AUSTRALIAN
RESEARCH
INDEPENDENT INVESTMENT RESEARCH

QEM Limited

ASX:QEM

November 2018

INDEPENDENT
INVESTMENT RESEARCH

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INDEPENDENT INVESTMENT RESEARCH

QEM Limited

Initiation - November 2018

Note: This report is based on information provided by the Company as of October 31, 2018.

Investment Profile	
Share Price - October 31, 2018	A$0.195
Issued Capital:	
Ordinary Shares (includes 65.7 million escrowed for various periods of up to 24 months)	100.0 m
Options	0.0 m
Fully Diluted	100.0 m
Market Capitalisation	A$19.5 m
Cash - October 23, 2018	A$4.45 m

Board and Management
Mr John Foley: Chairman
Mr David Fitch: Executive Director
Mr Daniel Harris: Non-Executive Director
Mr Scott Drelincourt: GM Geology and Development
Mr David Palumbo: Company Secretary

Top Holders	
David Fitch	23.49%
Tracey Loyden	20.59%
Directors	24.37%
Top 20	75.65%

Mark Gordon - Senior Analyst

RIDING THE VANADIUM WAVE

QEM Limited ("QEM" or "the Company"), was admitted to the official list of the Australian Securities Exchange on October 19, 2018 under the code QEM, with its sole project being the 100% owned Julia Creek Project ("Julia Creek" or "the Project") located near the town of Julia Creek in North Queensland. Julia Creek is located over the Toolebuc Formation, which is the host to widespread vanadium mineralisation, and is also considered an "oil shale", hosting significant petroleum resources.

The Company has a Mineral Resource Estimate ("MRE") of 1,700 Mt @ 0.34% V_2O_5 (5.78Mt contained V_2O_5) , with 3C Contingent Oil Resources of 589MMbbl, based on 90% extraction of Petroleum Initially In Place ("PIIP") of 654MMbbl, with a yield of 64.1 litres/tonne.

Resources are shallow, flat lying and potentially open pittable, with the Toolebuc Formation long being recognised for the vanadium and petroleum potential, with significant historic work being done for both commodities. The current vanadium price rises (possibly reflecting a structural change in the market, leading to stronger prices for the longer term) has awakened interest in the area, with at least four companies, including QEM, now having significant interests.

On the petroleum front (however with petroleum being of secondary interest behind the vanadium), shallow areas of the Toolebuc Formation could in the longer term (and in any times of significant conflict) be a strategic asset given Australia's reliance on crude oil and refined product imports, and a lack of reserve stocks. The Toolebuc Formation hosts a discovered petroleum resource of ~22Bbbl, however any development has been hampered by the need for treatment through retorting with high costs requiring long term +US$80/bbl oil prices to be economically viable.

Also on the petroleum treatment side, QEM has signed a Memorandum of Understanding ("MoU") with Petroteq Energy Inc ("Petroteq", PQE.TSX-V) with regards to a proprietary, environmentally friendly closed loop solvent extraction process for which commercial production has recently been initiated treating US oil sands. Under the terms of the agreement, Petroteq will carry out test work on samples of the Toolebuc Formation to assess the suitability of the process for Julia Creek. Should this be successful it could be a game changer, in allowing for the low cost treatment of the oil shales through modular equipment.

KEY POINTS

Strong vanadium markets: Due to structural changes in the markets and growing demand leading to supply deficits, recent months have seen very strong price rises for vanadium, with this recently reaching a spot price of over US$30/lb V_2O_5, after reaching a low of under US$5/lb V_2O_5 in 2016; this has led to a strong resurgence in the markets, with the expectation that prices will "stay stronger for longer".

Large, shallow resource: The Julia Creek Resource is large, and should work lead to a potentially viable operation, should be able to support such an operation for a considerable timeframe; in addition the resource is shallow with the potential for open cut mining.

Well recognised, stable jurisdiction: Queensland has a long history of mining, and ranked 12th globally and 2nd in Australia (behind only Western Australia) in the 2017 Fraser Institute Survey of Mining Companies.

Access to infrastructure and skills: The Project, being located on the Flinders Highway and Townsville-Mount Isa railway line is well located with respect to infrastructure, including port facilities in Townsville; there is also an experienced mining/exploration skills and services base in Mount Isa, just 270km from the Project.

Experienced personnel: Company personnel have extensive experience in the junior resources industry, including in vanadium.

Active work programme with steady news flow: There will be an active work programme initially leading towards the completion of a Pre-feasibility Study ("PFS"), which will result in a steady news flow.

SWOT ANALYSIS

Strengths

- **Experienced Personnel:** Personnel have extensive experience in resources, including in vanadium operations.
- **Large, shallow resource:** This will help the economics of any future operation, in allowing for relatively low cost open cut mining and a long mine life.
- **Dual commodity:** The potential to produce both vanadium and petroleum should enhance project economics, and provides an in built hedge against adverse price changes in any one of the commodities.
- **Access to transport infrastructure:** This again will be positive for the economics of any future project.
- **Forecast strong vanadium outlook:** Most commentators are seeing a strong outlook for vanadium for the foreseeable future.

Weaknesses

- **Low to moderate grade:** The vanadium grade when compared to other projects will necessitate a relatively low cost operation to be financially viable.
- **Difficult metallurgy:** Our view is that this is the key weakness in the Project, with work to date on Julia Creek (as well as other projects in the region) highlighting difficult and potentially high cost metallurgy.
- **Expensive petroleum processing:** As it currently stands the only technically viable way to extract the petroleum from the Toolebuc Formation is through the traditional energy intensive retorting route, with mining-retorting-transport operations being very capital intensive, requiring a long term incentive price of at least US$80/bbl oil and would require a very large scale operation, with the resultant operational and environmental challenges. On the other hand the Petroteq solvent extraction process, if successful, could be a game changer, allowing for a low capex, modular processing route.

Opportunities

- **Metallurgy:** A key breakthrough will be the development of a metallurgical process that will cost effectively extract the vanadium, and ideally other oil and metals in the coquina and shale - success with the Petroteq process here could be game changer.
- **Petroteq processing:** As mentioned above should this prove successful on treating the oil shales, it will potentially be a game changer; and allow for a relatively small scale but financially viable operation without the environmental and cost issues that would be associated with a large scale retorting operation. We note however that the Petroteq process is operating on oil sands, which contain bitumen, rather than the less soluble kerogen as found in the Toolebuc Formation; however it was reportedly initially developed for and tested on oil shale.
- **Combined processing:** A combined processing route, that extracts both the petroleum and metals from the oil shale and coquina should significantly improve the economics of any future operation.
- **Other acquisitions:** Upon listing, the Company will have a reasonably health bank balance, and will be in a position to look at other opportunities should Julia Creek not stack up.

Threats

- **Commodity prices:** These have a major effect on junior resource companies, both on the economics of any project and on the ability to raise funding. Given the grade and metallurgy, any vanadium operation at Julia Creek will require strong prices to be viable; this will also affect the ability to get future financing, including for exploration/evaluation and development.
- **Funding:** With the successful IPO, QEM is now well funded for the first few years, however will need to go to the market after that; the ability to raise further capital will depend on the results from the planned work at Julia Creek (or any other project that may be acquired) and the state of the markets.
- **Unsuccessful or non-commercially viable metallurgical test work:** This is the key technical threat to the project, and the one on which the commercial viability of the project largely hinges; the Company however has a number of options with regards to the metallurgy (including the Petroteq process, acid leach and the Fushun retorting process amongst others) should some processes prove not to be viable.

OVERVIEW

STRATEGY AND PROJECT OVERVIEW

- The increasing vanadium price and interest in the battery sector has prompted renewed activity over the vanadium-bearing "oil shales" of the Toolebuc Formation in NW Queensland.
- QEM has recently raised A$5 million (before costs) through an IPO to undertake activities on the 100% owned Julia Creek Project (Figure 1), with this containing Inferred Resources of 5.78Mt V_2O_5 and 3C Resources of 589MMbbl oil, in a shallow unit that could be readily mined using open cut methods.
- Although the primary focus is vanadium, the Company is also looking at options with relation to the petroleum in the shales; as such an MoU has been signed with North American based Petroteq, which has developed a proprietary solvent based technology for the low cost treatment of oil sands; QEM is looking at assessing the suitability of the process to treat the Toolebuc Formation oil shales which if successful could be a game changer in the region and allow for the financially viable extraction of the petroleum.

Figure 1: Julia Creek location map

Source: QEM

FINANCIAL POSITION

- As of October 23, 2018, the Company had A$4.45 million in cash and no debt - this follows a successful IPO raising of A$5 million at A$0.20/share.
- Planned expenditure over the three years subsequent to the IPO (as presented in the Prospectus) includes:
  - Exploration and development activities at Julia Creek - A$2.76 million,
  - Expected expenses of the offer - A$0.51 million; and,
  - Administration and working capital - A$2.21 million.

CAPITAL STRUCTURE

- The post IPO capital structure and escrow requirements are shown in Table 1.

Table 1: Capital structure

Capital structure		
Escrow Period	**No of Shares**	**%**
24 months from date of official quotation, being to 19 October, 2020	60,243,678	60.24
12 months from the date of issue, being to 1 May 2019	248,890	0.25
12 months from the date of issue, being to 29 April 2019	198,255	0.20
12 months from the date of convertible note agreements between the holders and the Company, being to 15 June 2019	5,000,000	5.00
No escrow requirements	34,309,178	34.31
Total ordinary shares	**100,000,001**	**100**

Source: QEM

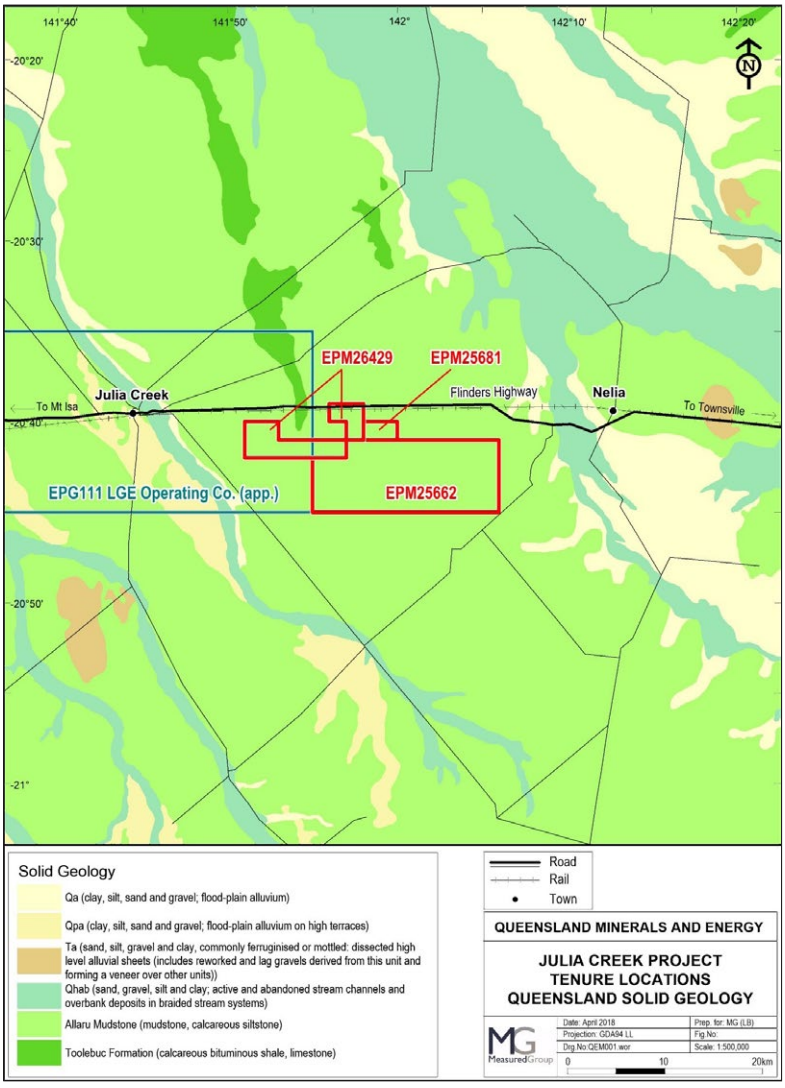
- The largest shareholder is the Executive Director, Mr David Fitch, with 23.49% of the shares; the Top 20 hold 75.65% of the stock with, at listing, QEM having 459 shareholders.

JULIA CREEK PROJECT

Location and Tenure

- The Project comprises three granted EPMs for an area of 55 graticular sub-blocks (176km^2), with all being in good standing and with expiry/renewal dates ranging from January 23, 2020 to March 16, 2022.

Figure 2: QEM tenement map



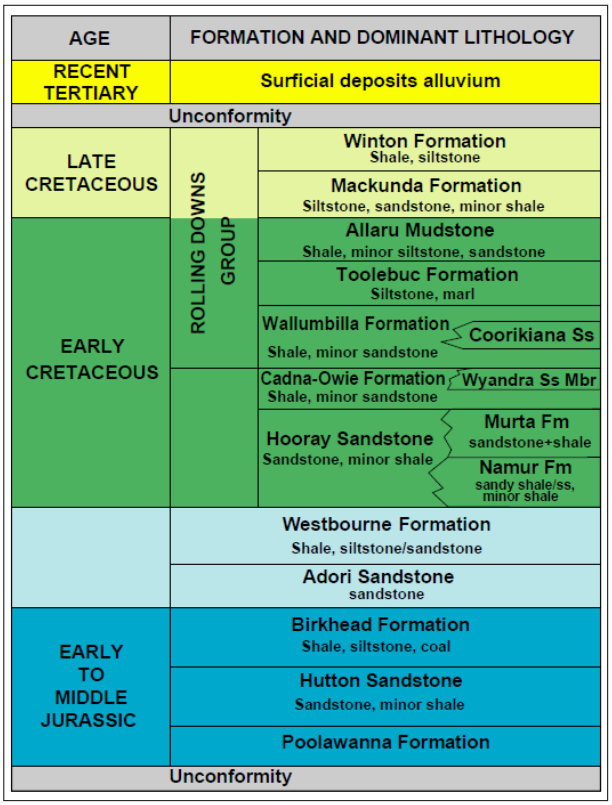
Source: QEM

- The Project is centred approximately 20km east of the town of Julia Creek, with Julia Creek being located 655km west of Townsville and 255km east of Mt. Isa, both major regional centres.
- Both centres are a ready source of experienced mining personnel and services.
- Julia Creek is well served by infrastructure, being located both on the Flinders Highway and railway connecting Mt Isa with the coast and port facilities at Townsville.

Geology

- The Project is located over the Allara Mudstone and Toolebuc Formation of the Rolling Downs Group, a Lower to Upper Cretaceous unit of the broader Eromanga Basin (Figures 2 and 3); the oil and vanadium bearing Toolebuc Formation is the target for exploration and development activities.
- The Eromanga Basin, which covers an area of some 1,500,000km^2 itself is part of the broader Great Artesian Basin and partially overlaps the Cooper Basin.
- The Toolebuc Formation is commonly covered by between 100m and 1,000m of younger units except near the basin margins, and also in the vicinity of Julia Creek, where it drapes over the St. Elmo Structure, which represents a basement high (Figure 3).
- The minimum depth to the top of the St Elmo Coquina is 37.75m within the Project area, with a maximum depth to the base of the Arrollo Siltstone of 104.42m.

Figure 3: QEM tenement map



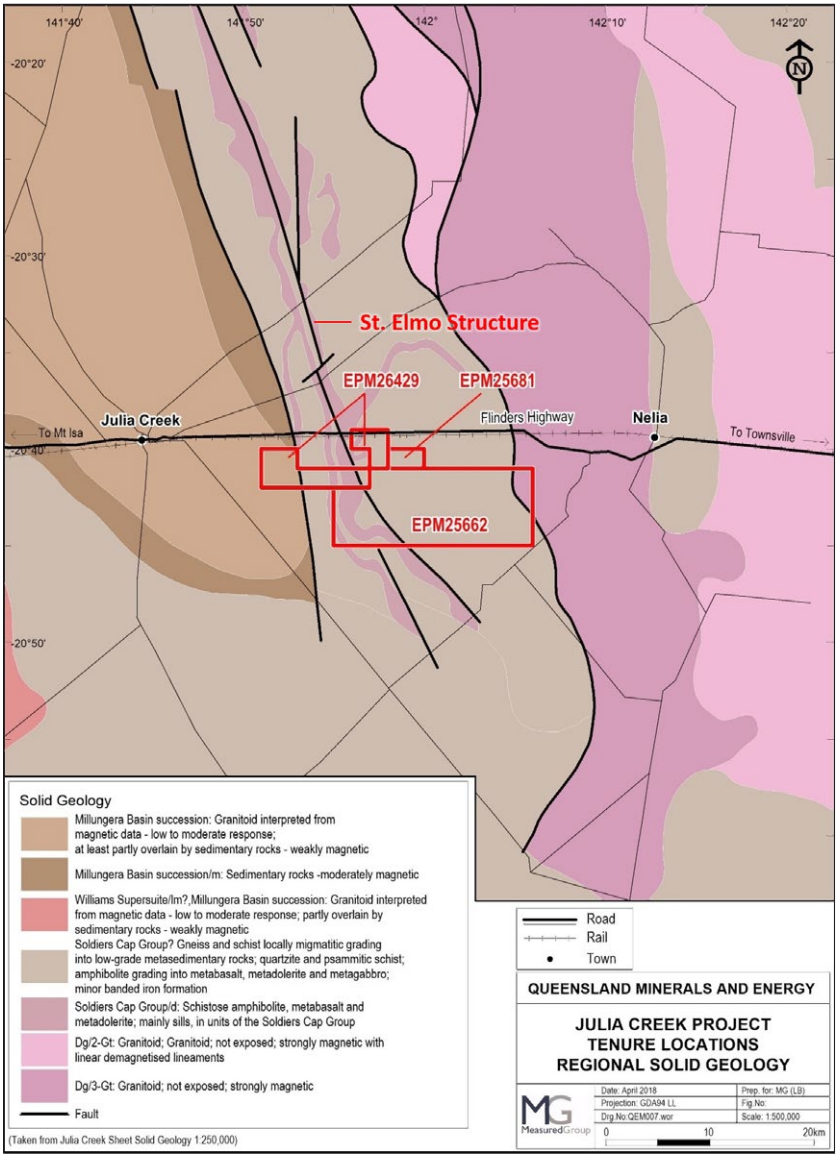
Source: QEM

- The Toolebuc Formation, which is laterally continuous and generally flat lying, reflects generally clear water deep marine to paralic (near marine shallow water) sediments, and has an age of ~110Ma.
- The lithologies evidence cyclical changes in sea-level, with a general trend from deeper, still water lower in the sequence to shallow marine in the upper parts.
- The Formation has a thickness of generally between 5m and 15m, and is comprised of a number of separate units, being (from upper to lower):
  - St Elmo Coquina or Coquina Upper Unit (CQU) - interbedded shelly limestone and kerogenous siltstone, with thin claystone (oil shale) bands between the limestone units - this has an average thickness of 4.05m in the 10 holes drilled by QEM, with a range of 2.59m to 5.02m,
  - Willats Crossing Siltstone (CQL) - similar to and gradational into the overlying St Elmo Cocqina, but differentiated by having over 50% of oil shale bands,

- Manfred Coquina (CQL) - this appears similar to the St Elmo Coquina, however is not as laterally extensive within the tenements, not being intersected in a number of holes; the unit has a noticeably lower vanadium content and a spike in phosphorous, due to a distinctive phosphatic band at the base which is an accepted marker with the Toolebuc Formation - the combined CQL unit has an average thickness of 3.14m, with a range of 1.29m to 5.41m; and,
- Arrollo Siltstone (OSU and OSL) - this is the oil shale unit, and consists of dark grey finely laminated, pyritic and kerogenous shales; there is a marked increase in clay content and fall in oil yield and organic matter in the lower half with this marking the change from OSU to OSL. The OSU unit averages 1.40m thick over the recent holes (with a range of 0.89m to 2.16m), with the OSL unit averaging 1.56m thick (with a range of 0.90m to 2.04m).

- The upper contact of the Toolebuc Formation with the Allaru Mudstone is gradational, with the lower contact generally being sharp.
- The Toolebuc Formation with the Project area is largely below the base of weathering, however there are some outcropping and weathered areas within EPM26429, which has ramifications for metallurgy as discussed later.

Figure 4: QEM tenement map



Source: QEM

Mineralisation

- The organic matter within the Toolebuc Formation, largely kerogen, is interpreted as being derived from planktonic algae and widespread benthic blue-green algal mats formed during deposition of the Toolebuc Formation, with the inorganic, largely carbonate matter reflecting the non-organic parts of benthic fauna, including algae.

- The presence of pyrite is indicative of anoxic conditions at the water sediment interface, which would have enhanced growth of the cyanobacterial community and preserved organic matter.
- Mineralogical work has determined that the Toolebuc Formation is largely composed of calcite, kerogen, quartz, kaolinite, smectite and pyrite; the presence of particularly calcite is vital with regards to vanadium metallurgy.
- The Toolebuc formation is anomalous in a number of metals, including vanadium, copper, zinc, nickel and molybdenum, with these interpreted as being fixed from the sea water by the living organisms, a process enhanced by anaerobic conditions.
- Vanadium is now largely associated with the mixed layer clays, which host 60% of the vanadium in the oil shale (with this possibly mobilising out of the organic material); the other 40% is hosted within other silicates, pyrite and organic compounds.

Historical Work

- Previous work in the immediate area of Julia Creek included that carried out by The Oil Shale Corporation and CSR (and then CSR alone) in the 1970s and 1980s, with this assessing the oil shale and vanadium potential; this followed on from earlier sedimentary uranium assessment by Australian Aquitaine Petroleum Ltd.
- Activities by CSR included drilling (with six holes within QEM's tenements), with this including research on oil shale production and culminating in a Feasibility Study in 1980.
- Also, in the early 1980s ESSO tested the area to the south and west of QEM's tenements for base metal mineralisation, with the drilling (nine holes) returning average V_2O_5 values of 0.35%, with anomalous zinc, copper, nickel, uranium and molybdenum - the figures are in line with others throughout the area.
- CRA Exploration Pty Ltd (CRA) took up a large tenement position around Julia Creek between 1991 and 1993 and drilled an additional five drillholes during that period.
- CRA compiled a database, completed summary reports on previous oil shale exploration and conducted several technical studies into potential beneficiation options for the oil shale deposit - at the time CRA concluded that treating Oil Shales for crude oil was not a viable option given that the estimated best case costs of production were above the projected long term oil price at that time.
- Work on vanadium near Julia Creek was also undertaken by Fimiston Mining in the late 1990s, with this summarised in a paper published by the AIG in 2000[1].
- This included a summary of the results of metallurgical testwork, with this including the potential to upgrade the coquina to 1.4% V_2O_5; however the high acid consumption, and in the case of alkali leaching, high sodium consumption (due to the formation of analcime in the autoclave) was noted, and has significant affects on the financially viability of any development.
- The potential for both petroleum and vanadium as by-products was discussed, particularly in light of then mooted sub-US$10/bbl costs of the proposed Stuart Oil Shale Project, located near Gladstone in central Queensland (however with those costs not being achieved).

Work by QEM

- Since acquiring the Project in 2015, QEM has carried out a number of activities, including the drilling -of 10 holes for 996m, with coring through the Toolebuc Formation and open hole drilling in the hanging wall - assay methods included:
  - Assaying for metals (ICP AES for 33 elements),
  - Proximate assaying, including total moisture, inherent moisture, ash content and volatile matter; and,
  - Modified Fischer Assay ("MFA") for hydrocarbon content.
- The results of this drilling, as well as previous drilling by CSR, were used in an initial Inferred MRE of 1,326Mt @ 0.36% V_2O_5 and an oil yield of 64.1 litres/tonne; the results are in line with those of historical work in the region and current work by other parties.
- The results were used in a Scoping Study for vanadium extraction only, published in June 2016, with the Company judging that the results warranted continuation of work on the Project; this study also indicated that there may the opportunity to gain additional value through the conversion of oil shale into oil and oil products.

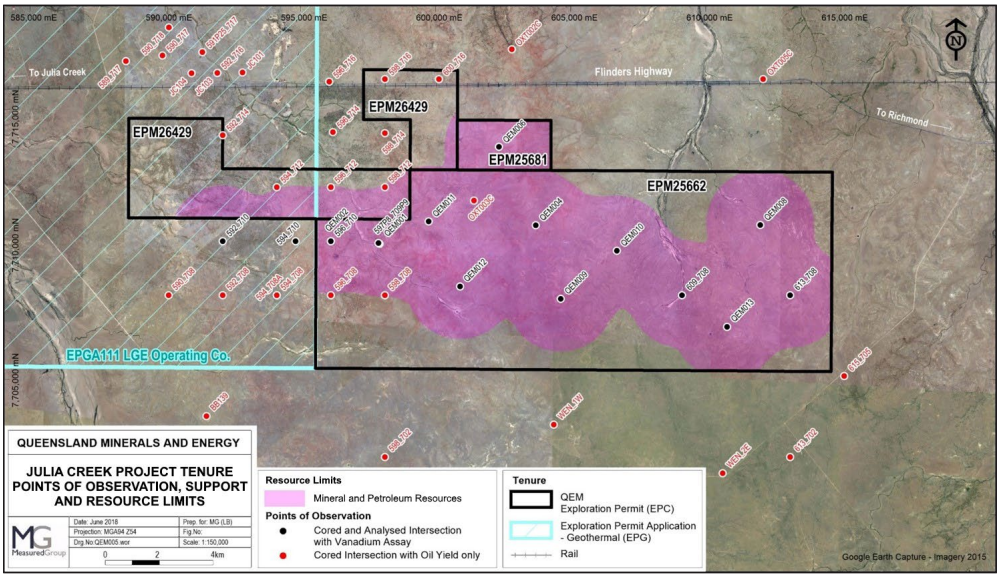
1 Coxhell, S and Fehlberg, B: (2000) Julia Creek Vanadium and Oil Shale Deposit, AIG Journal

- What we have noted however are that the costs and metallurgical processing used in the Study were based on those for magnetite bearing intrusive related mineralisation (such as the Gabanintha deposits in Western Australia), which are not entirely applicable at Julia Creek.
- In August 2017, the Company announced the signing of an MoU with TSX-V listed Petroteq Energy Inc., with a view to looking at using Petroteq's proprietary solvent based oil extraction technology; the Company drilled a further two holes in June 2018 to provide samples for test work by Petroteq.
- Vanadium metallurgical test work was completed in late 2017, with this looking at a number of different treatment options.
- As part of the IPO process, the Company has completed an updated MRE for vanadium, and initial Contingent Resource Estimates for oil shale.
- Key activities are detailed further below.

Drilling and Resources

- As mentioned, in 2015, the Company completed a ten hole, 994m drilling programme targeting both vanadium (and other metals) and oil shale - all holes, including historical holes drilled by CSR, are shown in Figure 5; drilling by QEM included two holes that twinned CSR holes, with a nominal drillhole spacing of 4km.
- There was a reasonable correlation between the historic and QEM drilling, some differences were noted and attributed to the different sampling intervals used.
- The Company's drilling intersected the full thickness of the Toolebuc Formation, with the shallowest depth to top of 37.75m and the deepest depth to the base of 104.42m.

Figure 5: Drilling and Resource area



Source: QEM

- A summary of the vanadium and oil shale resources is presented in Tables 2 to 4, with this broken up by geological unit.
- We note that no estimations have been completed for the CQU unit, although this hosts appreciable vanadium mineralisation; the reasons presented for this are that oil yields in this unit are less the 40 litres/tonne and the V_2O_5 grade is ~0.25%, and that the unit is lenticular and cannot be traced across all holes.
- This unit, when oxidised, has however been targeted by previous operators given that it has in places been screened to upgrade vanadium from around 0.25% to a concentrate containing 1.4% V_2O_5.
- There are apparently some areas within the Project where there is outcropping and oxidised Toolebuc Formation, which will be investigated as a part of ongoing studies.
- The MRE (Table 2) highlights the anomalism in other metals in addition to vanadium, with vanadium values generally comparable with those for MRE's completed in elsewhere in the Toolebuc Formation - the potential to extract other metals will be investigated as part of ongoing studies.

Table 2: Summary of Mineral Resources as at May 31, 2018

Summary of Mineral Resources as at May 31, 2018									
Resource Class	Strat. Unit	Mass (Mt)	Average Thickness (m)	Insitu Density (gm/cc)	V_2O_5 (wt%)	Cu (ppm)	Mo (ppm)	Ni (ppm)	Zn (ppm)
Inferred	CQL	811	3.39	2.12	0.38	242	247	226	1329
	OSU	454	1.77	2.1	0.31	241	146	193	1221
	OSL	445	1.81	2.13	0.29	223	127	170	1098
Total		**1700**		**2.12**	**0.34**	**237**	**190**	**203**	**1241**

Source: QEM

- Oil Shale Resources are presented in Table 3.
- The 3C Resources are predicated on a 90% recovery through standard treatment processes for shale oil from the PIIP.
- These figures compare well with historic estimates from the Toolebuc Formation.

Table 3: Summary of Oil Shale Contingent Resources as at May 31, 2018

Summary of Oil Shale Contingent Resources as at May 31, 2018								
Resource Class	Strat. Unit	Mass (Mt)	Average Thickness (m)	Total Moisture wt%	Oil Yield (L/tonne)	Oil Yield LT0M*	MMBarrels (insitu-PIIP)	MMBbls 3C
Contingent	CQL	811	3.39	8	62	63	298	268
	OSU	454	1.77	10	72	74	191	172
	OSL	445	1.81	10	63	65	165	149
Total		**1700**		**9**	**64**	**67**	**654**	**589**

Source: QEM, *L/tonne @ 0% moisture

Metallurgy

- Metallurgy (and oil extraction) is the key to the viability of any future operation.

Vanadium Metallurgy

- There has been reasonably extensive work done on vanadium extraction in the region, with the Company also completing a test work programme in 2017.
- The Company initially engaged with Griffith University in Queensland and their partners in China, Xian University, to conduct research on the use of a supercritical water process on test samples from the Julia Creek Project.
- The research was carried out to investigate the potential of using this technology to produce either hydrogen gas or liquid fuels from the oil shale - although these initial tests proved the technical potential for such a process, further investigation into the economic viability is still required.
- In late 2017 the Company commenced additional metallurgical testwork, with this being undertaken by Core Metallurgy - this looked at a number of processing methods, testing both the oil shale (OS, head grade of 0.33% V_2O_5) and lower coquina (OCL, head grade of 0.29% V_2O_5) zones, with concentration methods tested including:
  - Flotation,
  - Liquid-liquid separation; and,
  - Wet high intensity magnetic separation ("WHIMS").
- Follow up test work included roasting and leaching, using various lixiviants.
- Historical mineralogical test work concluded that the main minerals in the oil shale are calcite, kerogen, quartz, kaolinite, smectite and pyrite; XRD analyses in the latest study indicated that the coquina contained 86% calcite and 9% quartz, with the oil shale containing calcite (28%), quartz (27%), clay and plagioclase minerals with 5% pyrite; these do not account for non-crystalline materials including kerogen.
- It is estimated that the mixed layer clays can contain up to 5% to 10% vanadium, with 60% of the V_2O_5 in the clays in the oil shale; the association between vanadium and clay minerals was supported by the results of the recent work.
- Flotation of the OS sample using both sulphide and non-sulphide flotation reagents did not result in any significant upgrade of the sample, however sulphide flotation of the CQL sample was promising, with the best result (sample ST9, with a head grade of 0.42%

V_2O_5) being the recovery of 67% of vanadium into 30% of the mass, with a concentrate grade of 0.93% V_2O_5.

- Liquid-liquid separation using water and kerosene did not results in any upgrade, nor did WHIMS, with only 1.9% of the mass reporting to the magnetic fraction as would be expected in these rocks.
- On the basis of the concentration results, the subsequent leach test work was completed on the coquina samples only.
- Seven leach tests were completed, with four on CQL rougher concentrates and three on roasted concentrates - the roasting increased the feed grade from 0.60% V_2O_5 to 1.01% V_2O_5.
- Lixiviants included sulphuric acid, sodium hydroxide and hydrochloric acid; the first two were tested on both roasted and non-roasted concentrates, the latter on roasted concentrate only.
- Concentrated sulphuric acid leaches of the non-roasted material recovered ~77% of the vanadium, however with very high acid consumption due to reaction with carbonates; the weak sulphuric acid leach only recovered 8% of the vanadium, and the strong acid leach of the roasted material resulted in an interpreted reaction of the acid with calcium oxide (a product of roasting of calcium carbonate) to form gypsum.
- The alkali sodium hydroxide leach did not recover any vanadium from either sample, and the hydrochloric acid leach on roasted concentrate only recovered 2% of the vanadium.
- The overall conclusion is that the work could be considered a technical success with 57% V_2O_5 recoveries being achieved through flotation and leaching of the CQL sample; however acid consumption was very high and that an acid generation plant and acid recycling would be required in any commercial operation.
- These results are similar to those achieved in historical work, and with the then low vanadium prices the Company was of the view that an integrated processing rout be investigated to take advantage of the oil shale component - this lead to the agreement with Petroteq (discussed below).
- There are additional treatment options, including looking at alternative lixiviants, assessing the treatment of the ash residue following retorting for the hydrocarbons and looking at other alkaline leaching methods.

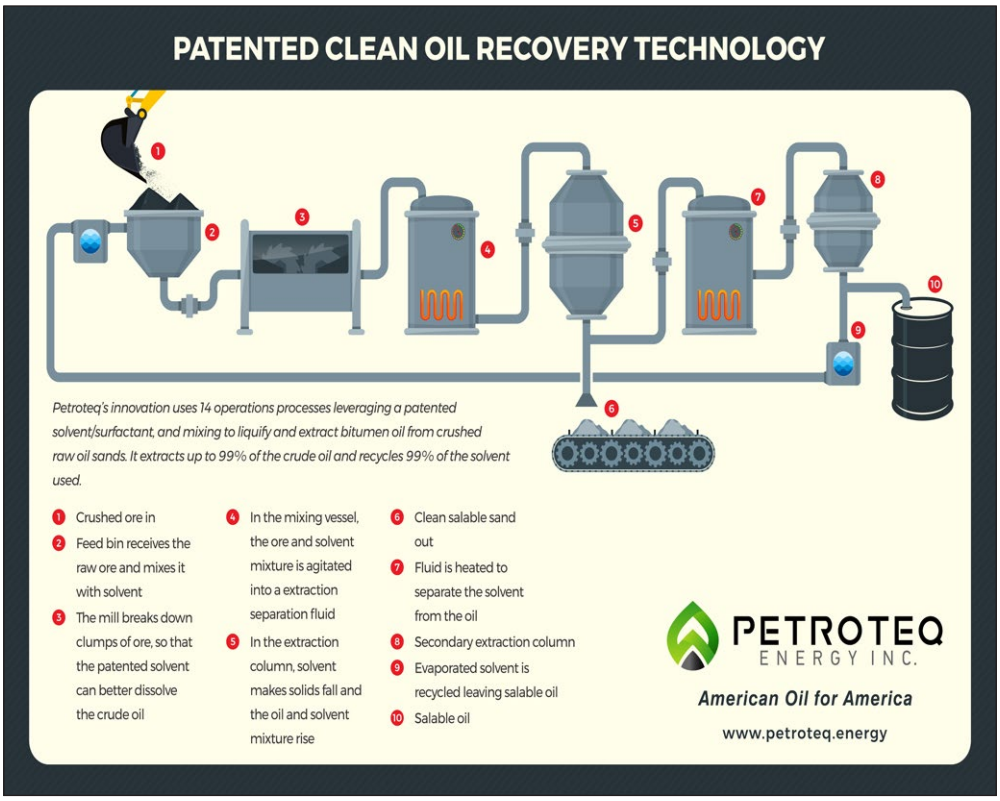
Oil Extraction

- The Company has not as yet completed any large scale test work on petroleum extraction, however the results of the Fischer Assay provide a reasonable guide to potential performance; in addition the ex-situ treatment of oil shales (generally through retorting) is a well developed and understood process with the potential recoveries of 90% reflected in the 3C Resources presented in Tables 3 and 4.
- The Company (as discussed below) has signed an MoU with Petroteq, to assess the suitability of treating Toolebuc oil shales using Petroteq's proprietary solvent processing, with samples from two holes drilled in June 2018 now being sent to Petroteq for assessment.
- Metallurgical and hydrocarbon extraction test work will be a key part of ongoing activities.

Petroteq MoU

- As stated earlier, the Company has signed an MoU with US-based Petroteq to investigate the potential to treat the Toolebuc oil shale using proprietary technology developed and tested on oil sands in the US, with commercial production at the Vernal, Utah facility having now been initiated as announced by Petroteq on September 27, 2018.
- Terms of the agreement include:
  - A mutual commitment to perform laboratory and bench testing on sample ore,
  - Upon successful test results being achieved on QEM material, a commitment that QEM will license the Petroteq Energy technology and design for use in Australia; and,
  - A commitment to support Petroteq's marketing efforts by inviting the company to demonstrate the Julia Creek operation to potential clients.
- One feature claimed by Petroteq is that it is a closed loop, solvent based process with 99% recycling of the solvents; an advantage over traditional oil sands treatment is that the large amounts of water are not required in the Petroteq process.

Figure 6: Petroteq process flow sheet



Source: Petroteq website, extracted July 31, 2018

- Any such system, should it prove technically and economically feasible, would be suitable for Julia Creek, given the arid location and hence lack of water; another factor at Julia Creek is the generally salty nature of ground water.
- Previous companies have looked at alternative methods of treating the Julia Creek oil shales; these included Blue Ensign Technologies (ASX:BLE, now de-listed) which was investigating using the solvent based Rendall Process; this however halted with the 2008 ban (lifted in 2013) on oil shale mining and the death of the technology developer.

PLANNED ACTIVITIES

- The Company has a planned three year exploration budget of A$2.76 million, not including overheads.
- Key activities, aimed at completing a Pre-feasibility Study and Environmental Impact Statement work programmes:
  - Drilling, to provide additional core samples for analysis and metallurgy and to allow an Resource upgrade to Indicated/Measured on at least part of the deposit,
  - Metallurgical test work for both metals and oil,
  - Surface mapping, including line of oxidation mapping to gain a more complete idea of the interface between the base of weathering and the mineralised zone (this has important ramifications for metallurgy),
  - Detailed topographical surveying; and,
  - Environmental studies and permitting activities.
- This should result in an active work programme over the period, and hence ongoing news flow.

PEER GROUP ANALYSIS

- There are a number of vanadium focussed companies both private and listed on the ASX and other exchanges, with these listed in Table 4.
- These fall into three main groups:
  - Those with mafic intrusive deposits, with vanadium hosted in magnetite,
  - The Toolebuc oil shale focussed companies; and,
  - Companies with vanadium/graphite deposits.

- The three groups have different characteristics, particularly with regards to metallurgy, and hence are not directly comparable; in addition some companies have other projects that we have not considered when calculating the EV.

Table 4: Vanadium company comparison

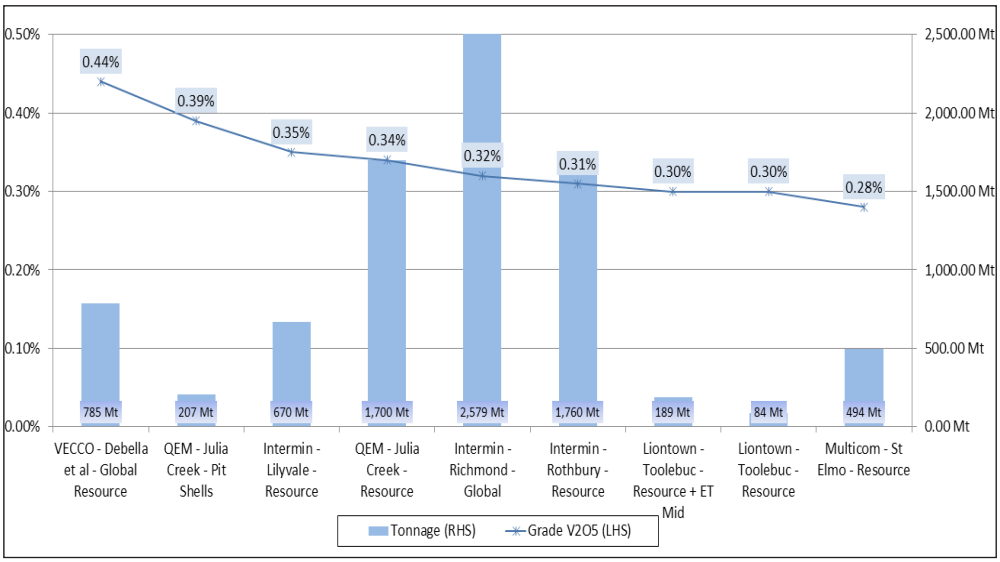
Vanadium company comparison							
Company and Project	**Deposit Type**	**Global Reource Tonnage**	**V_2O_5 Grade**	**Contained V_2O_5 - Mt**	**EV A$m**	**Stage**	**Notes**
Largo - Maracas - Resources	Intrusive	50.60 Mt	1.01%	0.51 Mt	$2,553.80	Production	Q2 2018 production of 2,458t V2O5 produced from the Menchen Mine at the Maracas Project. Initial estimated capex was US$250m for a planned production of 9,200t V2O5
Bushveld Minerals - Global	Intrusive	440 Mt	0.64%	2.82 Mt	$512.34	PFS	
Syrah - Mepiche	Graphitic	214.3 Mt	0.43%	0.92 Mt	$372.96	Scoping	Graphite focussed project
Neometals - Barrambie - Global	Intrusive	280.1 Mt	0.44%	1.23 Mt	$94.63	PFS	Largely a titanium project
TNG - Mt. Peake Resources	Intrusive	160 Mt	0.28%	0.45 Mt	$91.45	DFS Completed	Ti and Fe co-products in proposed TIVAN hydrometallurgical plant
King River Copper - Global	Intrusive	4,711 Mt	0.30%	14.13 Mt	$63.51	Scoping	Activities focussed on other assets
Australian Vanadium - Gabanintha - Global	Intrusive	175.5 Mt	0.77%	1.35 Mt	$59.20	Preliminary PFS completed	Has other projects, and is in the VRFB supply, installation and maintenance market
Technology Metals - Gabanintha - Global	Intrusive	119.9 Mt	0.80%	0.96 Mt	$26.96	PFS Completed	
Intermin - Richmond - Global	Oil Shale	2,579 Mt	0.32%	8.25 Mt	$26.81	Resource	Private company AXF earning in, Intermin has other assets
Vanadium Corp - Global	Intrusive	113.5 Mt	0.43%	0.49 Mt	$21.84	Resource	
Liontown - Toolebuc - Resource	Oil Shale	84 Mt	0.30%	0.25 Mt	$20.54	Resource	Main assets are lithium in WA
QEM - Julia Creek - Resource	Oil Shale	1,700 Mt	0.34%	5.78 Mt	$15.05	Scoping completed	64 l/t oil yield
New Energy Minerals - Caula - Resource	Graphitic	22 Mt	0.37%	0.08 Mt	$7.56	Scoping Completed	Graphite is main focus
Audalia - Medcalf	Intrusive	31.8 Mt	0.45%	0.14 Mt	$6.61	PFS completed	
Protean - Daejon - Resource	Black Shale	76 Mt	0.30%	0.23 Mt	$3.05	Resource	Has uranium credit, also developing VRFB technology
Atlantic - Windimurra	Intrusive	242.6 Mt	0.48%	1.16 Mt	$0.00	C & M	Private company
Vecco Group	Oil Shale	785.2 Mt	0.44%	3.45 Mt	$0.00	Resource	Private Company
Multicom - St Elmo - Resource	Oil Shale	493.5 Mt	0.28%	1.38 Mt	$0.00	Resource	Private Company

Source: IRESS, Company reports

- However, in the above we have five companies operating in the Toolebuc, and thus can be considered peers of QEM, although there are different facets to each - these include Intermin (farming out its interest to AXF with AXF to earn 75% through the expenditure of A$6 million and the subscription for A$410,000 in Intermin shares), Multicom and Vecco Group (private and solely focussed on the Toolebuc), and Liontown (which has a main focus on lithium in WA).

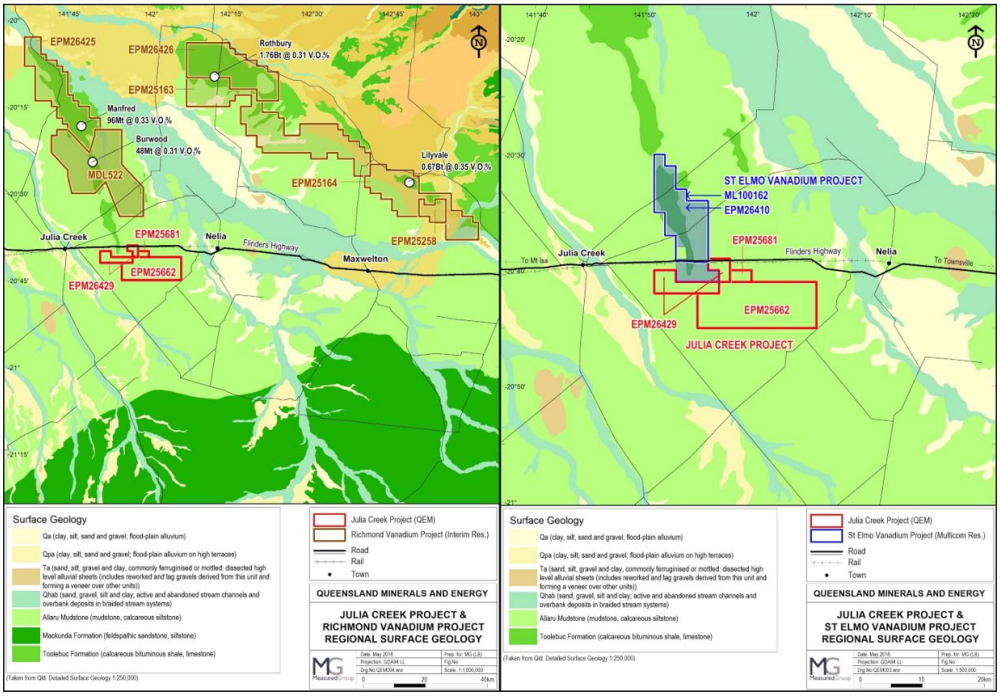
- All have similar global vanadium resource grades, as shown in Figure 7, however only QEM has published petroleum Resources; project locations are shown in Figures 8 and 9.
- All are at a broadly similar level of progress, although Multicom has lodged an Initial Advice Statement ("IAS") for an Environmental Impact Statement ("EIA") of its Mining Lease Application ("MLA") to the NE of QEM's project.
- Multicom's project is predicated on the production of 50,000tpa of V_2O_5 from open pit mining of the Toolebuc Formation.

Figure 7: Toolebuc Formation Resources



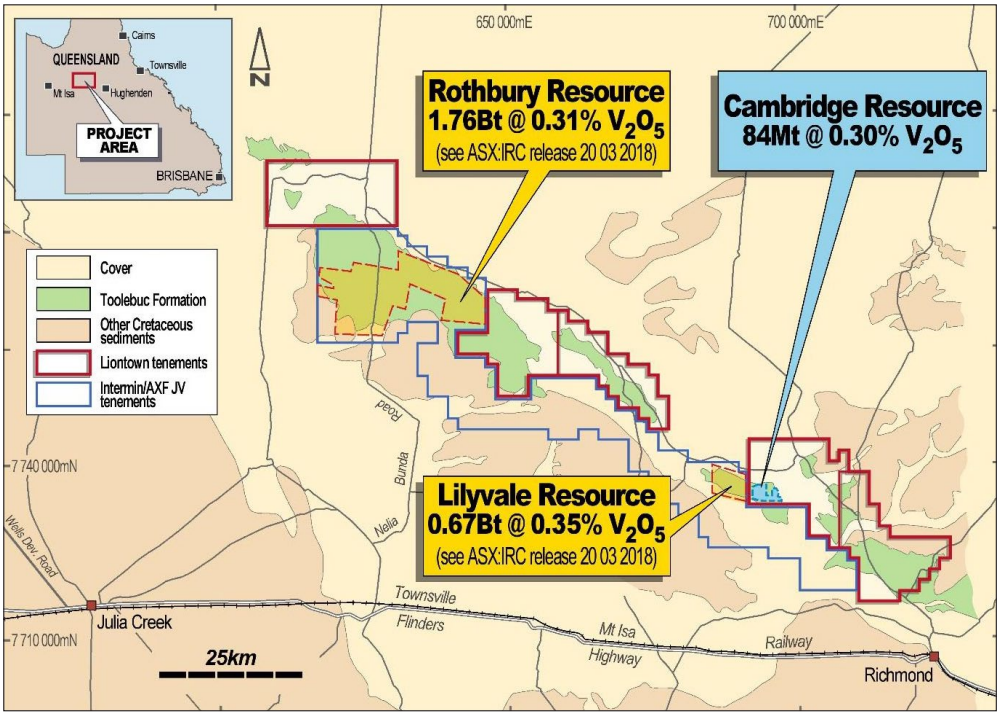
Source: Company reports, IIR analysis

Figure 8: Neighbouring projects - Richmond (Intermin, left) and St Elmo (Multicom, right)



Source: QEM

Figure 9: Neighbouring projects - Richmond (Intermin) and Cambridge (Liontown)



Source: Liontown

RISKS

- **Exploration and resource** – Given the style of mineralisation and the results of work completed to date this is not (except for the vanadium grade) a risk for QEM - the current MRE has the potential to support a long term operation for both oil and vanadium should any future project prove feasible.
- **Technology and processing risk:** This is the key risk for QEM (detailed below) - Julia Creek is not really an early stage resources play in the usual sense, but more of a technology/ metallurgical play.
- **Vanadium metallurgy** – This is the key risk regarding the vanadium - previous test work, although technically successful over a number of projects has highlighted high potential costs of production and "tricky" metallurgy; this is amplified by the low grade of the resource.
- **Oil extraction:** Although currently not central to the Company's strategy, the Petroteq process is now operating commercially on Utah oil sands, however is yet been tested on the Toolebuc oil shales.
- **Commodity prices and exchange rates** – These are key for the success (and a decision to go ahead) of any potential resource project, and a factor in which the operators have no control. After seeing a nadir in early 2016 and relatively flat prices following, the last 12 months, and particularly the last 6 months have seen significant rises in vanadium prices, pointing towards a possible longer term recovery in the metal. Oil prices will also determine the viability of any potential oil production operation.
- **Development funding:** Although down the track, the ability to raise project development funding will depend upon markets at that time, as well as the market capitalisation of the Company.
- **Permitting and sovereign risk** – Although Queensland is a relatively friendly mining jurisdiction, there are sovereign risk issues regarding oil shares; there has been a moratorium on oil shale in the past, and there were community concerns regarding Queensland Energy Resources' Gladstone pilot plant (now on care and maintenance). Offsetting the community concerns for QEM is the potential location of any facility near Julia Creek, a remote location with reportedly a very supportive local population and government.

BOARD AND MANAGEMENT

- **MrJohn Foley B.D., LL.B., B.L. (Dub), KHS., M.A.I.C.D – Chairman:** Graduating in law from the University of Sydney in 1969, John was admitted to practice as a barrister in New South Wales in 1971. He was subsequently admitted to practice in the jurisdictions of Victoria, ACT, the High Court of Australia and Ireland. He graduated with the post graduate degree of Barrister-at-Law from Trinity College Dublin and was called to the Irish Bar and admitted as a Member of the Honourable Society of King's Inns in Dublin. John spent two years as a lecturer in law at Macquarie University Sydney and has practiced as a Barrister for 40 years.

  He is currently a director of two public companies listed on the ASX, namely Citigold Corporation Limited (ASX:CTO) and Hudson Investment Group Limited (ASX:HGL).

  John was a founding director of the Australian Gold Council, the industry body. He is a long standing member of the Australian Institute of Company Directors and he is listed in Who's Who in Business in Australia.

  John has wide-ranging experience in the resources, financial and investment related industries, with extensive business experience in Australia and overseas. His leadership roles have covered a broad scope of senior positions, and his commercial and legal background will provide further depth, knowledge and experience to any enterprise.

  John has a large network of connections with people in government, industry and the Investment community. As a professional advocate he has represented industry bodies before various Commissions, Tribunals and Courts and has extensive experience in negotiations and representations with both State and Federal Governments.

- **Mr David Fitch B.Com., B.Juris.,G.A.I.C.D - Executive Director:** David Fitch is currently the Chief Operating Officer and joint major shareholder of the Fitch Group – a group of companies with assets in excess of $250 million spread across the commercial, residential, manufacturing, retail and hotel industries.

  David has extensive experience in strategic planning, commercial negotiations and business operations and asset management with a particular focus on greenfield development sites for the commercial and retail sectors, residential development and is also actively involved as director of BioCentral Laboratories Ltd, a company producing advanced products for the firefighting industry as well as dust suppressants for mining and road construction.

  David is a cornerstone investor in the Company and a Graduate Member of the Australian Institute of Company Directors.

- **Mr Daniel Harris BSc. (Chem) – Non-Executive Director:** Daniel is a seasoned and highly experienced mining executive and director and has most recently held the role of interim CEO and Managing Director of ASX listed Atlas Iron, a mid-sized, independent Australian iron ore mining company with operations in the Northern Pilbara of Western Australia. Daniel remains an independent Director to the Atlas Iron Board

  Daniel has been involved in all aspects of the industry for over 37 years and held both COO and CEO positions in Atlantic Ltd. The company's subsidiary, Midwest Vanadium, owned a +$500 million-dollar production plant and vanadium mine in Western Australia. As COO, Daniel was tasked with the start-up of the newly constructed vanadium plant in and brought it into commercial operation, before moving to the CEO role.

  Daniel is also the former Vice President of EVRAZ Plc, Vanadium assets responsible for their global vanadium business. EVRAZ plc is a £4.2 billion publicly traded steel, mining and vanadium business with operations in the Russian Federation, Ukraine, Europe, USA, Canada and South Africa. EVRAZ consolidated vanadium business produces and markets approximately one third of the world's vanadium supply, with annual turnover, in excess of $600 million dollars.

  Prior to EVRAZ, Daniel held numerous positions with Strategic Minerals Corporation. Throughout his 30 years with the company, he advanced his career from junior engineer, through to CFO and CEO roles within the group and was responsible for increasing the capacity of the Hot Springs Project by 50%.

  Daniel also acts as a technical executive consultant to GSA Environmental in the UK, a process engineering company that is well credentialed in the vanadium and oil industries. GSAe is the UK's leading technology company for extraction and recovery of metals from ashes, minerals, refinery residues, spent catalyst and industrial by-products.

Daniel brings a wealth of experience, in all aspects of mining and project development and will assist QEM in creating a world class project in Queensland, Australia.

- **Mr Scott Drelincourt B.Sc (Geol), MAusIMM - General Manager of Geology and Development:** Mr Drelincourt is a qualified geologist having completed a Bachelor degree in Science at the University of Newcastle. He has over 10 years' experience in all facets of the resource and mining industry and has consulted and worked for a number of small and large companies across Australia and internationally, including Cuesta Coal, Santos, Whitehaven Coal and Origin Energy.

  Mr Drelincourt's industry experience includes identifying and evaluating potential resources targets and progressing the projects through initial exploration phase to operational development. He has significant operational mining experience having worked in many mine sites in Australia as a mine geologist. More recently Mr Drelincourt has focused on business development for resource companies, identifying and valuing assets for acquisition or investment.

  Scott has managed over 30 exploration and operating mine tenements in Queensland and was crucial in increasing the JORC resource of the Moorlands Basin from 146Mt to 318Mt.

  Mr Drelincourt is a member of The Australasian Institute of Mining and Metallurgy (AusIMM).

- **Mr David Palumbo BCom, CA - Company Secretary:** David is a Chartered Accountant with over ten years' experience in the accounting and financial reporting of ASX listed and unlisted companies, which includes five years as an external auditor.

  David provides corporate advisory and financial management advice and specialises in corporate compliance, statutory reporting and financial accounting services. He has also been involved in the listing of several junior exploration companies on the ASX.

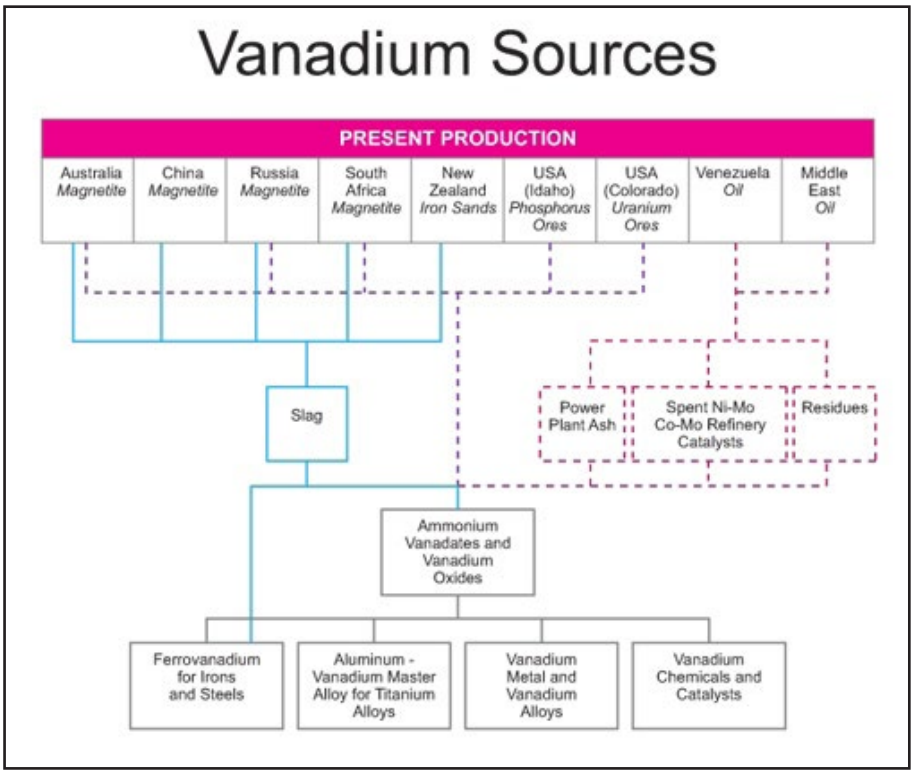
  David is currently Company Secretary and Director for ASX listed companies Krakatoa Resources Limited, High Grade Metals Limited and Roto-Gro International Limited and company secretary for European Cobalt Ltd and a number of unlisted public and private companies.

VANADIUM AND VRFBS

Introduction

- The main use of vanadium is as a steel additive in high-strength steel, which accounts for about 92% of the current global demand of ~100,000t of vanadium metal (equivalent to ~180,000t V_2O_5, with the oxide containing 56% V).
- Other uses include chemicals, catalysts and in batteries - vanadium is produced as two main products – FeV for steel-making and V_2O_5 for chemical and battery applications.
- Global production was reportedly ~83,181t in 2017, with the largest source being as a by-product from slag produced from the smelting of titaniferous magnetite ores for steelmaking (Figure 10) – it is estimated that this accounts for ~73% of total supply, with 17% being derived from mining as a primary product and the remainder from secondary sources, including oil residues and fly ash.
- However estimated consumption in 2017 was 85,800t, of which ~9,000t was high purity material, used in aerospace, chemical catalyst and battery electrode applications.
- Supply is concentrated, with over 80% of vanadium products produced in South Africa, China, Russia and Brazil.
- New developments include Largo Resources Maracas Project in Brazil, which is now in full production, and exceeding the planned output of 9,200t of V_2O_5 per year, with a planned FeV plant to be added at a later date.
- Demand has outstripped supply since 2010, with successive drawdowns on inventory; part of this has been due to industry rationalisation and environmental constraints in China, with this now resulting in the inventories being depleted and hence significant recent increases in prices after falling for over 10 years (Figures 11 and 14).

Figure 10: Vanadium sources



Source: Vanitec

Figure 11: V_2O_5 price increases, US$/lb

Source: QEM October 23, 2018 presentation

- This is pointing towards a major structural change in the industry, with the potential to result in a significantly higher price floor in the longer term.

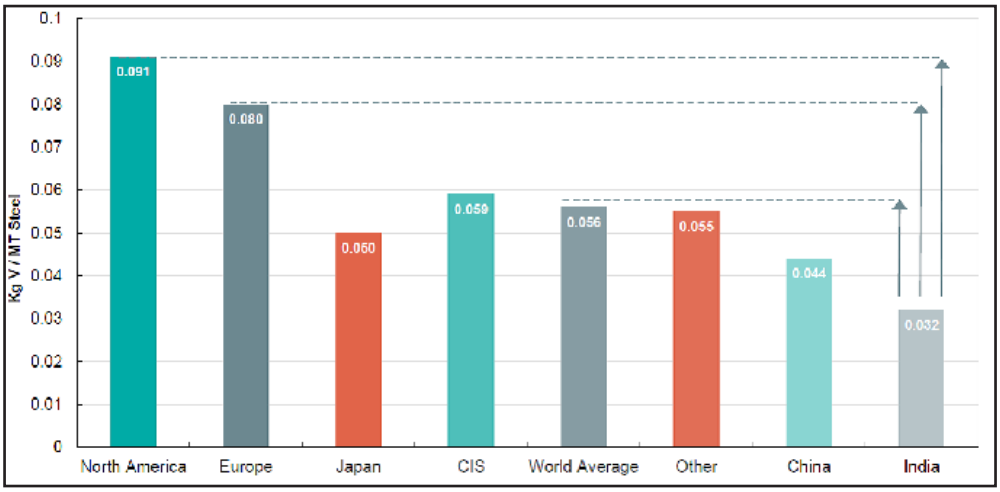
Demand Drivers

Steelmaking

- The current key demand driver is as an additive in steel – demand for vanadium closely follows the production of steel. This includes two factors – firstly the natural organic growth in steel production and secondly increasing vanadium intensity in steel with the move to lighter weight and higher strength steels – the addition of just 0.2% vanadium to steel increases steel strength by up to 100% and reduces the weight of steel required in relevant applications by up to 30%.

- This second factor is particularly relevant in China, where there is increasing vanadium intensity in rebar due to changes in building standards (with new regulations set to become effective in November 2018), partly following on from the 2008 earthquake - there is still a fair way to go with this and thus significant potential growth in use in this application, however this has the potential to increase Chinese vanadium consumption by up to 50% (15,000tpa).
- One of the main reasons behind the recent sharp price rises is believed to be stockpiling and hoarding by Chinese steelmakers ahead of the November introduction of the rebar standards.
- Roskill estimate that, although steel production will only grow at 1% CAGR over coming years, the increasing intensity of vanadium in steel along with other end uses will result in a long term demand growth of 3.45% CAGR from ~100,000tpa V in 2015 to 131,000tpa contained V in 2025, with the forecast supply deficits now being seen.
- The graph below shows the relative vanadium intensities in rebar between various jurisdictions.

Figure 12: Vanadium steelmaking intensity



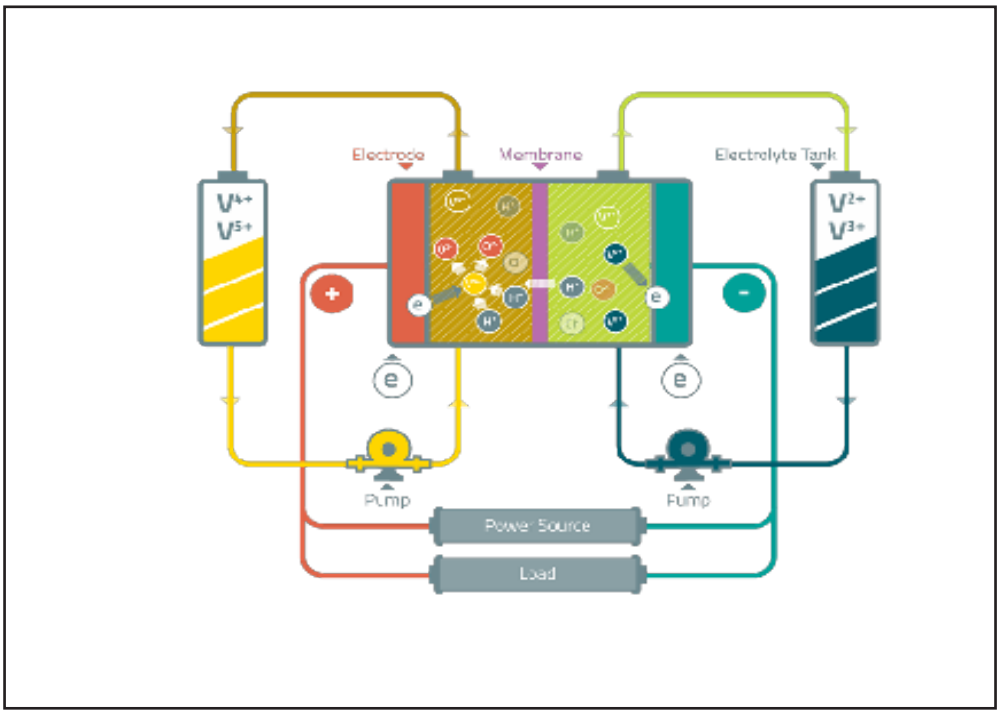
Source: Australian Vanadium

Energy Storage – VRFB's and Li-Ion Batteries

- The blue sky in demand, and the potentially disruptive technology is in grid scale battery usage - the key here will be the adoption of VRFB's that have the capacity for multi-megawatt scale storage - this makes them useful for grid scale applications, including grid balancing and storing energy from variable output sources, including wind turbines and solar cells.
- The batteries are inherently simple, relying on the changing redox state of vanadium to store and then supply power.
- Other attributes of these batteries include:
  - Scalability
  - Long lifespan – up to 20 years
  - Up to a 1 year charge retention
  - 100% discharge without damage, and,
  - Only one element – V in various oxidation states – in electrolyte.
- There are widely differing forecasts on the growth in VRFB's, however some commentators see the potential for VRFBs to provide up to 30% of the growing energy storage market, with some forecasting an additional demand of 300,000t of vanadium over coming years to meet this need.
- There are a number of active VRFB developments globally at the moment, reportedly with the largest being the development of a 200MW/800MWh battery in Dalian, China, which reportedly uses 6,950 tonnes of V_2O_5, at an intensity of 8.7t/MWh; we have also seen documentation for other batteries with a usage intensity of 7.25t of V (12.94t of V_2O_5) per MWh of capacity.
- Other recent developments include a US$200 million, 15MW/60MWh facility by Sumitomo on the Japanese island of Hokkaido.

- Development of VRFBs has been partly hamstrung by the lack of a suitable battery grade V_2O_5 supply – batteries require a higher purity product than that used in steelmaking, and hence arises the opportunity for manufacturers of high purity material.
- Some forecasts see the Australian energy storage market reaching 3,000MWh by 2030 – should the VRFB penetration reach an estimated 30% of the market this will result in the requirement of 900MWh of VRFB capacity over the same period.

Figure 13: VRFB schematic



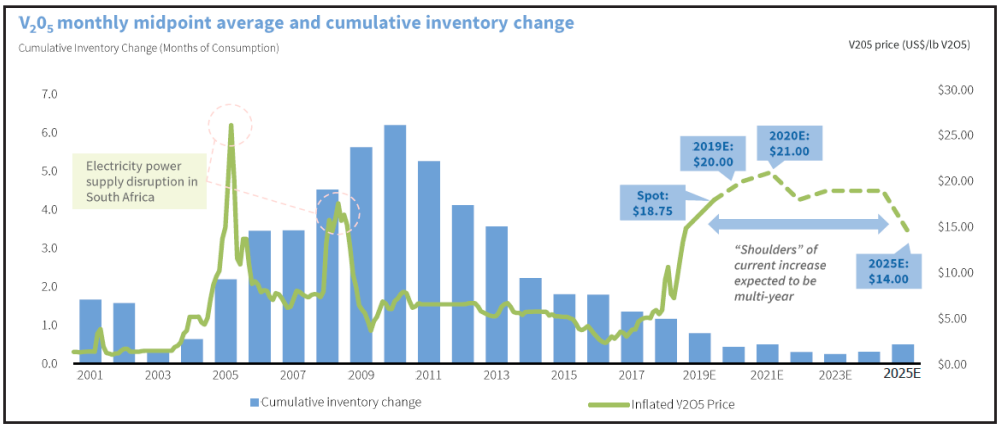
Source: Australian Vanadium

- Australia is an ideal market for fringe-of-grid and off-grid storage facilities given the extended power networks and large off-grid areas, thus potentially providing a domestic market for any V_2O_5 producers.
- Assuming a capital intensity of A$1,000,000/MWh, this equates to a A$900 million market, and using an average V_2O_5 intensity of 10t/MWh, this results in a potential domestic demand for an additional 9,000t of V_2O_5 by 2030.
- There is also significant forecast demand (~1/3 of that for VFRB's) for vanadium in Li-ion batteries.

Pricing

- Figure 11 above highlights the recent price recovery to over US$30/kg (US$14 - US$14.50/lb) due to de-stocking of inventories over recent years and supply constraints due to rationalisation of the iron ore industry in China (with vanadium being a major by-product) along with environmental constraints leading to a sharp decline in production; this is combined with what is understood to be, as mentioned above, stockpiling ahead of the introduction of the new rebar standards in China.
- Figure 14 presents a longer term chart of real V_2O_5 prices adjusted to November 2016, and shows the commencement of the recent recovery, which has followed a period of sustained falls in prices, largely post the GFC.
- The 30 year average price has been US$5/lb V_2O_5, with the inflation adjusted mean since 2014 being ~US$8/lb as shown in Figure 14.
- It is expected that pricing may remain reasonably strong, although as shown in Figure 14 vanadium pricing has a history of volatility.
- The market is not particularly transparent, and also prices do not correlate with steel production even though this is the key demand driver.
- As mentioned earlier wide acceptance of VRFBs may go some way to breaking the price "spike-collapse" pattern over recent times, due to the requirement for a consistent supply of high purity V_2O_5 for the electrolyte.

Figure 14: V_2O_5 price and stocks chart - note that prices have subsequently reached over US$30/lb



Source: Largo presentation

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For further information, please contact IIR at: client.services@independentresearch.com.au

INDEPENDENT
INVESTMENT RESEARCH

Independent Investment Research (Aust.) Pty Limited

SYDNEY OFFICE
Level 1, 350 George Street
Sydney NSW 2000
Phone: +61 2 8001 6693
Main Fax: +61 2 8072 2170
ABN 11 152 172 079

MELBOURNE OFFICE
Level 7, 20–22 Albert Road
South Melbourne VIC 3205
Phone: +61 3 8678 1766
Main Fax: +61 3 8678 1826

HONG KONG OFFICE
1303 COFCO Tower
262 Gloucester Road
Causeway Bay, Hong Kong

DENVER OFFICE
200 Quebec Street
300-111, Denver Colorado USA
Phone: +1 161 412 444 724

MAILING ADDRESS
PO Box H297 Australia Square
NSW 1215