Exploration Permit for Minerals No. 27970

Buckland Volcano Project, Central Queensland

Annual Report for the period:

22/03/2022 to 21/03/2023

Holder: Rockminsolutions Pty Ltd A.C.N 642 143 780

Operator: Rockminsolutions P/L

1:250,000 Sheet: SE55-3

1:100,000 Sheet: Consuelo

Author: M.E. I'Ons

Submitted by: Ardent Group P/L

Date: April 2023

EPM 27970 Annual Report for 22/03/2020 to 21/03/2023

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LIST OF FIGURES:

1. SUMMARY

EPM 27970 covers an area of approximately 44 square kilometres mostly underlain by Tertiary basaltic ignimbrites (extensive volcanic ash deposits) and tuff with a thickness of around 200m.

Undo (https://un-do.com/) and Lithos Carbon (https://www.lithoscarbon.com/) are organisations in the UK and USA respectively that are currently using crushed basalt spread on agricultural land to remove carbon dioxide from the air and turn it into carbonate minerals for permanent sequestration. The huge advantage of this technology is that it is low tech, inexpensive and has the added benefit of improving soil fertility and productivity at the same time. These organisations are using crushed hard basalt as a source but there is a limited amount of this material produced as a by-product at basalt quarries producing aggregate for concrete and road base. Additional crushing requires a high energy input. Much of the basaltic rock in EPM 27970 is in the form of basaltic ignimbrite or volcaniclastic debris flows and is not strongly lithified. A low energy input would be required to crush this material and once exposed to air and rainwater it disintegrates.

Rockminsolutions Pty Ltd has identified the most promising and extensive resource of the appropriate rock formations in Australia for carbon dioxide draw-down through advanced weathering. The Buckland Basaltic Sequence, up to 250m thick in EPM 27970, is an aerially extensive accumulation of basaltic ignimbrites, hyaloclastites and volcanoclastic debris flows that should have extensive lateral permeability. While basalt rock is common, it is rare for such a thick and extensive ignimbrite and debris flow formations to be found with the right lithological characteristics. The resource is also ideally situated in relation to coal, gas, forestry and agricultural resources and would underpin a leading global hub for negative emissions technology including CCS (Carbon capture and storage) and BECCS (Bioenergy with carbon capture and storage) while enhancing forestry and agricultural productivity across large tracts of central and southern Queensland. These basaltic ignimbrites are capped and preserved by extensive welded tuff horizons below which the material is largely poorly lithified and very amenable to crushing. It is ideal for applying to agricultural land with the benefits of advanced weathering carbon capture as well as improved soil structure, water holding capacity and fertility. Research into this application is already underway on one neighbouring property.

Sub-blocks:

BIM	BLOCK	SUB-BLOCKS
Charleville	483	B, C, G, H, J, M, N, Q, P, R, S, T, U
Charleville	484	Q

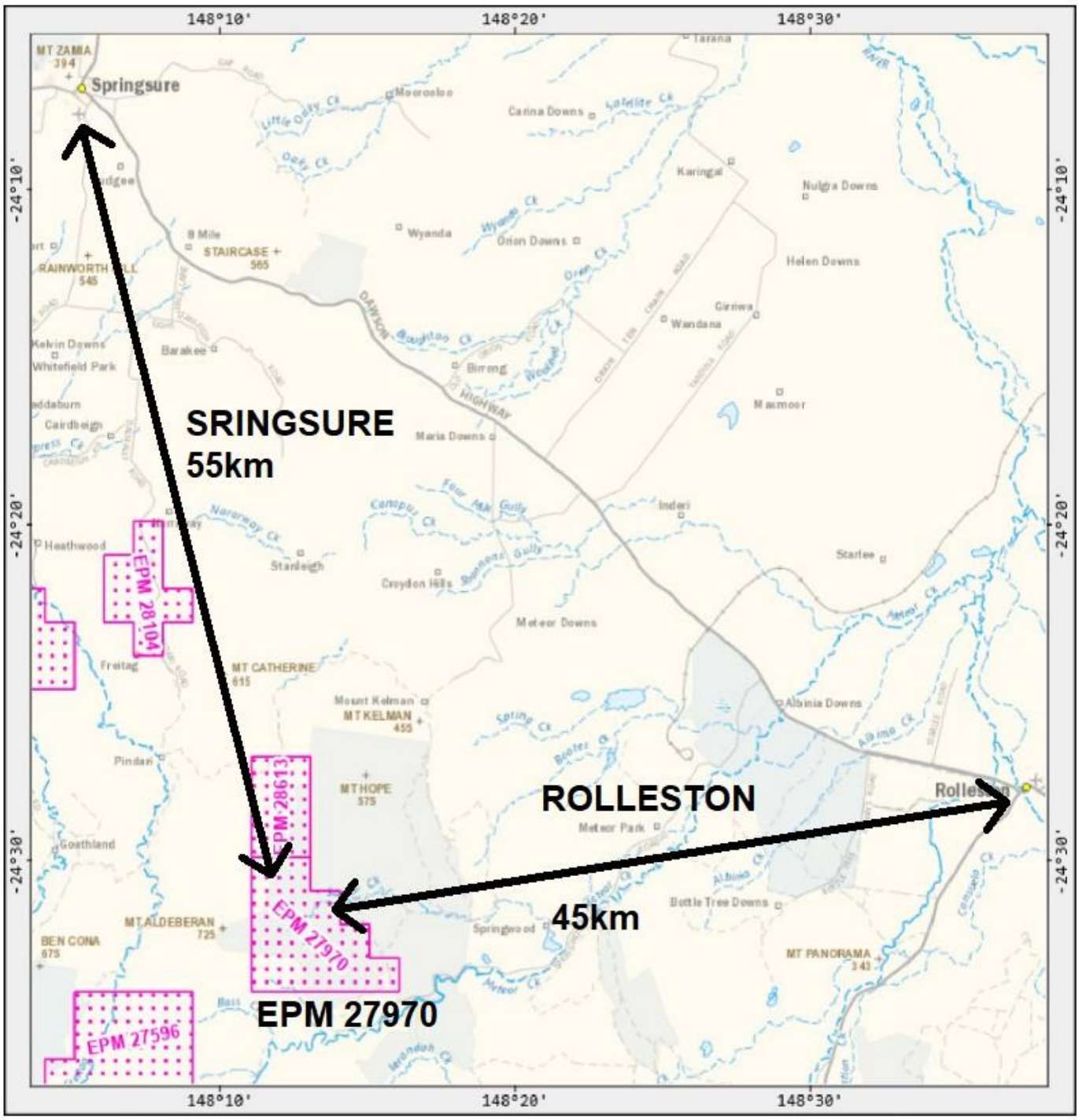
Total: 14 sub-blocks

2. INTRODUCTION

EPM 27970 is located south of Springsure and west of Rolleston as shown in Fig 1. The EPM was selected to cover the north-eastern portion of one of the thickest and most extensive accumulations of Tertiary basaltic ignimbrites and volcaniclastic debris flows in Queensland.

The EPM covers the north-eastern remnant of the Buckland volcanic sequence that has been significantly dissected and eroded in this area. Exposures in road cuttings elsewhere beyond this EPM, mainly on roads

that ascend the Buckland Tableland, provided evidence that the bulk of the sequence is a basaltic ignimbrite, capped by extensive resistant welded layers that have preserved the underlying mostly non-welded ash material. XRF and XRD analyses infer that this non-welded ash material has very similar compositional properties over a significant vertical interval of over 100m. A simple absorption test of the non-welded ash found it to be very absorptive and permeable. This implies that this ash material has a good potential to be applied to agricultural land where advanced weathering processes would absorb significant quantities of CO2 from the atmosphere through carbonation (converting CO2 to bicarbonate and then carbonate minerals) while also supplying essential plant nutrients and improving soil texture leading to productivity increases.



A product of
GeoResGlobe

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Legend

- EPM application
- EPM granted
- EPM special application
- EPM special granted

N

0 10 km

Scale: 1:320932

Printed at: A4

Print date: 22/2/2023

Projection: Web Mercator EPSG 102100 (3857)

For more information, visit https://georesglobe.information.qld.gov.au/help-info/Contact-us.html

Queensland Government
Department of Resources

Fig. 1 Location of EPM27970 approximately 55km to the south of Springsure and 45km west of Rolleston, Central Queensland. Map base supplied by GeoResGlobe.

3. REGIONAL CONTEXT

EPM27970 lies approximately 55km south of Springsure and 45km west of Rolleston in Central Queensland and covers the north-eastern outlier of the 200 to 300m thick Buckland Volcanic sequence. The underlying basement is the Springsure Shelf that is covered by Permian and Triassic sediments that are prospective for coal and gas. State Gas Ltd ATP 2062 overlaps most of EPM 27970. State Gas Ltd is targeting coal seam gas in the Permian coal measures. The Tertiary Buckland Volcanic Province has been dated at between 25 and 28 Ma (Sutherland et al 1989). Assuming that Australia has been moving north at 7cm/year since then, this area would have been located around 40 degrees south where Bass Strait now is. The remnants of the Buckland Volcanic Sequence that have been targeted by this EPM have not previously been subjected to analysis, mainly due to limited access. The aeromagnetic images of EPM 27970 clearly illustrate that there was a reversal of the earth's magnetic field during the accumulation of the Buckland Basaltic sequence. This is particularly useful in mapping the geology of the EPM.

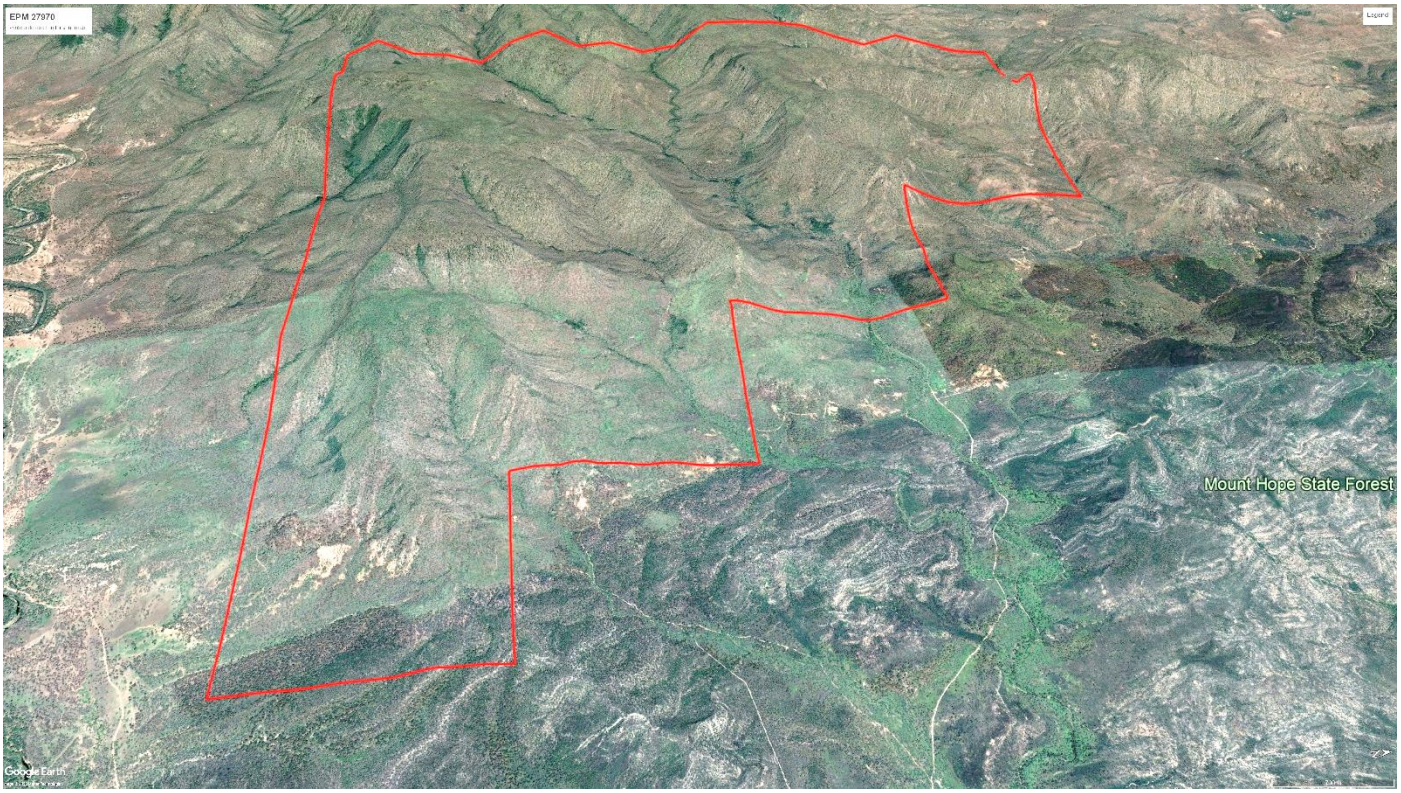

Fig. 2 Oblique view of EPM 27970 looking west on Google Earth imagery. The outline of EPM27970 is draped over the strongly dissected 250m thick 27 to 28my basaltic ignimbrite and volcaniclastic sequence of the Buckland Volcano**.**

4. PREVIOUS EXPLORATION

The area covered by EPM 27970 has had no previous mineral exploration.

5. GEOLOGICAL INTERPRETATION

The main body of EPM 27970 was selected on the basis of the Buckland Volcanic PhD Thesis by Andrew Skae submitted to the University of Oxford in 1998. This thesis described the Petrology of the Buckland Volcanic Province and identified it as a shield area 60km across and up to 300m thick with an age of 27 to 28 Ma. These characteristics identified the area as having some potential for carbon dioxide sequestration

using the process pioneered by Carbfix in Iceland, converting CO2 to carbonate minerals. However, none of Andrew's sample sites were within the boundaries of EPM 27970 or EPM 27596.

Fieldwork has found that the portion of the Buckland Tableland selected for EPM 27970 is comprised of 150m of basaltic ignimbrite overlying about 100m of basaltic volcaniclastic debris flows. Welding of the upper layers of the ignimbrite has protected a large volume of non-welded, relatively soft basaltic ash that is both permeable and porous. This non-welded material is likely to have a high capacity to absorb carbon dioxide and fix it as carbonate minerals. The underlying volcaniclastic debris flows are poorly lithified but have a high magnesium to calcium ratio which differs from the overlying non welded ignimbrite. They contain clasts of hard basalt and may require more energy to crush.

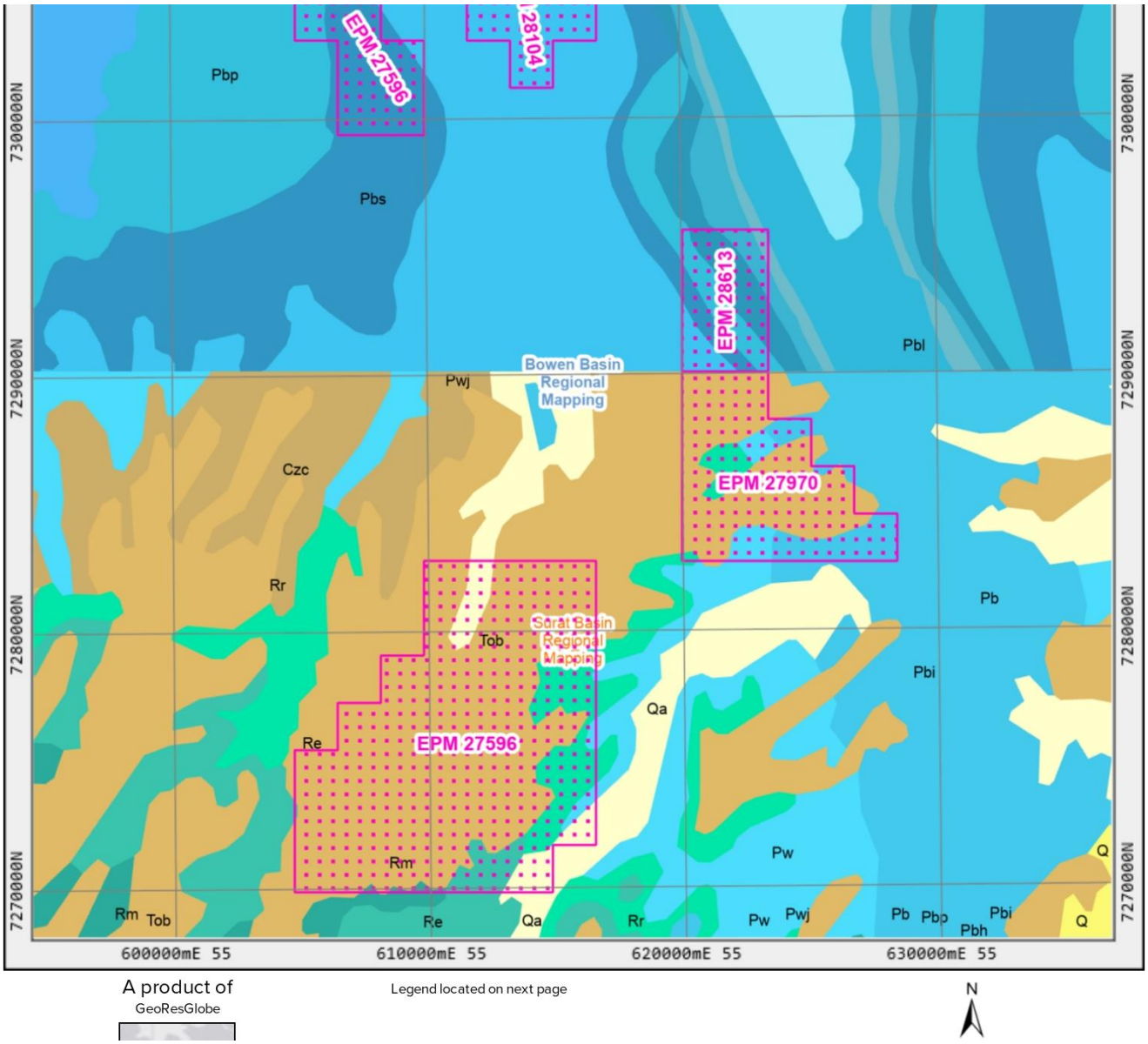

Fig. 3 The geological map produced by the Bowen Basin Regional Mapping Project shows that EPM 27970 covers the north-eastern extent of the Tertiary Basalt outlier that forms the Buckland Tableland. The area between EPMs 27596 and 27970 is occupied by MDL 3006 for coal.

Buckland East

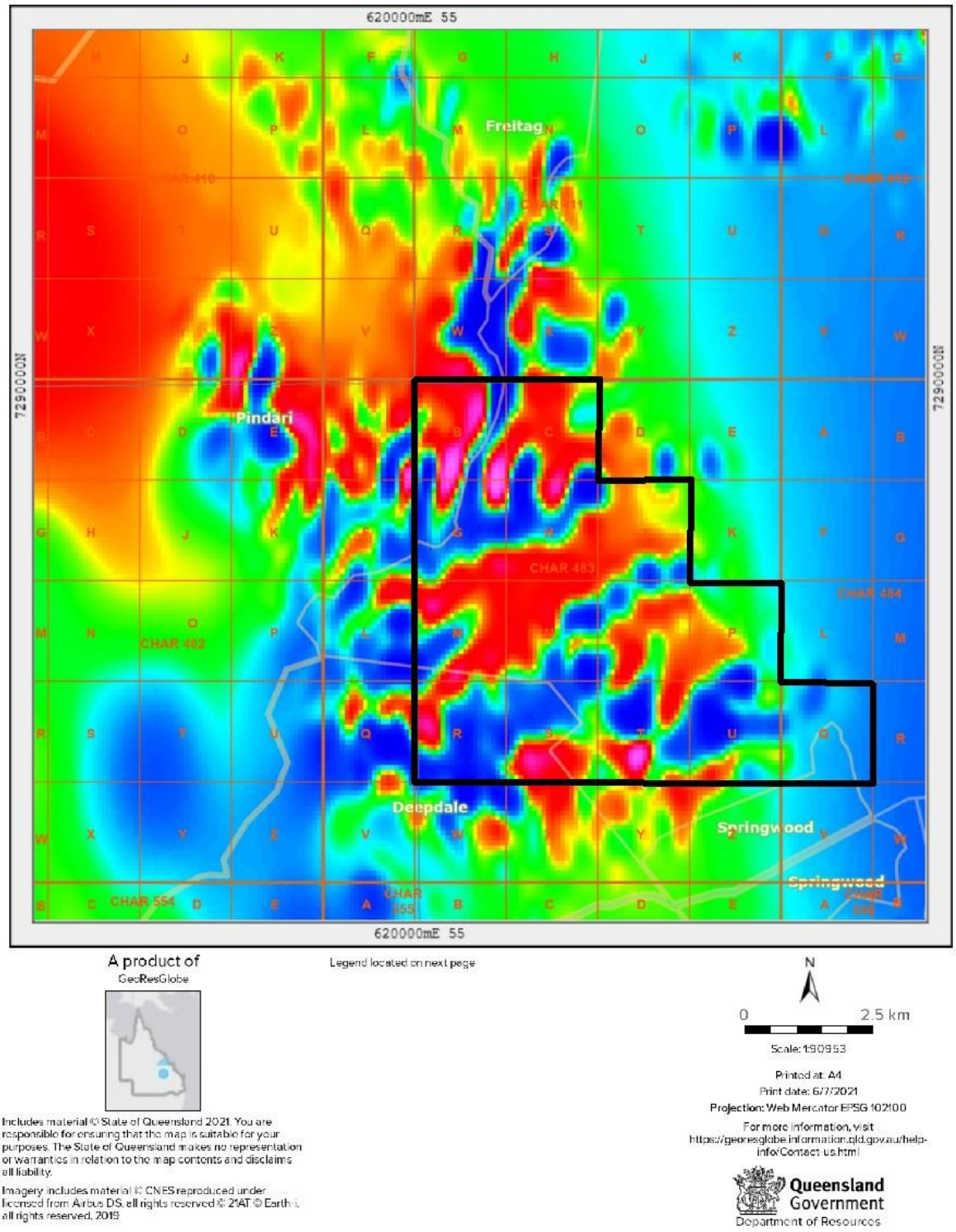

Fig. 4 The RTP aeromagnetic image from GeoResGlobe clearly shows that the earlier portion of the basaltic sequence was erupted when the Earth's magnetic field was 'normal' while when the upper portion erupted when the Earth's magnetic field had reversed.

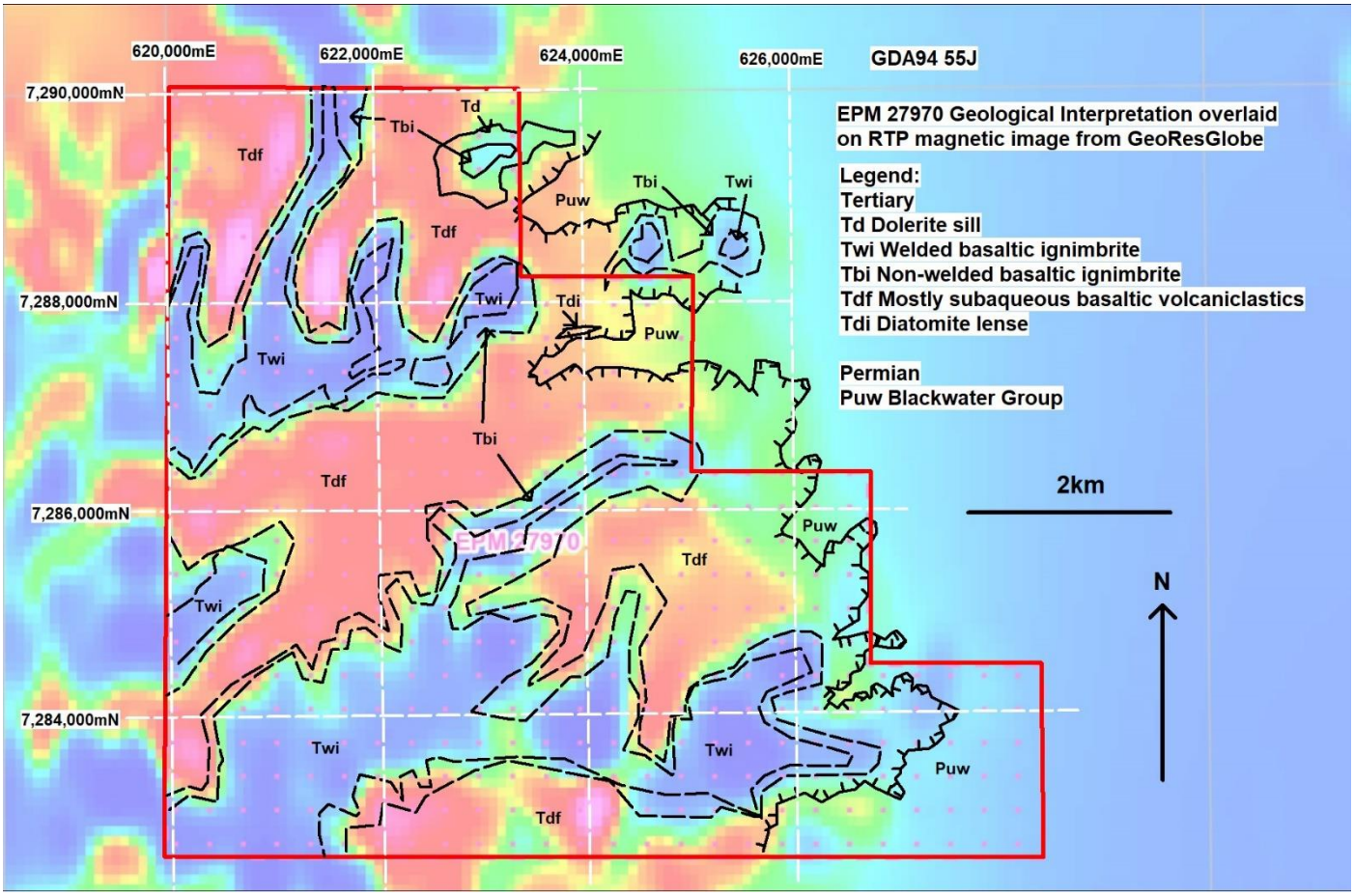

Fig. 5 Geological Interpretation based on field observations and interpretations of aerial photography, satellite imagery and the RTP magnetic image.

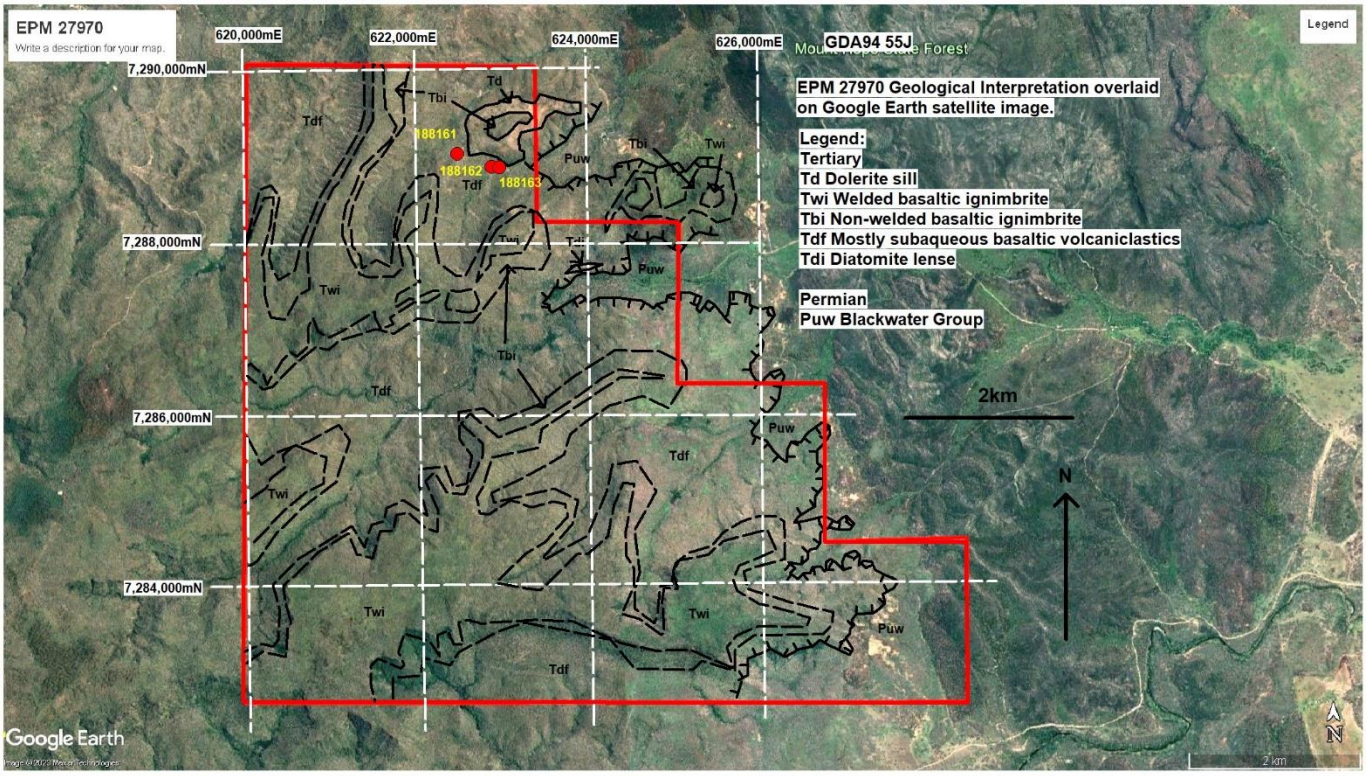

Fig. 6 Geological interpretation overlaid on Google Earth satellite image. Sample locations for 188161, 188162 and 188163 shown as red dots.

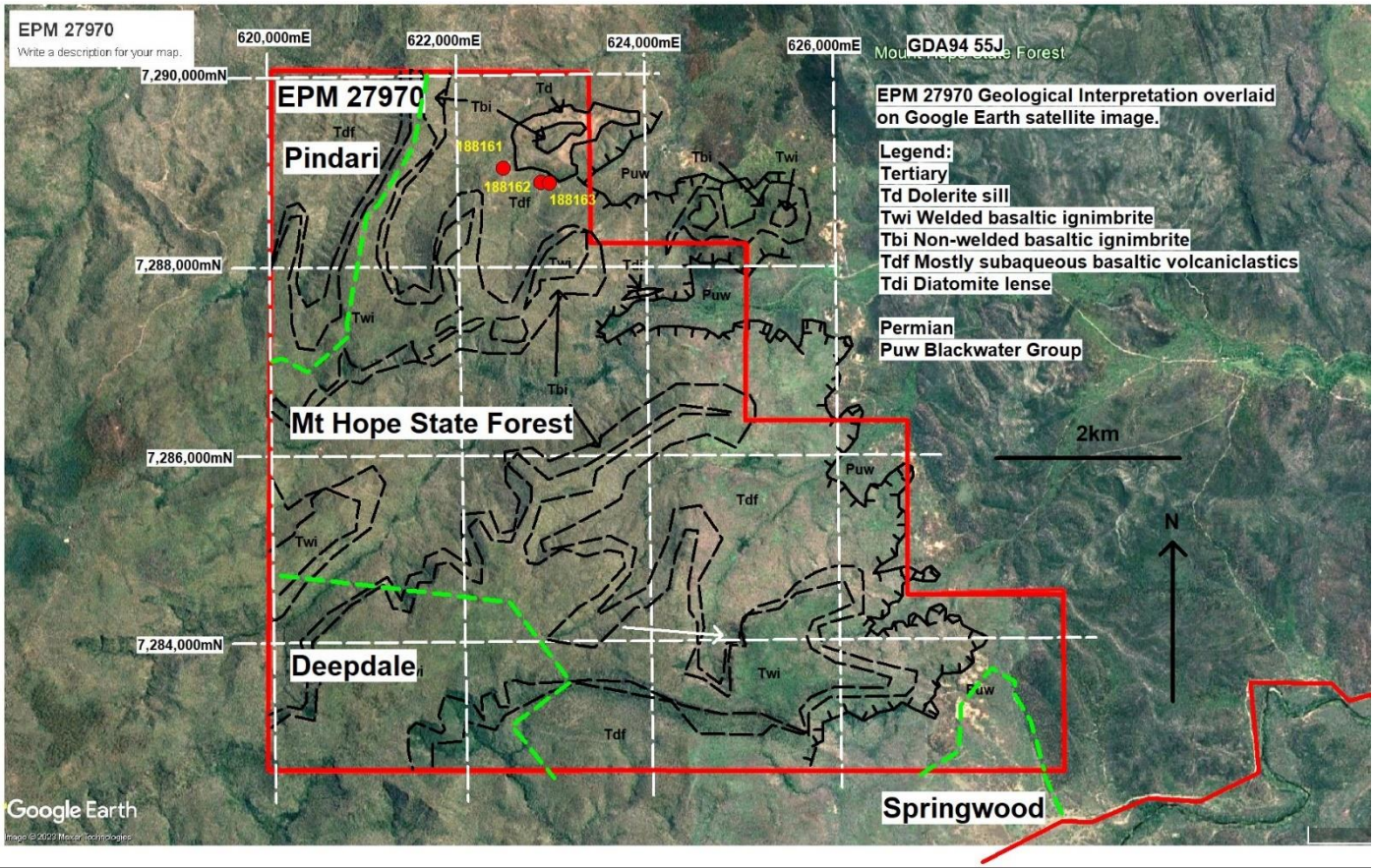

Fig.7 Landholder boundaries on EPM 27970 in green dashed lines. The bulk of the EPM falls on the Mt Hope State Forest but the timbered area in the State Forest falls to the east of the EPM.

Fig. 8 Thick exposure of sub-aqueous basaltic volcaniclastic debris flow, Tdf on geological interpretation above. Note large basalt clasts near centre. Stringers of white carbonate minerals produced by the interaction with CO2 dissolved in percolating rainwater occur throughout. 622953mE 7288937mN GDA94 55J.

Fig. 9 Another exposure of basaltic volcaniclastic subaqueous debris flow, Tdf on the geological interpretation above. Hand lens for scale. 622487mE 7287711mN GDA94 55J

Fig. 10 Diatomaceous earth exposure in the road. Samples resting on the mirror. This lens is at or near the base of the Tertiary basaltic sequence, Tdi on geological interpretation. See Fig. 5 for location. 623927mE 7287711mN GDA94 55J

6. AGRICULTURAL ANALYSIS RESULTS OF TWO SAMPLES

Sample numbers Zone 55 J	Easting	Northing
188161 volcaniclastic debris flow	622,476mE	7,228,904mN
188162 palagonite in pillowed basalt	622,869mE	7,288,883mN
188163 volcaniclastic debris flow – similar to 188161	622,950mE	7,288,885mN

Samples 188161 and 188162 were submitted to the EAL Laboratory at Southern Cross University for analysis as agricultural soils. Results below:

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AGRICULTURAL SOIL ANALYSIS REPORT

3 samples supplied by M E I"ons & Associates Pty Ltd on 4/07/2022 . Lab Job No.N0233
Analysis requested by Martin Ions. Your Job: 188161/188162/188166

PO Box 481 TENTERFIELD NSW 2372

	Parameter		Method reference	Sample 1	Sample 2	*Heavy Soil*	*Medium Soil*	*Light Soil*	*Sandy Soil*
		Sample ID:		188 161	188 162				
		Crop:		Soil	Soil				
		Client:		MEIA	MEIA	*Clay*	*Clay Loam*	*Loam*	*Loamy Sand*
				N0233/1	N0233/2	Indicative guidelines - refer to Notes 6 and 8			
	Soluble Calcium (mg/kg)			1,756	2,566	*1150*	*750*	*375*	*175*
	Soluble Magnesium (mg/kg)		**Inhouse S10 - Morgan 1	1,297	1,362	*160*	*105*	*60*	*25*
	Soluble Potassium (mg/kg)			163	43	*113*	*75*	*60*	*50*
	Soluble Phosphorus (mg/kg)			121	17	*15*	*12*	*10*	*5.0*
	Phosphorus (mg/kg P)		**Rayment & Lyons 2011 - 9E2 (Bray 1)	9.3	3.9	*45 note 8*	*30 note 8*	*24 note 8*	*20 note 8*
			**Rayment & Lyons 2011 - 9B2 (Colwell)	28	13	*80*	*50*	*45*	*35*
			**Inhouse S3A (Bray 2)	149	182	*90 note 8*	*60 note 8*	*48 note 8*	*40 note 8*
	Nitrate Nitrogen (mg/kg N)			0.46	0.91	*15*	*13*	*10*	*10*
	Ammonium Nitrogen (mg/kg N)		**Inhouse S37 (KCl)	44	1.2	*20*	*18*	*15*	*12*
	Sulfur (mg/kg S)			27	21	*10.0*	*8.0*	*8.0*	*7.0*
	pH		Rayment & Lyons 2011 - 4A1 (1:5 Water)	7.16	8.75	*6.5*	*6.5*	*6.3*	*6.3*
	Electrical Conductivity (dS/m)		Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.027	0.085	*0.200*	*0.150*	*0.120*	*0.100*
	Estimated Organic Matter (% OM)		**Calculation: Total Carbon x 1.75	0.27	0.63	*> 5.5*	*>4 .5*	*> 3.5*	*> 2.5*
	Exchangeable Calcium	(cmol+/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	38	45	*15.6*	*10.8*	*5.0*	*1.9*
		(kg/ha)		16,982	20,108	*7000*	*4816*	*2240*	*840*
		(mg/kg)		7,581	8,977	*3125*	*2150*	*1000*	*375*
	Exchangeable Magnesium	(cmol+/kg)		37	32	*2.4*	*1.7*	*1.2*	*0.60*
		(kg/ha)		10,147	8,618	*650*	*448*	*325*	*168*
		(mg/kg)		4,530	3,847	*290*	*200*	*145*	*75*
	Exchangeable Potassium	(cmol+/kg)		0.51	0.73	*0.60*	*0.50*	*0.40*	*0.30*
		(kg/ha)		444	638	*526*	*426*	*336*	*224*
		(mg/kg)		198	285	*235*	*190*	*150*	*100*
	Exchangeable Sodium	(cmol+/kg)		0.37	1.2	*0.3*	*0.26*	*0.22*	*0.11*
		(kg/ha)		191	605	*155*	*134*	*113*	*57*
		(mg/kg)		85	270	*69*	*60*	*51*	*25*
	Exchangeable Aluminium	(cmol+/kg)	**Inhouse S37 (KCl)	0.01	<0.01	*0.6*	*0.5*	*0.4*	*0.2*
		(kg/ha)		2.3	1.3	*121*	*101*	*73*	*30*
		(mg/kg)		1.0	<1	*54*	*45*	*32*	*14*
	Exchangeable Hydrogen	(cmol+/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	<0.01	<0.01	*0.6*	*0.5*	*0.4*	*0.2*
		(kg/ha)		<1	<1	*13*	*11*	*8*	*3*
		(mg/kg)		<1	<1	*6*	*5*	*4*	*2*
	Effective Cation Exchange Capacity (ECEC) (cmol+/kg)		**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	76	78	*20.1*	*14.3*	*7.8*	*3.3*
	Calcium (%)		**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100	50	57	*77.6*	*75.7*	*65.6*	*57.4*
	Magnesium (%)			49	40	*11.9*	*11.9*	*15.7*	*18.1*
	Potassium (%)			0.67	0.93	*3.0*	*3.5*	*5.2*	*9.1*
	Sodium - ESP (%)			0.49	1.5	*1.5*	*1.8*	*2.9*	*3.3*
	Aluminium (%)			0.01	0.01	*6.0*	*7.1*	*10.5*	*12.1*
	Hydrogen (%)			0.00	0.00				
	Calcium/Magnesium Ratio		**Calculation: Calcium / Magnesium (cmol+/kg)	1.0	1.4	*6.5*	*6.4*	*4.2*	*3.2*

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	Sample ID:		188 161	188 162				
	Crop:		Soil	Soil				
	Client:		MEIA	MEIA	*Clay*	*Clay Loam*	*Loam*	*Loamy Sand*
	Parameter	Method reference	N0233/1	N0233/2	Indicative guidelines - refer to Notes 6 and 8			
	Zinc (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	1.8	<0.5	*6.0*	*5.0*	*4.0*	*3.0*
	Manganese (mg/kg)		2.6	1.5	*25*	*22*	*18*	*15*
	Iron (mg/kg)		15	7.5	*25*	*22*	*18*	*15*
	Copper (mg/kg)		0.99	0.57	*2.4*	*2.0*	*1.6*	*1.2*
	Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)	<0.1	0.10	*2.0*	*1.7*	*1.4*	*1.0*
	Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	196	112	*50*	*45*	*40*	*35*
	Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)	0.16	0.36	*> 3.1*	*> 2.6*	*> 2.0*	*> 1.4*
	Total Nitrogen (%)		0.08	0.07	*> 0.30*	*> 0.25*	*> 0.20*	*> 0.15*
	Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen	1.9	5.5	*10–12*	*10–12*	*10–12*	*10–12*
	Basic Texture	**Inhouse S65	Loam	Loam	..	..	..	..
	Basic Colour		Brownish	Brownish	..	..	..	..
	Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640	17	54	..	..	..	..
	Total Calcium (mg/kg)	Rayment & Lyons 2011 - 17C1 Aqua Regia	9,889	16,025	*1000–10 000 Ca*			
	Total Magnesium (mg/kg)		33,987	54,844	*500–5000 Mg*			
	Total Potassium (mg/kg)		1,357	2,235	*200–2000 K*			
	Total Sodium (mg/kg)		114	643	*100–500 Na*			
	Total Sulfur (mg/kg)		<50	<50	*100–1000 S*			
	Total Phosphorus (mg/kg)		1,255	1,105	*400–1500 P*			
	Total Zinc (mg/kg)		93	82	*20–50 Zn*			
	Total Manganese (mg/kg)		1,389	1,234	*200–2000 Mn*			
	Total Iron (mg/kg)		78,183	57,580	*1000–50 000 Fe*			
	Total Copper (mg/kg)		60	57	*20–50 Cu*			
	Total Boron (mg/kg)		2.1	2.7	*2–50 B*			
	Total Silicon (mg/kg)		446	600	*1000–3000 Si*			
	Total Aluminium (mg/kg)		36,406	36,538	*2000–50 000 Al*			
	Total Molybdenum (mg/kg)		<0.2	0.42	*0.5–3.0 Mo*			
	Total Cobalt (mg/kg)		63	69	*5–50 Co*			
	Total Selenium (mg/kg)		<0.5	<0.5	*0.1–2.0 Se*			
	Total Cadmium (mg/kg)		<0.5	<0.5	*<1 Cd*			
	Total Lead (mg/kg)		6.1	5.9	*2–200 Pb*			
	Total Arsenic (mg/kg)		<2	<2	*1–50 As*			
	Total Chromium (mg/kg)		148	200	*5–1000 Cr*			
	Total Nickel (mg/kg)		308	352	*5–500 Ni*			
	Total Mercury (mg/kg)		<0.1	<0.1	*< 0.2 Hg*			
	Total Silver (mg/kg)		<1	<1	*.. Ag*			

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		Sample 1	Sample 2	Sample 3	*Heavy Soil*	*Medium Soil*	*Light Soil*	*Sandy Soil*
	Sample ID:	188 161	188 162	188 166				
	Crop:	Soil	Soil	Soil				
	Client:	MEIA	MEIA	MEIA	*Clay*	*Clay Loam*	*Loam*	*Loamy Sand*
Parameter	Method reference	N0233/1	N0233/2	N0233/3	Indicative guidelines - refer to Notes 6 and 8			

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia*. CSIRO Publishing: Collingwood.
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
4. "Morgan 1 Extract" adapted from "Science in Agriculture", "Non-Toxic Farming" and LaMotte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils.
6. Indicative guidelines are based on "Albrecht" and "Reams" concepts.
7. Total Acid Extractable Nutrients indicate a store of nutrients.
8. National Environmental Protection (Assessment of Site Contamination) Measure 2013, Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater. Table 5-A Background Ranges.
9. Information relating to testing colour codes is available on sheet 2 - "Understanding your agricultural soil results".
10. Conversions for 1 cmoL/kg = 230 mg/kg Sodium, 390 mg/kg Potassium, 122 mg/kg Magnesium, 200 mg/kg Calcium
11. Conversions to kg/ha = mg/kg x 2.24
12. The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimate
13. ** NATA accreditation does not cover the performance of this service.
14. Analysis conducted between sample arrival date and reporting date.
15. This report is not to be reproduced except in full. Results only relate to the item tested.
16. All services undertaken by EAL are covered by the EAL Laboratory Services Terms and Conditions (refer SCU.edu.au/eal/t&cs).
17. This report was issued on 15/07/2022.

NATA
WORLD RECOGNISED ACCREDITATION
Accreditation No. 14960
Accredited for compliance with ISO/IEC 17025 - Testing

Quality Checked: Kris Saville
Agricultural Co-Ordinator KS

The analyses of these poorly lithified volcaniclastics indicate that they have high levels of total magnesium relative to calcium and more than adequate phosphorous. Although the totals for zinc, copper and boron are more than adequate their availability (DTPA and hot CaCL2 extraction) is restricted by the high pH, particularly in sample 188162. Carbon and nitrogen are low in this material. Cation exchange capacities are unusually high, indicating a high non-swelling smectite clay component. The low total calcium content at 1.6% for sample 188162 (confirmed by hand-held XRF analysis) combined with high magnesium at 5.5% renders this material not very suitable for agricultural use, except where magnesium is deficient.

More research and sampling is required to investigate the potential of this rather unique volcaniclastic material. Due to the steep nature of the terrane, it has not been possible to get representative samples of the non-welded ignimbrite (Tbi on the geological interpretation map) so far. Another field visit will be required to obtain some of this material, made easier now that the full extent of the formation has been determined from the RTP magnetic image. This has identified outliers with easier access.

7. CONCLUSIONS

The dissected terrain on EPM 27970 with a vertical relief of 250m makes access difficult and another field visit to the area is required to sample the upper part of the Tertiary basaltic sequence to determine if it is suitable for use in removing CO2 from the atmosphere through the advanced weathering process. The high levels of magnesium relative to calcium in the volcaniclastic debris flows in the lower part of the sequence may have other applications apart from agriculture, such as improving ocean alkalinity and fertilising seagrass submarine pastures (see MacDonnell et al below). These need to be investigated.

The discovery of diatomaceous earth requires further investigation to determine extent and purity. If the purity is high enough (>90% SiO2) it can be dried and milled for use as a physical insecticide against small insect pests such as weevils in grain. This application is used extensively by organic growers.

8. REFERENCES

McPhie J Doyle M and Allen R Volcanic Textures. A guide to the interpretation of textures in volcanic rocks. Centre for Ore Deposit and Exploration Studies, University of Tasmania, 1993.

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