

Current and potential lime sources in South Australia

Andrew Harding

Brian Hughes

Senior Consultants

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Primary Industries
and Regions SA

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Prepared by:

Andrew Harding and Brian Hughes

Senior Consultants: Sustainable Agriculture

Office (08) 8842 6231

Mobile: 0417 886 835

E-mail: andrew.harding@sa.gov.au

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All enquiries

To Dr Kathleen Giles
Primary Industries and Regions SA (PIRSA)
Level 15, 25 Grenfell Street
GPO Box 1671, Adelaide SA 5001
M 0407 798 937
E: Kathleen.giles@sa.gov.au

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Executive Summary

This report is part of a project 'Raising the soil [pH] bar 2018' funded by the Department for Environment and Water (formerly Department of Environment, Water and Natural Resources) to to up-date and document the quality and availability of current and potential lime sources in South Australia.

Lime is used to treat acid soils and is available in a number of forms including lime sand, limestone, dolomite and magnesite. There are currently 17 suppliers registered with the Resources and Energy Group of the Department of Premier and Cabinet that can sell lime as an agricultural source.

There are other suppliers throughout SA that have a mineral lease and are selling lime as a fine sand and could register and sell their by-product as an agricultural product and also there are some landowners that do not have a mineral lease but who have identified new and potential lime sources.

Of the registered lime sources 68% had a NV \geq 90% and 60% had an ENV greater than 65%. Selecting lime with a higher proportion of fine particles or a higher ENV is important if a quick improvement in soil pH is required. Some of the lime sources are more dispersive than others. The Agricola products (from old lake beds) have nearly twice the ENV with wet sieving compared to dry sieving.

Other tests that can be carried out on lime samples to determine effectiveness, include solubility (Aragonite) and specific surface area. More work needs to be carried out with these tests.

All of the regions have good sources of lime. The region with limited sources of lime is the N&Y region. Investigations need to be carried out to find other lime sources.

Many of the current lime sources have a high life span of lime however, due to crushing and screening the annual supply can be limited. Many of the quarries will only screen a small amount of lime at a time or screen on demand as they do not want stockpiles of lime on site that can create dust issues.

Information from this report will be used by Rural Solutions SA consultants as a reference guide and to be used in the lime comparative decision support tool.

1. Introduction

Throughout South Australia more than 2.1 million hectares of agricultural land are susceptible to the risk of soil acidification (Soil and Land program, 2007) that can reduce crop and pasture growth.

The application of lime is the most economic and cost-effective method to treat acid soils. It has been estimated that approximately 131,000 tonnes of lime is required per year in SA to off-set the annual acidification rate for those soils with a pH (CaCl_2) less than 5.5 (Appendix 1). This does not include the amount of lime to raise the soil pH for those soils that are already regarded as acidic.

This report is part of a project 'Raising the soil [pH] bar 2018' funded by the Department for Environment and Water (formerly Department of Environment, Water and Natural Resources) to up-date and document the quality and availability of current and potential lime sources in South Australia.

Some of the major lime suppliers throughout the State were visited or contacted to identify the availability of liming materials. With permission of the lime supplier a representative lime sample was collected from the stockpile(s) and then analysed through APAL Agricultural Laboratory, Magill SA. The lime samples were tested for their neutralizing value (NV) and particle size.

Information from this report will be used by Rural Solutions SA consultants as a reference guide and to be used in the lime comparative decision support tool.

2. Regulations

Under the *SA Mining Act (1971)* it is a requirement that a holder must have an Extractive Mineral Lease (EML) or Mineral Lease (ML) to mine or sell extractive minerals such as sand, gravel, stone, shell, shale or clay.

In limestone quarries there is often a fine material that is stock-piled as a by-product. For this source to be sold as an agricultural lime product it needs to be included within the lease and registered with the Resources and Energy Group of the Department of Premier and Cabinet. The lease holder will need to maintain accurate sale records.

Lease holders will also need to comply with the conditions set out in the *Agricultural and Veterinary Products (Control of use) Act 2002* and the *Agricultural and Veterinary Products (Control of use) Regulations 2004*. The lime must be analysed and a label or advice note must state whether the lime is grade 1, 2 or 3 based on the neutralising value. The label or advice note must be available to the buyer or agent.

Table 1 shows all the suppliers throughout SA that have a Mineral Lease and are registered with the Resources and Energy Group of the Department of Premier and Cabinet to sell their product as an agricultural lime source.

Table 2 shows the suppliers throughout SA that have a Mineral Lease and are in the process of registering, or could register and sell their by-product as an agricultural product. Table 2 also outlines landowners that do not have a Mineral Lease but who have identified new and potential lime sources

Figure 1 shows the geographical distribution of the main lime deposits throughout SA.

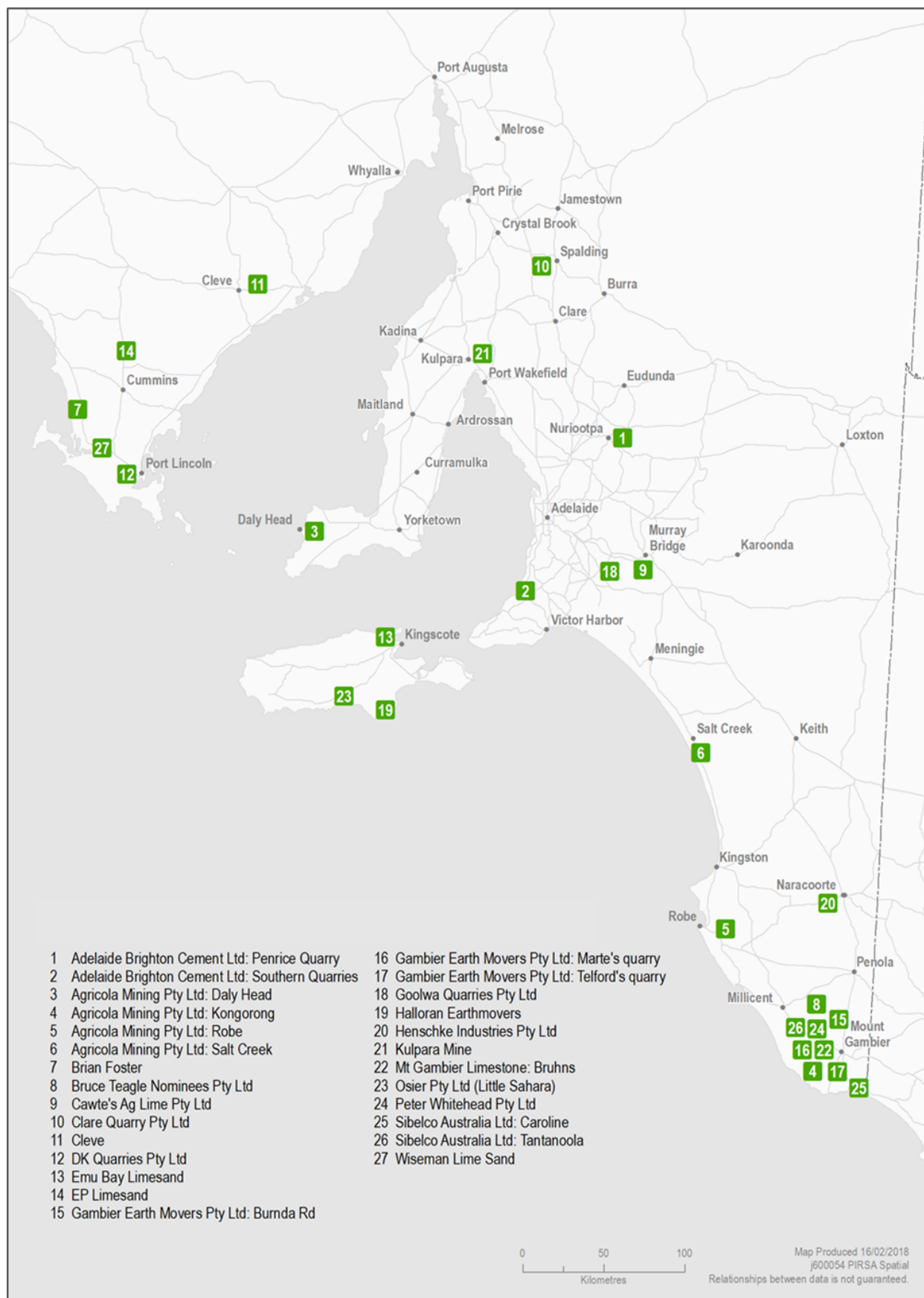


Figure 1: Geographical distribution of main lime deposits throughout SA

3. Lime quality

There are various sources of lime. Pure lime is 100% calcium carbonate. Limestone contains mostly calcium carbonate but can also contain a small amount of magnesium carbonate. Dolomite contains both calcium and magnesium carbonate and is generally defined as having a minimum magnesium carbonate content of 28% and a minimum calcium carbonate content of 35% (Victorian Limestone Producers Association). Magnesite is mostly magnesium carbonate. Lime sand is fine lime that contains a high calcium carbonate content and that does not require crushing as opposed to limestone. Other sources of lime include burnt lime (calcium oxide) and hydrated lime (calcium hydroxide).

The quality of lime depends on the neutralizing value (NV) and particle size. Table 1 & 2 and Figure 2 & 3 show the NV and particle size for different lime products.

Neutralising value (NV)

The NV is the measure of the purity of the product. It is how much carbonate the lime contains to neutralize the acid in the soil. It does not matter if the carbonate comes from lime sand, limestone, dolomite or magnesite. It is expressed as a percentage of pure calcium carbonate which is given as a value of 100%. The higher the NV the greater capacity the lime has to neutralize the acidic conditions and raise the soil pH. Ideally the NV should be greater than 80%. Burnt lime or hydrated lime can have a NV greater than 100%

Particle size

The particle size determines how effective the lime can neutralize the soil. Lime with a higher proportion of fine particles has a larger surface area and therefore more coverage and exposure to soil particles and will react quicker in the soil compared to coarser particles. Although, the finer the lime the more difficult it is to spread. A mixture of fine and coarse particles will overcome spreading difficulties but the coarse particles will react more slowly. Ideally greater than 60% of the particle sizes should be less than 300 micron. Cregan *et.al* (1989) notes that for high NV lime applied at rates greater than 2.5 t/ha the relative efficiency of the coarse particles increase because of the greater total density of particles.

Effective neutralizing value (ENV)

The effective neutralizing value (ENV) is the NV taking into account particle size. APAL base the ENV on the Victorian particle size method where the particle sizes are discounted to take account for the reduced capacity to change the soil pH in the short term. The NV of particle sizes under 300 microns are not discounted. The NV of the 300-850 microns are discounted by 40% and the particle sizes greater than 850 microns are discounted by 90%. The ENV is only a guide for the NV within the short term. Ideally the ENV should be greater than 65%.

The particle size is based on dry sieving however, the fine fractions of lime can generate electrostatic charges causing the fine particles to clump together and therefore unable to pass through sieves (Miller, 2017). Wet sieving is thought to reduce the electrostatic forces and also wash finer particles off larger particles. Work by Miller (2017) with lime sources from south eastern Australia showed that the ENV improved with wet sieving for a number of lime sources particularly the soft limes. There has been limited amount of work done with wet sieving vs dry sieving for SA limes however, the Agricola products (from old lake beds) do perform better with wet sieving compared to dry sieving. Wet sieving of Agricola products provides an ENV of twice that of dry sieving.

Miller notes (2017) that wet sieving is generally regarded as a more accurate measurement of the fine and more valuable fraction but it is more labour intensive to measure and therefore more expensive. Commercial laboratories that will measure particle size with wet sieving are difficult to find and there does not seem to be a standard methodology available.

		Table 1: Analysis of current registered lime sources (guide only)										Analyses are based on an air dry basis					
NRM Region	Source	Product	Year	Lab	CaCO3 (%)	MgCO3 (%)	% CaCO3 equiv	NV (%)	Ca (%)	Mg (%)	Particle size			ENV (%)	Direct cost \$/t	Comments	Years supply
											>850u	300-850u	<300u				
AMLR	AB Cement Ltd: Penrice: Penlime Plus™	Limestone	2017	APAL	96.00	1.71	2.03	98	38.5	0.5	0.6	9.4	89.2	93		High NV and high ENV	
AMLR	AB Cement Ltd: Penrice Original Penlime™	Limestone	2015	APAL	91.44	1.61	1.91	93	36.6	0.5	43.5	23.1	33.1	48		High NV and low ENV	
AMLR	AB Cement Ltd: Southern Quarries Pty Ltd	Limestone	2018	APAL	59.70	25.5	30.3	90	23.9	7.4	0.0	0.5	99.5	90		High NV and high ENV	
AMLR	Goolwa Quarries Pty Ltd	Limestone	2014	APAL	55.86	20.88	24.79	81	22.3	6.0	52.3	23.6	23.6	35		Mod NV and low ENV	
EP	Brian Foster (EP Super Spreaders)	Limesand	2014	APAL	91.85	4.43	5.26	97	36.8	1.3	0.6	49.8	49.2	77		High NV and high ENV	
EP	EP Limesands	Limesand	2016	APAL	79.98	2.42	2.87	83	32.0	0.7	0.0	39	61	70		Mod NV and high ENV	75
EP	Wiseman Limesand	Limesand	2014	APAL	85.68	3.70	4.39	90	34.3	1.1	0.2	49.4	50.3	72		High NV and high ENV	
KI	Emu Bay Limesand (Hardy's)	Limesand	2015	APAL	41.49	2.02	2.39	44	16.6	0.6	9.3	13.7	76.9	38		Low NV and low ENV	
KI	Halloran Earthmovers	Limesand	2014	APAL	68.20	2.12	2.52	71	27.3	0.6	2.3	48.8	48.5	55		Mod NV and mod ENV	
KI	Osier Pty Ltd: Little Sahara	Limesand	2014	APAL	72.80	3.93	4.66	77	29.2	1.1	0.0	28.2	71.6	69		Mod NV and high ENV	
N & Y	Agricola Mining Pty Ltd: Daly Head YP	Dolomite	2014	APAL	49.10	42.11	49.99	99	19.7	12.1	31.3	45.2	22.7	52		\$54 ex Curramulka (1)	
N & Y	Clare Quarry Pty Ltd	Limestone	2015	APAL	34.33	12.39	14.71	49	13.7	3.6	18.0	12.4	69.3	39		Low NV and high ENV	200
SA MDB	Cawte's Ag-Lime Pty Ltd	Limestone	2015	APAL	58.65	11.85	14.07	73	23.5	3.4	12.3	33.7	54.2	55		Mod NV and mod ENV	
SE	Agricola Mining Pty Ltd: Kongorong	Lime	2006	APAL	93.00	5.00	5.93	100	37.0	1.0				80		High NV and high ENV	
SE	Agricola Mining Pty Ltd: Robe	Lime	2014	APAL	62.48	16.54	19.64	82	25.0	4.8	51.2	24.9	24.2	36		Mod NV and low ENV (1)	
SE	Agricola Mining Pty Ltd: Salt Creek	Magnesite	2014	APAL	22.20	52.9	62.80	85	8.9	15.3	70.0	13.2	16.9	27		High Mg (1)	
SE	Bruce Teagle Nominees Pty Ltd	Limestone	2014	APAL	90.75	4.87	5.78	97	36.3	1.4	6.3	27.0	66.5	80		High NV and high ENV	
SE	Gambier Earth Movers Pty Ltd (Burnda Rd)	Dolomite	2014	APAL	58.42	38.67	45.91	104	23.4	11.2	15.5	24.8	59.2	79		High NV and high ENV	
SE	Gambier Earth Movers Pty Ltd (Marte's Q)	Limestone	2014	APAL	95.17	1.67	1.98	97	38.1	0.5	40.4	34.1	24.8	48		High NV and low ENV	
SE	Gambier Earth Movers Pty Ltd (Telford's Q)	Limestone	2014	APAL	95.58	2.05	2.44	98	38.3	0.6	11.9	24.8	62.6	77		High NV and high ENV	
SE	Henschke Industries Pty Ltd	Limestone	2014	APAL	95.55	0.89	1.06	97	38.3	0.3	15.7	32.4	51.9	70		High NV and ENV value	
SE	Mount Gambier Limestone (Bruhn)	Limestone	2017	APAL	98.90	1.26	1.43	97	38.4	0.4	21.3	39.2	38.6	63		High NV, mod ENV	

Figure 2: Registered lime sources and quality

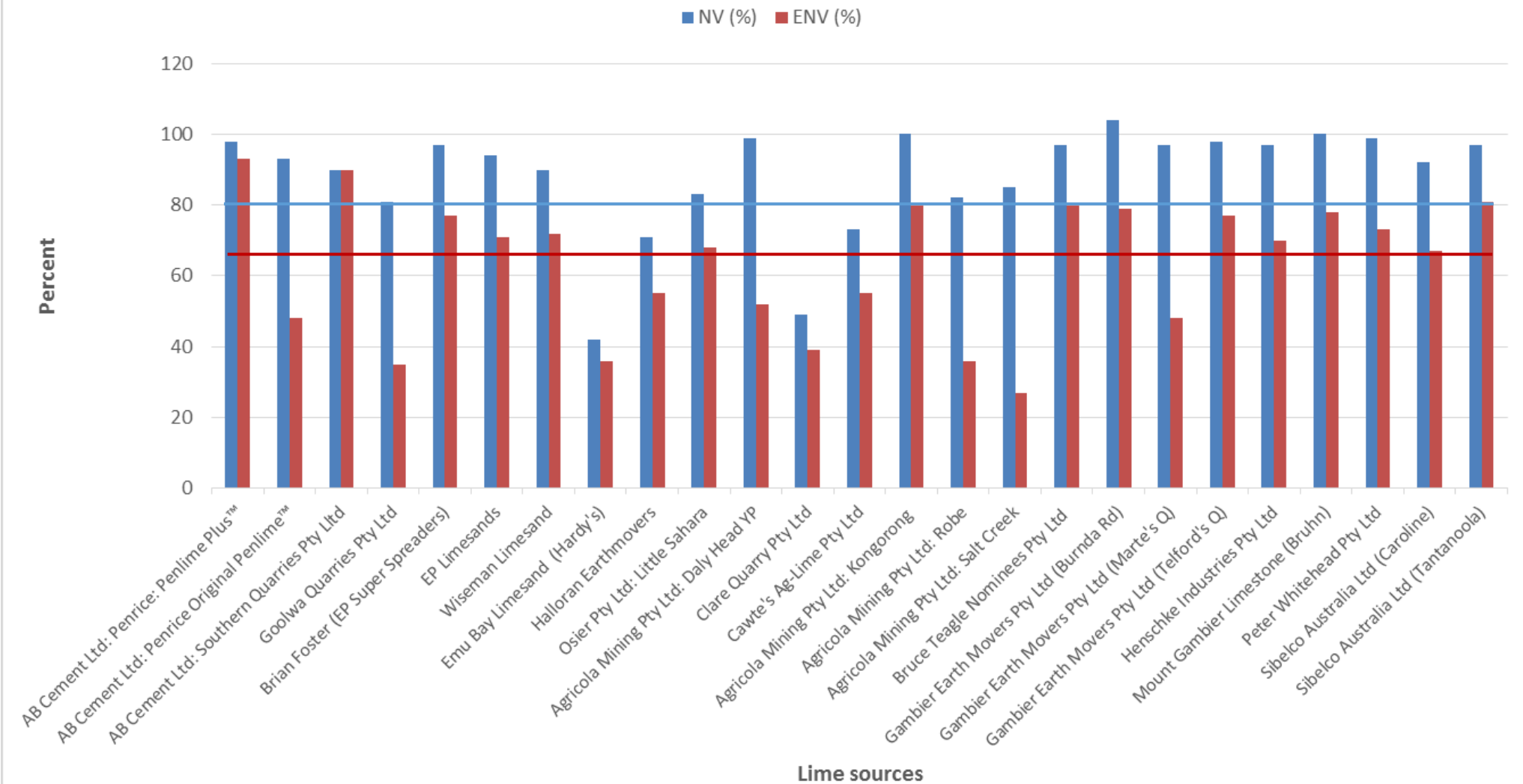
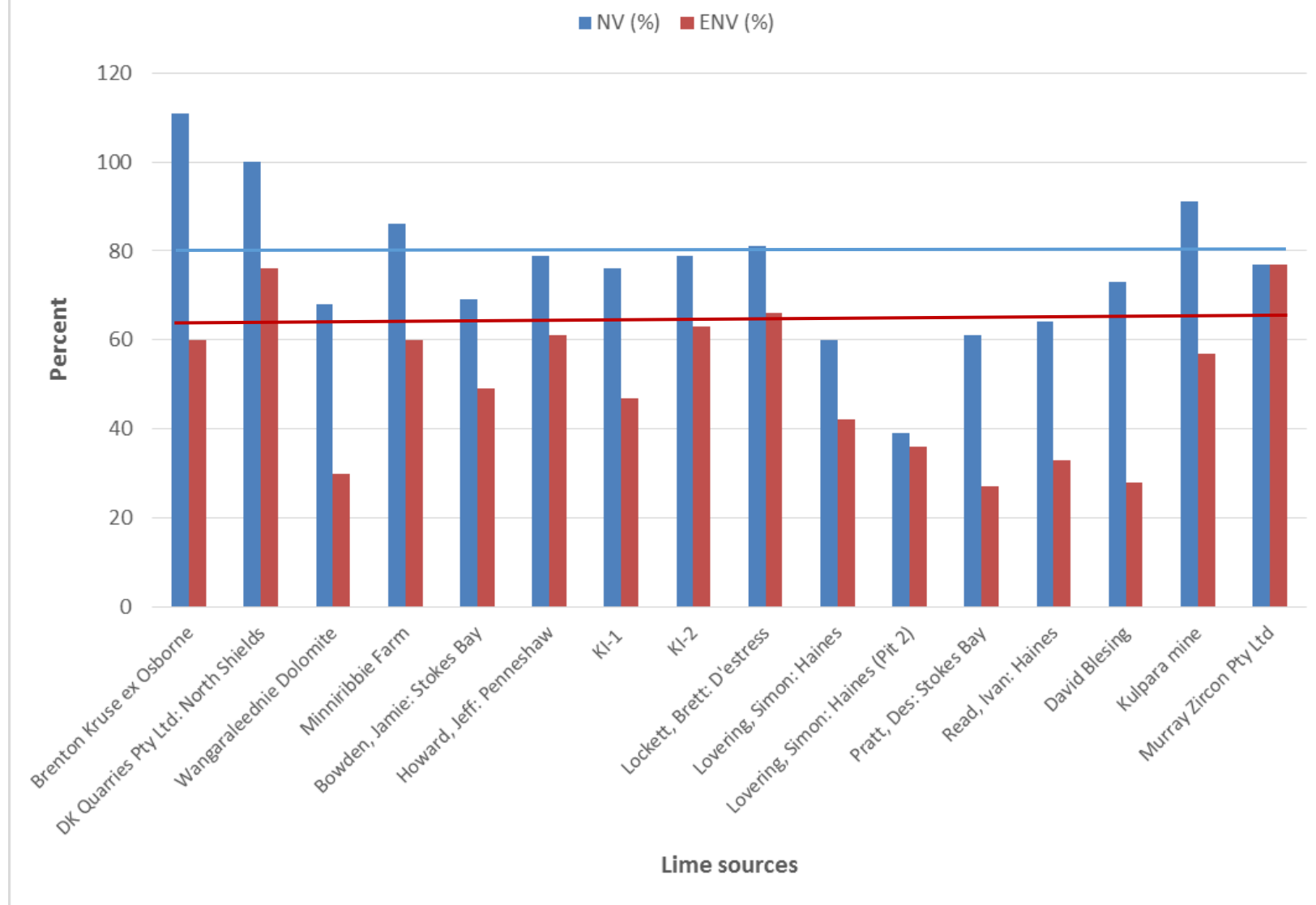


Table 2: Analysis of new and potential lime sources (guide only)									Analyses are based on an air dry basis								
NRM Region	Source	Product	Year	Lab	CaCO3 (%)	MgCO3 (%)	% CaCO3 equiv	NV (%)	Ca (%)	Mg (%)	Particle size			ENV (%)	Direct Cost \$/t	Comments	Years supply
AMLR	Brenton Kruse ex Os	Hydrated	2016	APAL	108.39	1.86	2.21	111	43.4	0.5	44.0	14.7	41.4	60		High NV and 1-2	
EP	DK Quarries Pty Ltd:	Limesand	2009	APAL	96.42	3.08	3.66	100	38.6	0.9	7.4	42.7	49.9	76		Sold as sand, High NV and ENV	
EP	Wangaraleednie Dol	Limestone	2014	APAL	35.91	26.89	31.93	68	14.4	7.8	49.3	26.7	23.8	30		Low NV and Low ENV	
EP	Minniribbie Farm	Limesand	2014	APAL	82.14	3.54	4.20	86	32.9	1.0	12.1	48.7	39.1	60		Mod NV and Mod ENV	
KI	KI-1 (Willson)	Limesand	2014	APAL	73.28	2.16	2.57	76	29.3	0.6	18.1	53.9	28.0	47		New deposit: Mod NV and low ENV	
KI	Lockett, Brett: D'estre	Limesand	2014	APAL	76.96	3.01	3.57	81	30.8	0.9	4.9	34.8	60.1	66		New deposit: Mod NV and Mod ENV	
KI	Lovering	Limesand	2014	APAL	57.73	1.97	2.33	60	23.1	0.6	23.3	24.6	52.2	42		New deposit: Low NV and Low ENV	
KI	Pratt, Des: Stokes Ba	Limesand	2014	APAL	55.56	4.31	5.12	61	22.2	1.2	52.0	23.6	24.4	27		New deposit: Low NV and Low ENV	
N&Y	David Blesing	Limestone	2018	APAL	55.00	15.20	18.10	73	22.0	4.4	62.0	15.0	22.9	28		New deposit: Mod NV and low ENV	
N & Y	Kulpara mine	Dolomite	2017	APAL	45.57	38.35	45.53	91	18.3	11.1	32.5	18.9	48.4	57		Sold as sand: High NV and mod ENV	
SAMDB	Murray Zircon Pty Lt	Dolomite	2014	APAL	43.37	28.14	33.41	77	17.4	8.1	0.0	0.0	100.0	77		New deposit, Mod NV and High ENV	

Figure 3: New and potential lime sources and quality



For farmers who want to raise their soil pH quickly then it would be best to use a lime source with a high ENV. To maintain the soil pH then a lime with a lower ENV would be adequate.

Calcium and magnesium content

Calcium and magnesium content of liming materials can be important in the selection of liming products. Dolomites have a higher magnesium content while limestones and lime sands have higher levels of calcium. Some horticultural plants can be sensitive to very high or very low levels of calcium and magnesium. Prolonged use of one type of product can lead to an abundance of one nutrient and inducing deficiencies of others. In areas where livestock suffer from grass tetany (low magnesium) then applying dolomite as a liming material may increase soil magnesium levels.

Solubility

Lime is regarded as being insoluble although the degree does vary amongst the types of lime sources. Work by Conyers *et al.* (1995) as cited in Miller (2017) found that soft limes created a 20% more pH change compared to that of hard limes for the same particle size over six to twelve months and it was thought that this was due to solubility. The dolomites due to their magnesium carbonate content are more insoluble and created approximately 15% less change for their particle sizes. The initial effects occurred in the first twelve months after application but then after this time the pH change was the same. There is no current laboratory tests for lime solubility.

It is thought that lime samples with a higher level of Aragonite might be more soluble than calcium carbonate. Aragonite is a naturally occurring crystal form of calcium carbonate that is formed by biological and physical processes, including precipitation from marine and freshwater environments.

Three samples: Angaston Penlime®, Agricola (Robe) and Kangaroo Island lime sand were submitted to the CSIRO for a quantitative X-ray diffraction analysis. The results (Table 3 & 4 and Figures 4 to 6) show that lime sources contained calcite (calcium carbonate) and / or magnesium substituted calcite as their mineral component. Dolomite or calcium substituted dolomite were present in trace amounts in the Angaston Penlime® and a minor component in the Agricola Robe sample (Raven and Gomez-Camacho 2018).

Aragonite was found as a trace component in the Agricola sample and a minor component of the Kangaroo Island lime sand (Raven and Gomez-Camacho 2018) and this may indicate that these samples are slightly more soluble than the Angaston Penlime®. The X-ray diffraction analysis also showed that the lime samples had various traces of amphibole, chlorite, smectite, feldspar, mica and halite (Table 4 to 6).

Table 3: Mineral analysis of lime sources (Raven and Gomez-Camacho 2018).

Sample	Quartz (%)	Calcite (%)	Mg-Calcite (%)	Dolomite (%)	Ca-Dolomite (%)
Angaston Penlime®	6	90			
Agricola (Robe)	5	8	64		12
KI Lime sand	19	16	46		

Table 4: Mineral analysis of lime sources (Raven and Gomez-Camacho 2018).

Sample	Aragonite (%)	Amphibole (%)	Chlorite (%)	Smectite (%)	Feldspar (%)	Mica (%)	Halite (%)
Angaston Penlime ®		<1	<1		2	<1	
Agricola (Robe)	4			5			1
KI Lime sand	17				2		

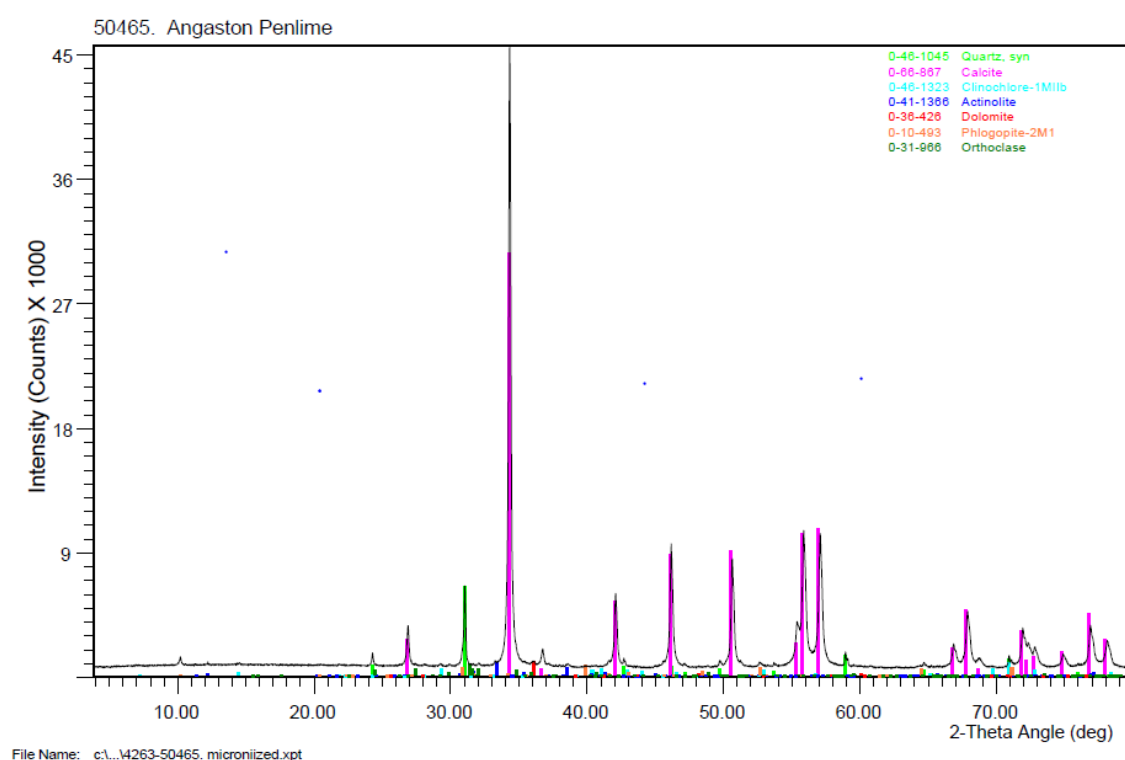


Figure 4: XRD pattern of Angaston Penlime® sample (Co K α radiation) (Raven and Gomez-Camacho 2018)

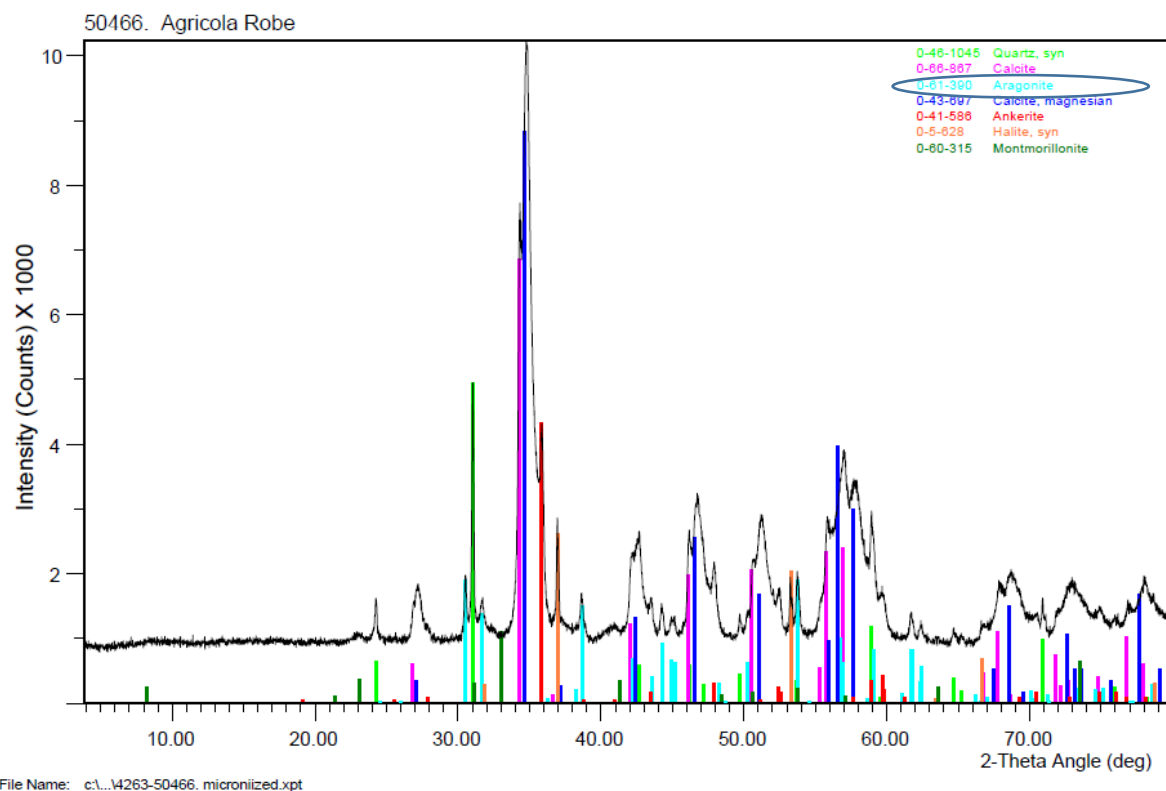


Figure 5: XRD pattern of Agricola (Robe) sample (Co K α radiation) (Raven and Gomez-Camacho 2018)

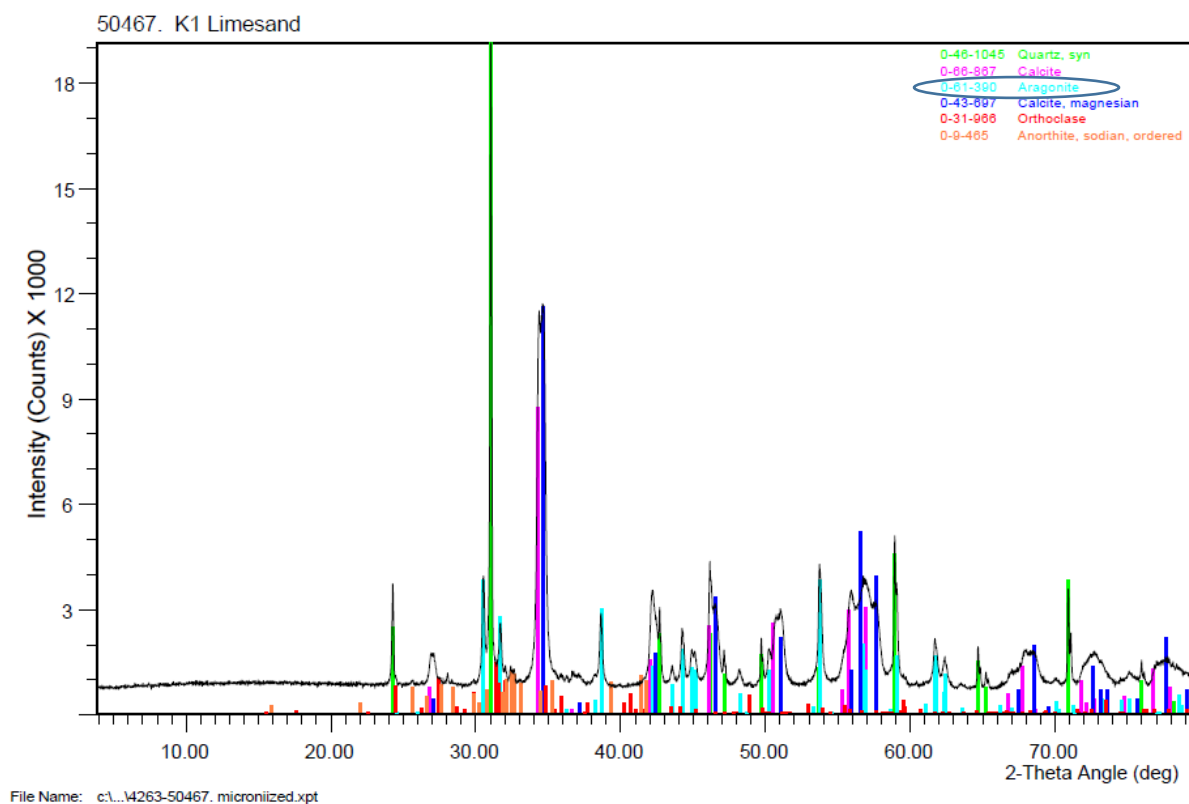


Figure 6: XRD pattern of Kangaroo Island lime sand (Co K α radiation) (Raven and Gomez-Camacho 2018)

It would be interesting to have a look at the Aragonite levels with soft limes (marine deposits). The X-ray diffraction test is available through the CSIRO but is reasonably expensive.

Other tests

Some other tests sometimes used in lime analysis include the Resin Suspension Neutralisation (RSN) test and porosity. The RSN method assesses the ability of a lime sample to alter the pH of a weak acid solution. This test, however, is not currently available through commercial soil testing laboratories.

Porosity assesses the effectiveness of liming material. Using a scanning electron microscope CSIRO researchers have found that some lime products such as those formed from coral have a 'honey comb' particle structure that greatly increases the surface area and its effectiveness. Mount Gambier limestone is one such liming material.

Merry R. (unpublished data) has investigated specific surface areas (SSA) for different lime products. Table 5 shows some of the selected products.

Table 5: Lime surface area (Merry unpublished)

Source	Product	SSA (m ² /g)	Source	Product	SSA (m ² /g)
Tantanoola	Dolomite	0.9	Lockett KI	Lime sand	1.40
Whitehead		1.10	GEM		1.45
Coffin Bay	Lime sand	1.10	Little Sahara	Lime sand	1.90
GEM Telfords	Limestone	1.10	Southern Quarries	Limestone	4.0
GEM 'E'		1.20	Henschke	Limestone	4.1
P. Whitehead	Dolomite	1.20	Lake Leak		7.5
Howard KI	Lime sand?	1.30	Murray Bridge		15.5
Rapid Bay	Lime sand?	1.33	Murray Bridge		18.8

Southern Quarries, Henschke, Lake Leak and Murray Bridge lime sources have a much greater surface area indicating that these are much finer sources than the others.

4. Lime supplies

Many of the major quarries such as Clare quarry and Penrice have a high life span of lime however, due to crushing and screening process the annual supply can be limited. For example, the Clare Quarry has a life span of over 200 years. The dust collected from the crushing process is a by-product and sold as lime and therefore they can only sell a certain amount of lime per year. They are hoping to install a third dust collector in 2018 which will slightly increase the amount of lime available. Some of the quarries will only screen a small amount of lime at a time or screen on demand as they do not want stockpiles of lime on site that can create dust issues.

The Agricola mine at Robe has been operating for 23 years and they have estimated that they have sold 100,000 tonnes over that time. They have estimated that they have 20 years left at the current mining site but have a high supply at different sites. They only scrape a certain amount of lime per year.

The current mining area at EP lime sand has a life span of 75 years but the mining area can be expanded to the edge of the lease.

Brenton Kruse has purchased some of the remaining hydrated lime from the Penrice soda-ash manufacturing plant at Osborne and supplying this to farmers. It is estimated that this will only last for another one or two years.

5. Summary

Agricultural lime is currently available in a number of forms including lime sand, limestone, dolomite and magnesite.

There are currently 17 suppliers registered with the Resources and Energy Group of Department of Premier and Cabinet that can sell lime as an agricultural source.

There are other suppliers throughout SA that have a mineral lease and are selling lime as a fine sand and could register and sell their by-product as an agricultural product and also there are some landowners that do not have a mineral lease but who have identified new and potential lime sources.

All of the regions have good sources of lime. The region with the limited sources of lime is the N&Y region. Investigations need to be carried out to find other lime sources.

Of the registered lime sources more than 68% of the lime sources had a NV \geq 90% and 60% had an ENV greater than 65%. Selecting lime with a higher proportion of fine particles or a higher ENV is important if a quick improvement in soil pH is required. Some of the lime sources are more dispersive than others. The Agricola products (from old lake beds) have nearly twice the ENV with wet sieving compared to dry sieving.

Calcium and magnesium content of liming materials is important in the selection of liming products. Dolomites have a higher magnesium content while limestones and lime sands have higher levels of calcium. Some horticultural plants can be sensitive to very high or very low levels of calcium and magnesium. Prolonged use of one type of product can lead to an abundance of one nutrient and inducing deficiencies of others.

Other tests that can be carried out on lime samples to determine effectiveness could include solubility (Aragonite) and specific surface area. More work needs to be carried out with these tests.

Many of the current lime sources have a high life span of lime however, due to crushing and screening the annual supply can be limited. Many of the quarries will only screen a small amount of lime at a time or screen on demand as they do not want stockpiles of lime on site that can create dust issues.

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8. Appendix I

