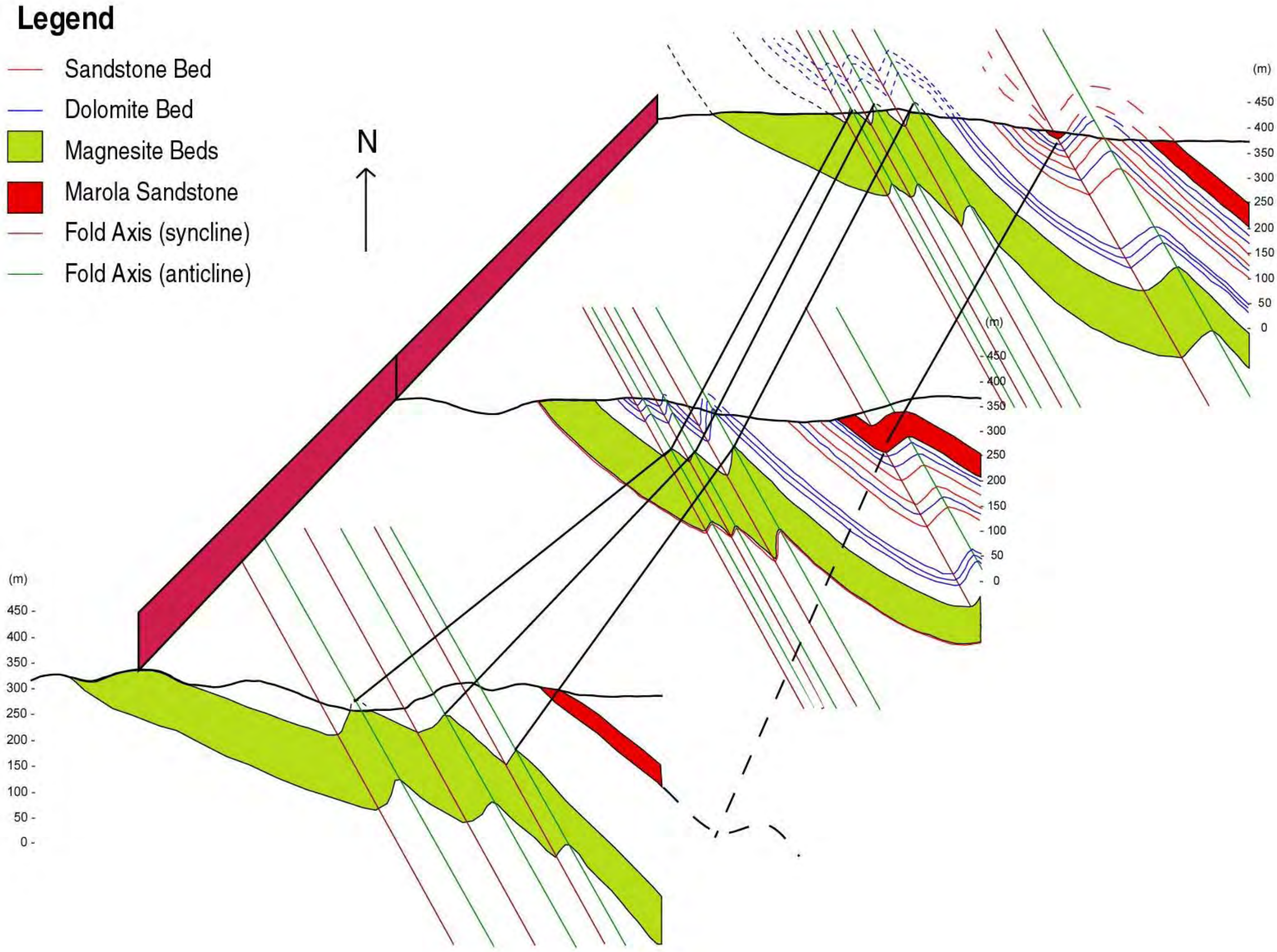

Figure 6: Combined comparative cross sections

The three sections are aligned by their relative positions. The dark red bar along the left hand side demonstrates the change in elevation between the sections. The top of this bar is 450 m. A selection of the folds are linked to show how their relative position changes through the area. The top two sections show the effect of the plunge, whilst the southern section displays the change in relative position along the western limb.

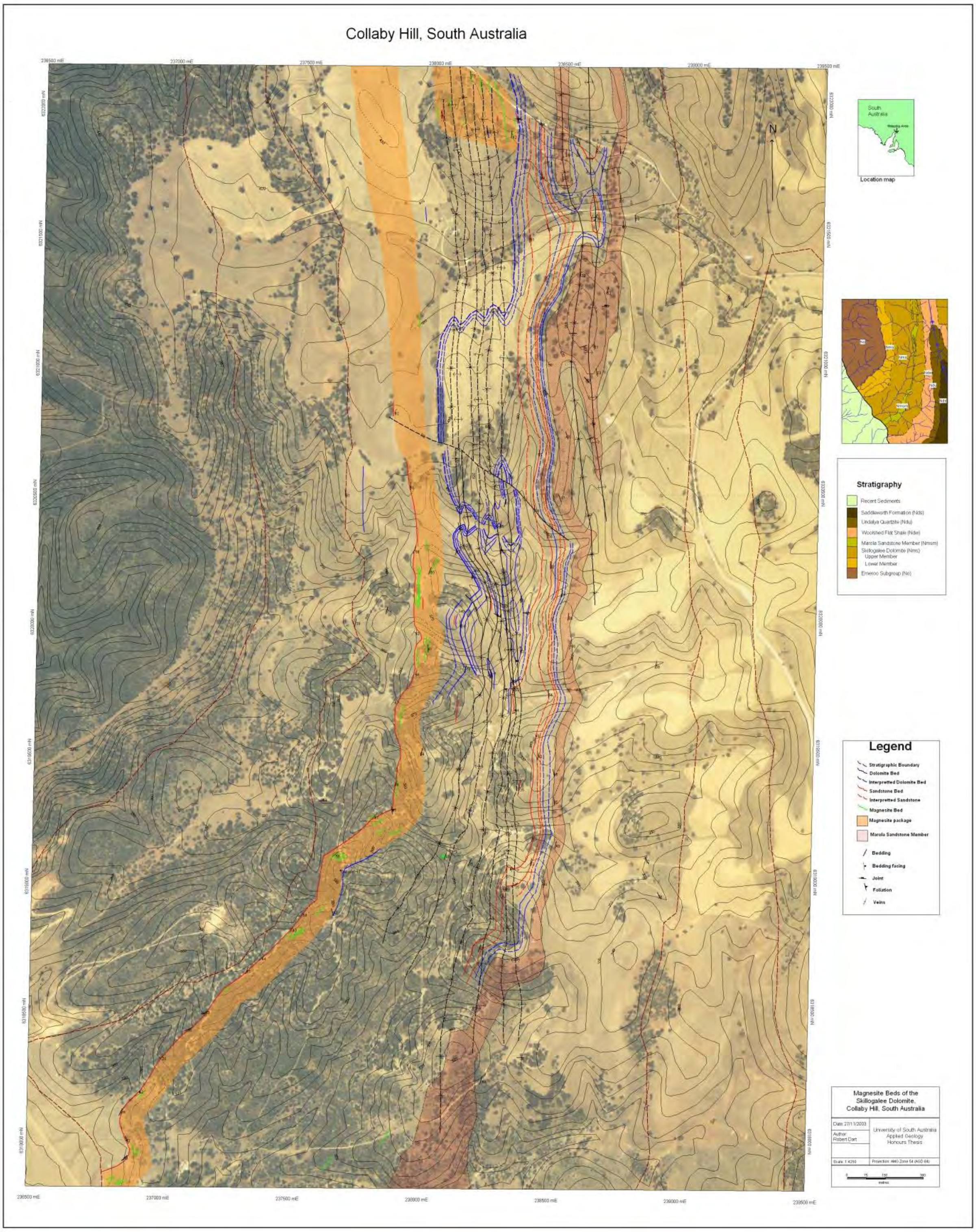

Fig 7. Detailed geological map of the magnesite beds and relevant structural geology within the Skillogalee Dolomite, EL 4639, Collaby Hill South Australia.

7. Expenditure

Expenditure for the period 7 January 2011 to 6 January 2012 is detailed in Table 6 below:

Table 6 Expenditure for EL 4639 – Collaby Hill

EL 4639 Collaby Hill	
Minimum annual expenditure	70 000

Detailed annual expenditure for the period 7 January 2011 to 6 January 2012

Activity	Expense $
Personnel (Geologists, Consultants)	20,000
Tenement maintenance	5,000
Geophysics	9,500
Software	4,000
Vehicle Costs	2,250
Food, travel, accommodation	5,500
Admin/overheads (12%)	5,550
Total	51,800

The exploration expenditure tenement during the reporting period.was underspent by $19,200.

It ia anticipated that expenditure during the next annual reporting period is $90,000, and therefore, it is expected that current and future expenditure combined will exceed the minimum expenditure requirement for the 2 year period.

8. Conclusions

Geological and structural mapping around the Collaby Hill area has determined that magnesite is present in what appears to be a series of continuous beds that extend from the western escarpment in the south through to the north of the mapping area and beyond. The magnesite package is around 80 m thick and consists of around 10 beds that are up to 1.5 m thick.

The importance of the mapped parasitic folding in the area is of major significance. Since the amount of magnesite at near surface levels is increased substantially. This could be the difference between an economic or non-economic resource.

The magnesite beds are folded and structurally repeated by parasitic Z-folds evident in the more resistant dolomite and quartzite beds. These folds are tight to chevron shaped and like the main syncline, plunge gently towards the south. The amount of magnesite present at near surface levels may be triple that observed in the main package due to the effect of this folding. This is especially evident in the north of the mapping area where magnesite outcrop is up to 300 m thick.

In the south of the area the shallower dip and lower elevation has also increased the amount of near surface magnesite. This is a significant factor to consider and would make further investigation of the area through the use of costeans or drilling.

The magnesite beds located around 238,250E 6322000 N appear to be about twice the thickness as those measured in other locations.

Repetition of the magnesite beds due to parasitic folding especially in the north of the area can be expected to triple the amount of near surface magnesite.

In the south of the area magnesite float was identified in areas some distance from the main package. The shallow dip of the beds in this area, parasitic folding and steep topography is possibly maintaining the magnesite nearer to the surface than in the north.

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Figures

Magnesium Minerals Pty Ltd

Annual Technical Report for EL 4639

7 January 2012 – 6 January 2013

Table of Contents – Figures

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30 March 2013

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Minerals and Energy Resources
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Final Technical Report, EL 4639

Magnesium Minerals Pty Ltd did not conduct exploration during the final reporting period from 06/01/2013 to 06/01/2014 on EL 4639.

Please refer to attached 6-month Summary Reports for the period for detail of minor expenditure during the period.

Regards,

Stephen Biggins

Director

Magnesium Minerals Pty Ltd