

# Metals and Mining Note

## Talga Resources\*

MiFID II Compliant

31 July 2019

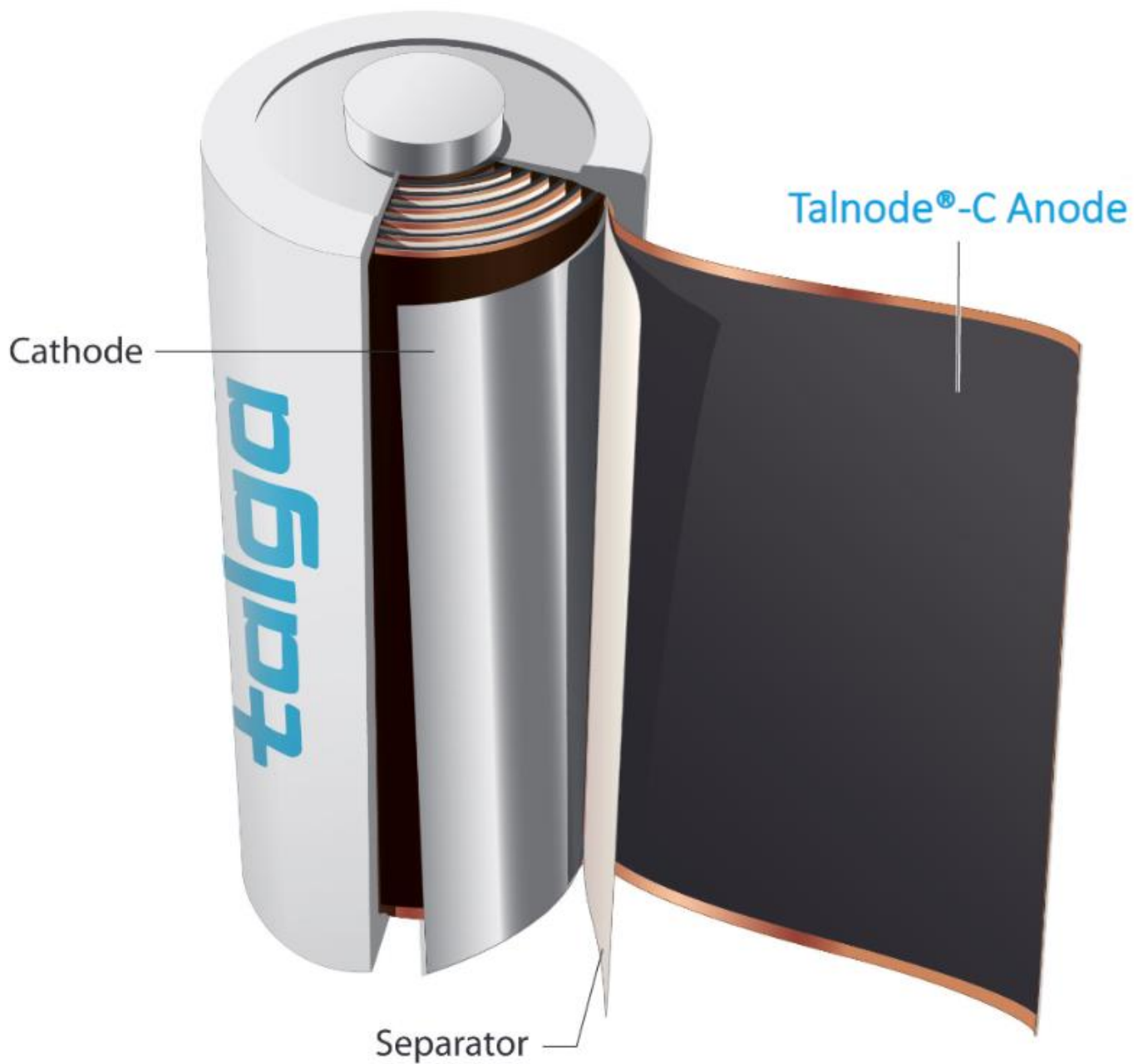
John Meyer

Simon Beardsmore

Sergey Raevskiy

James Mills

SPANGEL



*Front page photograph Talnode®-C active graphite anode material*

**31 July 2019**

#### Stock Data

Ticker	TLG AU
Share Price	A\$0.42
Market Cap	A\$93m

#### Price Chart



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# Mining Note

## Talga Resources\*

### TLG AU

**Strong Buy – TP A\$1.80**

## Fundamental European graphite anode supply

Vertically integrated advanced materials company, Talga Resources, principally focus on delivering premium electrochemical performance from the flagship Talnode®-C engineered, coated anode graphite electrode material. Developing the world's highest grade JORC graphite deposit in Sweden, ore morphology and processing techniques yields competitive superior graphite into the fledgling decarbonising Li-ion battery industry. Organic research and development progress provide significant value upside from enabling stronger, lighter and more functional graphite and graphene products for the global coatings, polymer composites, construction and energy storage markets.

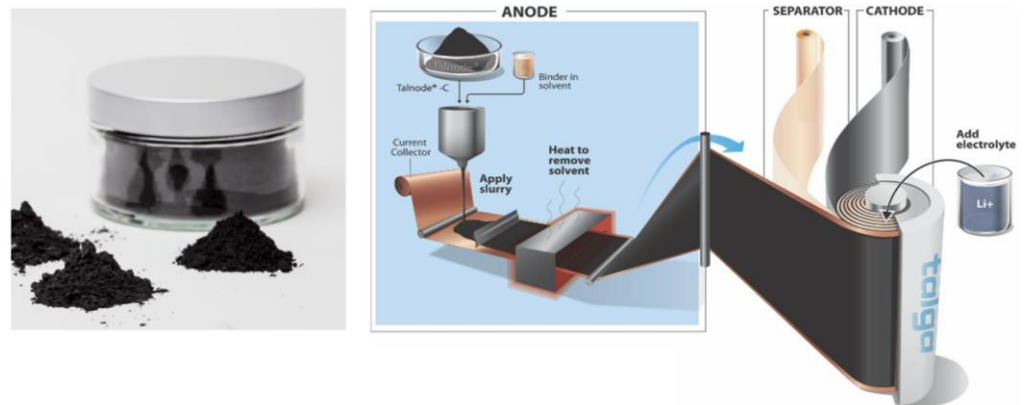
### Key takeaways

- **Vertical integration, phased-development, stringent cost controls and high margins for the premium high-performance fully engineered and coated lithium-ion battery anode product supports superior project economics for Vittangi Graphite Project, yielding post-tax NPV8 of US\$767m with strong 51.0% IRR.**
- Talga Resources' Pre-Feasibility Study proposes a phased conventional open-pit mining operation with on-site concentrator and coastal anode refinery to produce, at final design, target 19,000tpa Talnode®-C.
- Determined evaluation tests and market qualification efforts over the last 12 months has demonstrated the suitability of Talnode®-C as a fully engineered, coated anode electrode powder, with ongoing testwork giving robust indication for premium electrochemical properties. The company are proactively engaged in supplying significant quantities of Talnode®-C for ongoing validation and customer engagements as part of funding exploration.
- Future battery requirements will drive consumption to over 348,000t anode graphite by 2028, with Europe currently supplying <4% global output. There is a significant discrepancy and regional supply chain risk associated with the European graphite industry, with the development of Talga Resources' Swedish Vittangi graphite project addressing the challenge.
- **In deriving a 12-month price view for Talga Resources, SP Angel take a 40% risked valuation of the project in light of the early-phase of development and potentially protracted market growth opportunities within the nascent European lithium-ion battery industry. This is equivalent to approx. A\$1.80/share (~4.1x growth), and we fully expect the target price to appreciate with additional technical study.**
- SP Angel foresee Talga Resources' unlocking significant value upside from the commercialisation graphite and graphene product suite into specialist advanced materials markets.
- Complementary battery mineral value is attributed to a significant geophysical anomaly at Talga's broader Kiskama Co-Cu-Au opportunity.

## Talga functionalised graphite fundamental to decarbonised global economy

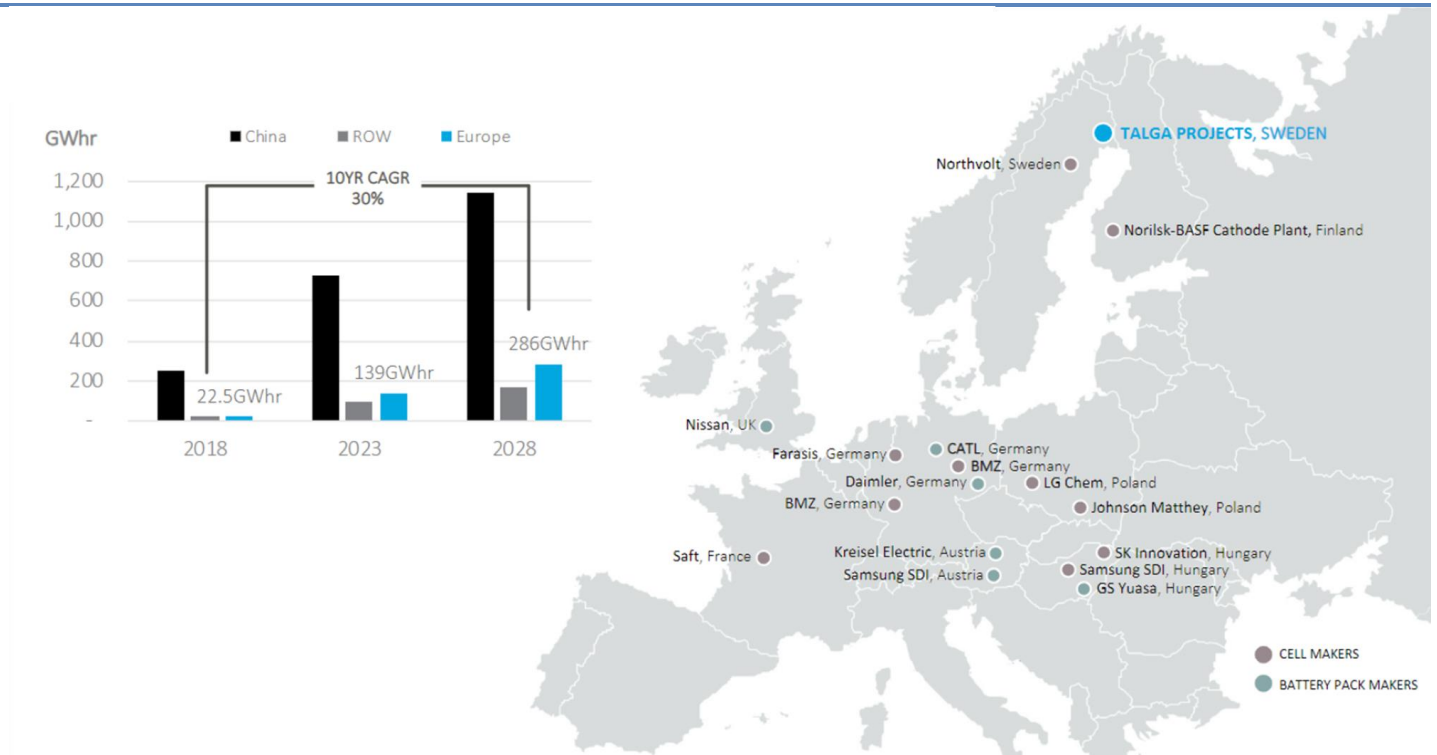
- Vertically integrated advanced materials developer, Talga Resources, is focused on the development and commercialisation of a fully engineered, coated Li-ion battery ("LiB") graphite anode material, trademarked as Talnode®-C.
- The company have been proactively and efficiently performing evaluation tests and market qualification to demonstrate Talnode®-C's suitability as an anode electrode; confirming it has outstanding electrochemical properties for premium performance in terms of capacity and temperature range. Talga's active anode powder product is expected to be delivered to the commercial market by 2021 to coordinate with the accelerating global lithium-ion battery market.

### Talnode®-C active anode material for lithium-ion batteries



Source: Talga Resources

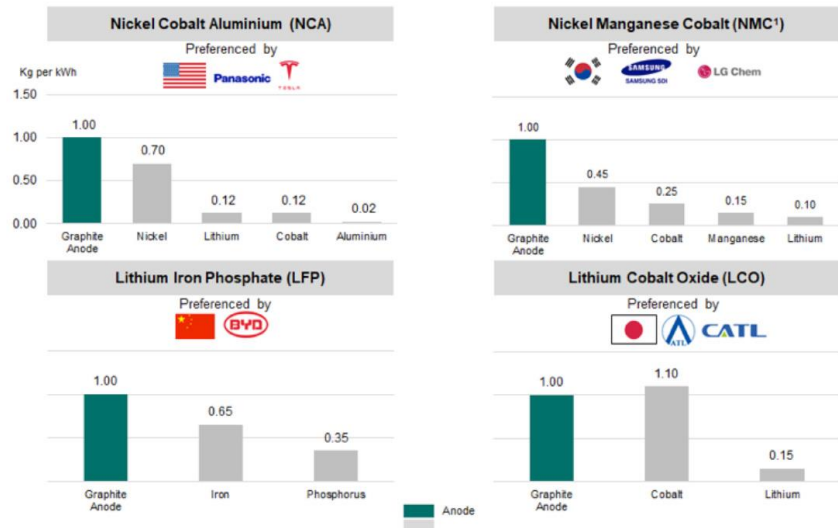
- Roughly 80% of the world's existing and planned battery production capacity is in Asia, according to Bloomberg data. China alone has 69%, with the US at 15% and the EU at under 4%. A slew of recent announcements and commitment by the EU for billions of euros funding for electric battery plants will ensure the domain remains relevant in the global race for electrification.
- Coordinated European decarbonisation efforts focus on ever-stringent, forceful emissions-related legislation to create a climate neutral economy by 2050.
- Bloomberg New Energy Finance forecast European nameplate LiB manufacturing capacity to top 198GWh/annum by 2023, rising from approx. 18GWh currently.
- Accelerating growth will encourage the EU to overtake North American commitments, which is set to rise to approx. 130GWh manufacturing capacity over the same period.
- Asian growth will still dwarf regional expansion efforts, with China expected to boast around 800GWh annual capacity by 2023, equivalent to two-thirds of global total of just over 1.2TWh, Bloomberg NEF figures project.
- Aggressive investment plans of Asia-centric technology companies across Europe, is forcing European Union leaders to seek ways of fostering a domestic industry, ensuring the continent's auto sector does not end up being beholden to Asian battery giants.
- Plans include China's Svolt Energy Technology planning 24GWh capacity by 2025 and South Korean manufacturers including LG Chem, Samsung SDI and SK Innovation planning to expand their European operations.
- The EU's Horizon 2020 research fund has set aside €200m for battery projects, while €800m is available to finance building demonstration facilities and the European Fund for Strategic Investment is available from the European Investment Bank to co-fund the billions of euros capital requirement to develop capacity.



Source: Benchmark, Roskill, Talga Analysis of Company reports

- Battery minerals, including graphite, have been designated critical status across Europe due to the evident divergence in rapidly rising manufacturing capacity and the supporting raw material supply chain.
- Recognising the trend, the EU raw materials strategy and the launch of the European Innovation Partnership on Raw Materials looks to address challenges of securing supply conforming to:
  1. Sustainable sourcing of raw materials from global markets;
  2. Sustainable domestic raw materials production, and;
  3. Resource efficiency and supply of secondary raw materials.
- In particular, the existing supply chain for these speciality chemical materials are vulnerable to disruptions, evident from China's 2010 export restrictions on rare earths resulting from geopolitical tensions.
- During 2017, the European Commission launched the European Battery Alliance, combining automakers, chemical and engineering executives in a bid to deliver a competitive strategy with Asian and American manufacturers. The European Battery Alliance state the strategic imperative for the Commission's "*new industry policy strategy*" goal is to make the EU the world leader in innovation, digitisation and decarbonisation.
- Global expansion of Li-ion battery manufacturing capacity is expected to draw major graphite consumption, with commercial products comprising almost 50% by mass high-purity graphite anodes.
- The metal mass consumption per unit kWh is battery technology specific, with graphite dominating the breakdown of Nickel-Cobalt-Aluminium (NCA), Nickel-Manganese-Cobalt (NMC) and Lithium-Iron-Phosphate ("LFP") batteries. Typically, this can translate to ~55kg for a 50kWh EV battery.

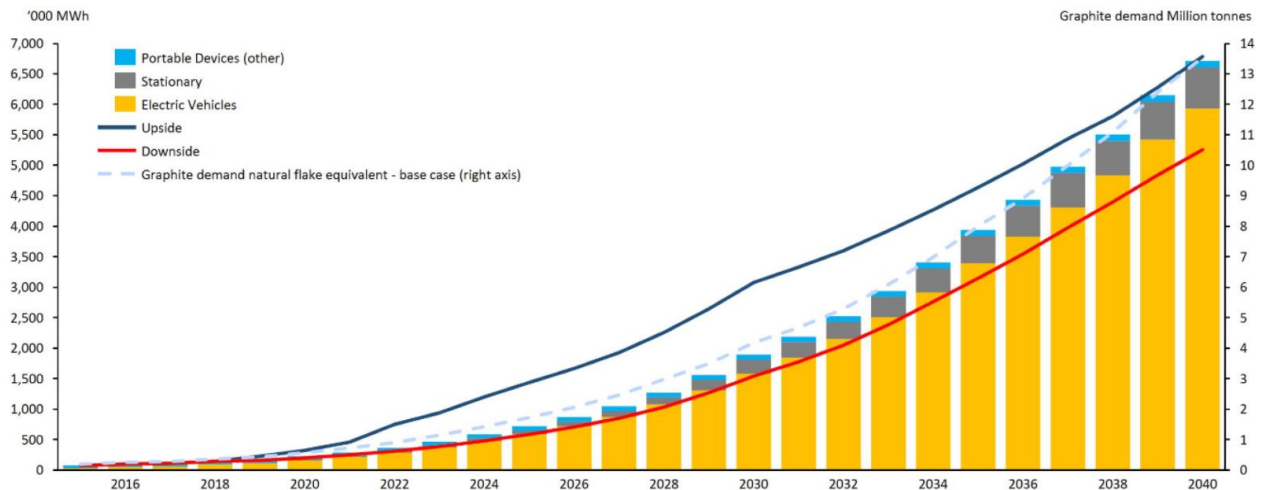
## Graphite intensity for variable Lithium-ion battery technology (kg/kWh)



Source: Syrah Resources

- The intensity of high-purity graphite in current iterations of LiB's is significant, translating into global volumes exceeding 2Mt by 2028 and 13Mt by 2040, according to Benchmark Mineral Intelligence forecasting.

## Global demand for LiB anodes

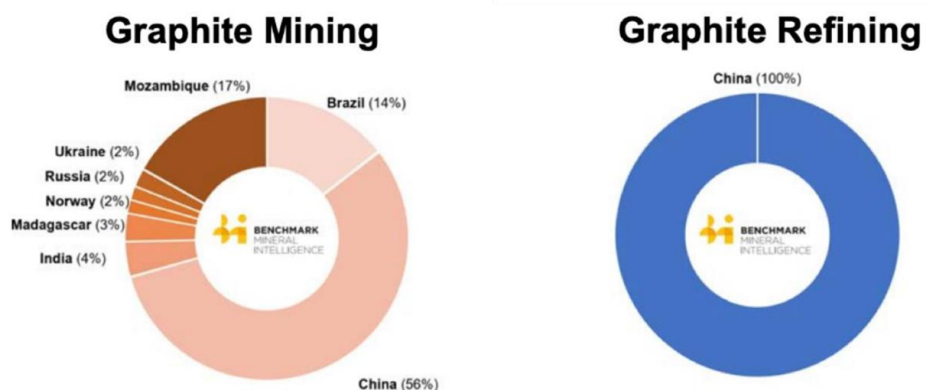


Note this is in addition to existing graphite markets in electrodes, refractories, industrial uses etc

Source: Benchmark Mineral Intelligence forecast

- Currently Europe produces <4% global mined graphite, yet future requirements will drive consumption to over 348,000t anode graphite by 2028. There is a significant discrepancy and regional supply chain risk associated with the European graphite industry, with the development of Talga Resources' Vittangi graphite project addressing the challenge.

## Europe "right place" for sustained investment and expansion of battery-purity graphite production



Source: Benchmark Mineral Intelligence

## Highest graphite resource geological advantage

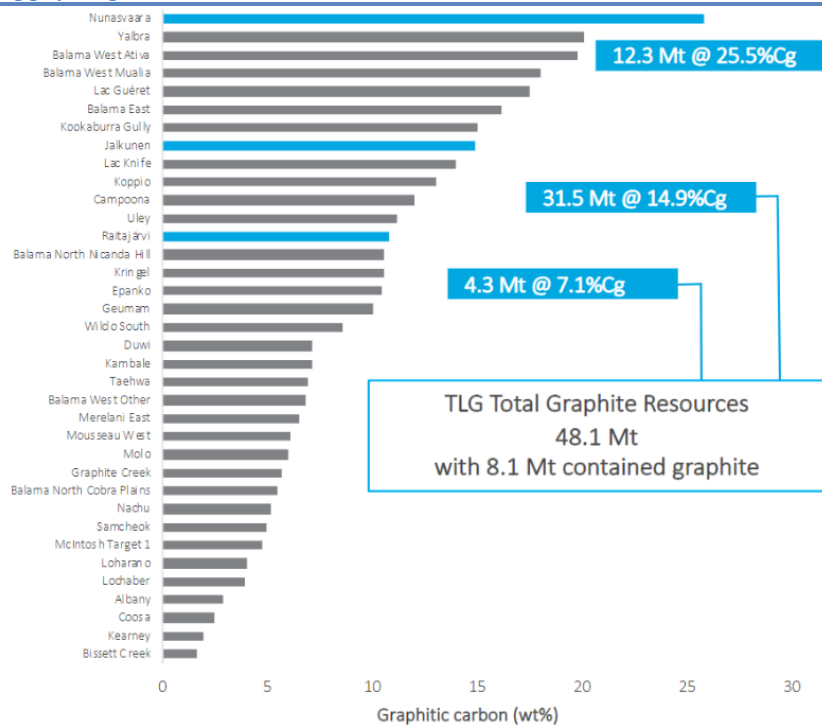
- Mining industry mantra “*Grade is king*” is certainly prevalent for Talga Resources, with the Vittangi Graphite Project hosting the world’s highest-grade graphite resource.
- The bedrock geology of the Vittangi graphite district is dominated by greenstone sequences (basalts to andesites), metasediments (quartzite, schists and marble) and metadolerites, hosting graphite mineralisation of the Nunasvaara Resource. The deposit comprises sub-vertical, 20-30m wide lithologically-continuous units of micro-crystalline (very fine-grained) grey-black rock containing up to 48% graphitic carbon (“Cg”).
- The discrete Vittangi graphite deposits were originally discovered in 1898, with geological trenching focused during 1916-1918. Early work during the 1920s reviewed the possibility of using the graphite as a reducing agent in the production of pig iron, and Nunasvaara was declared a state mining field in 1929.
- Subsequent and extensive work was conducted during 1970-1982 by the SGU and LKAB including geophysics, trenching, core drilling (20 holes for 949m) and bulk sampling.
- Talga Resources exploration initiated in July 2012 with a diamond drill program of 19 holes for 1697m. The work yielded the maiden JORC-2004 compliant resource of 7.6Mt @ 24.4% Cg, with 5.6Mt @ 24.6% Cg classified Indicated.
- Utilising subsequent phases of exploration during 2014, and the bulk trial mining undertaken during 2015-2016, updated the resource statement to JORC-2012. The total Nunasvaara Mineral Resource Estimate (“MRE”) stands at 12.3Mt @ 25.5% Cg for 3.1Mt contained graphite, based on a 17% Cg lower cut-off grade.
- The MRE incorporates a higher-grade domain of 2.0Mt @ 32.6% Cg based on an elevated 30% Cg cut-off.

Vittangi Project Nunasvaara Mineral Resource Estimate				
Domain	Category	Tonnes (Mt)	Cg (%)	Contained Cg (t)
Nunasvaara North	Indicated	8.9	25.0	2,225,000
	Inferred	1.5	23.0	345,000
Sub-total		10.4	24.8	2,579,200
Nunasvaara South	Indicated	1.8	29.4	529,200
	Inferred	0.1	27.4	27,400
Sub-total		1.9	29.20	554,800
<b>Total Resource</b>		<b>12.3</b>	<b>25.50</b>	<b>3,134,000</b>

Vittangi Project Nunasvaara Mineral Resource - MRE-High grade				
Domain	Category	Tonnes (Mt)	Cg (%)	Contained Cg (t)
Nunasvaara North	Indicated	1.1	32.2	354,200
Nunasvaara South	Indicated	0.9	33.0	297,000
<b>Sub-total</b>		<b>2.0</b>	<b>32.6</b>	<b>652,000</b>



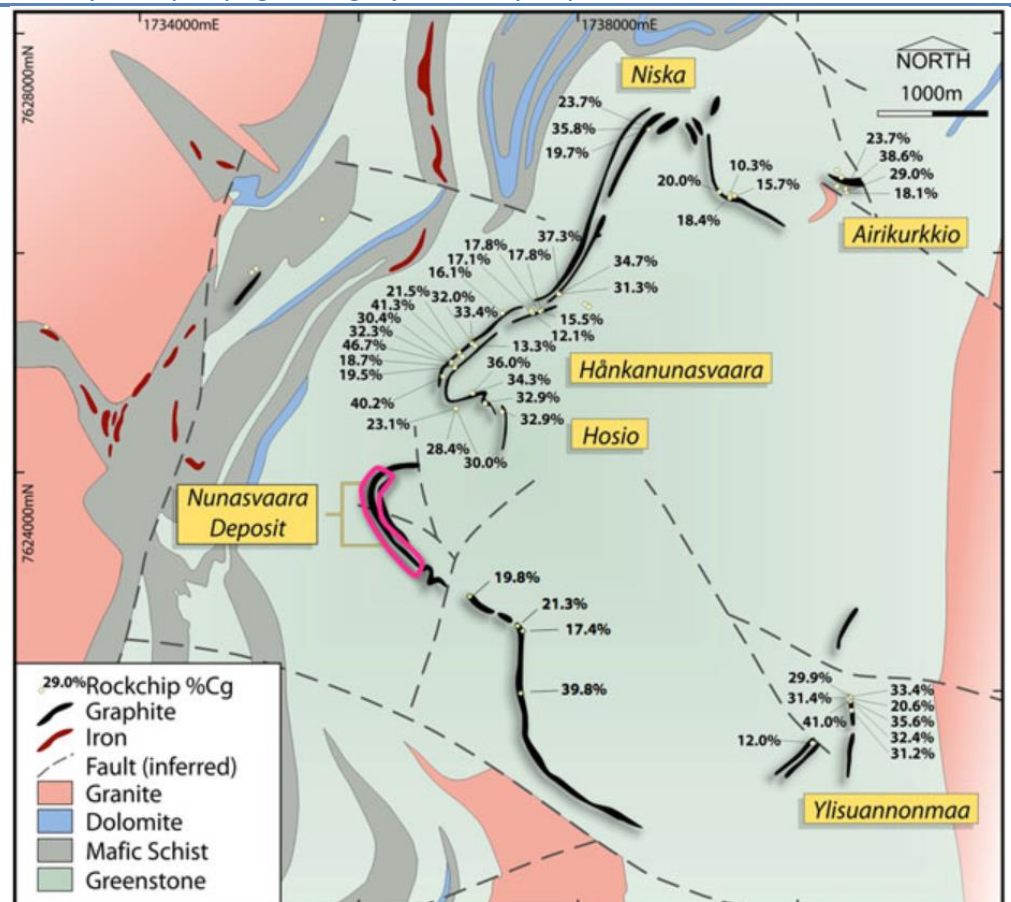
### Global leading graphite grades



Source: Talga Resources

- Analysis maintains the deposit's position as the world's highest-grade graphite mineral resource, with only approximately 8% of the 15km strike graphite unit drill tested to date. Rock sampling obtained by Talga exploration indicates graphitic unit average 26.2% Cg, with grades as high as 46.7% Cg encountered, giving significant resource upside.

### Preliminary rock chip sampling indicating major resource upside potential



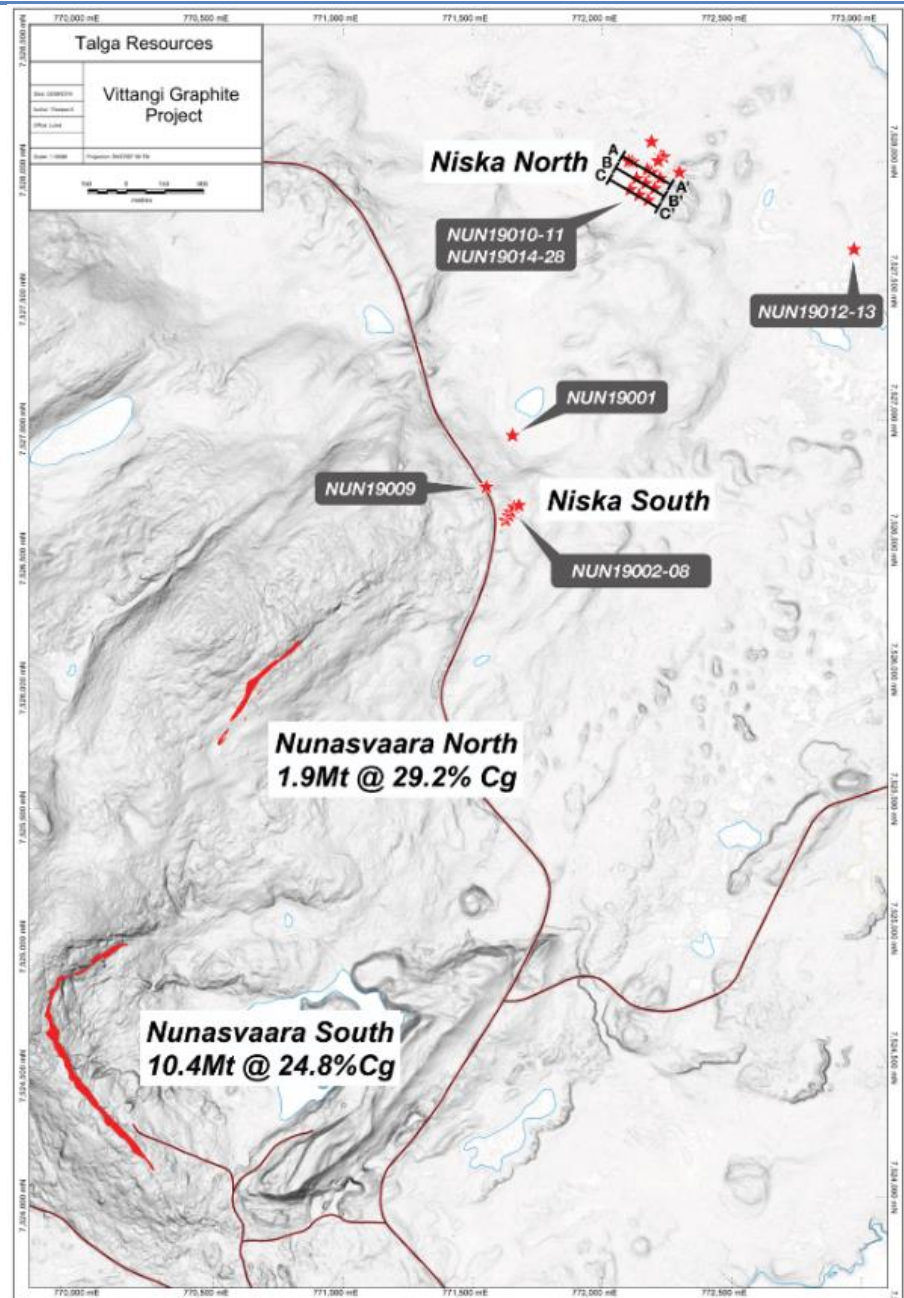
Source: Talga Resources

- In early 2019, Talga's exploration team completed a total 28 diamond drillholes for 3046.5m at the Niska prospect, targeting a series of electro-magnetic anomalies and



outcropping discrete objectives located 1-2km northeast along strike of the defined Nunasvaara Mineral Resource.

**Drillhole locations at Niska North and South with delineated graphite resources at Nunasvaara North and South**



Source: Talga Resources

- The drill results indicate exceptionally wide and high grade graphite downhole interceptions including:

**Hole NUN19023:** 72.0m @ 29.9% Cg from 105.5m, including 32.0m @ 41.9% Cg from 127.5m

**Hole NUN19026:** 73.0m @ 29.7% Cg from 112.1m, including 18.0m @ 41.4% Cg from 145.1m

**Hole NUN19015:** 106.4m @ 25.5% Cg from 24.8m

**Hole NUN19022:** 25.9m @ 32.8% Cg from 5.7m & 26.4m @ 20.5% Cg from 41.8m

**Hole NUN19016:** 25.3m @ 25.4% Cg from 41.6m & 38.1m @ 25.5% Cg from 80.7m

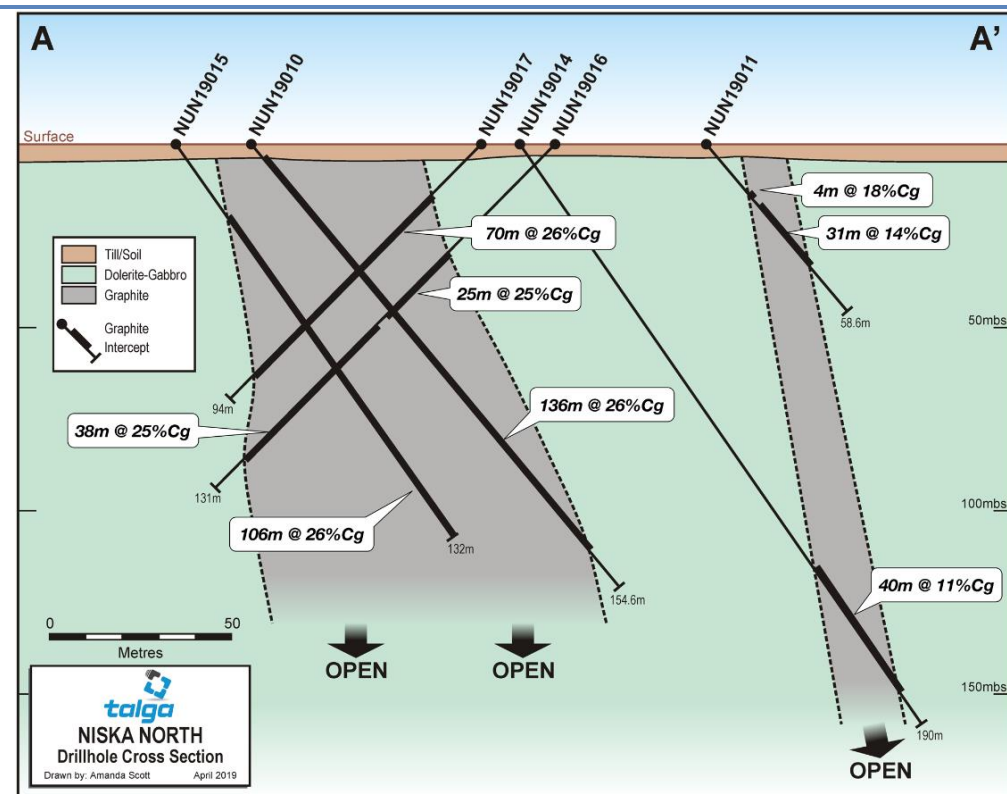
**Hole NUN19017:** 70.2m @ 25.6% Cg from 19.4m

**Hole NUN19024:** 72.0m @ 24.8% Cg from 50.8m

**Hole NUN19025:** 63.5m @ 23.1% Cg from 6.6m

- Graphite mineralisation at Niska is understood to be direct extensions of the Nunasvaara North graphite units that host the disproportionately higher-grade portions of the Nunasvaara MRE. Interpretation is formed on the basis of stratigraphy, geophysical signature, high-grade nature, similar geochemical composition, distinct lack of primary sedimentary textures found in the lower grade units, common quartz-amphibole-sulphide tension veins and frequent hydrothermal brecciation.

Drillhole cross-section from Niska North showing graphite intercepts from both the western and eastern graphite units



Source: Talga Resources

- The discovery is significant in raising the potential mining inventory at Vittangi, with true widths ranging ~18m to >80m, presented in the figure above. This could offer Talga Resources fundamental raw material supply to support the accelerating European lithium-ion battery market.

## Unique technology and ore type yields premium anode products

- Currently undergoing full-cell qualification with a range of technical and commercial partners, Talga Resources is proactively progressing through the fundamental validation processes for the Talnode®-C product.
- Talga's battery technologies are led by a wealth of in-house battery expertise to support the development of its active functionalised graphite anode products:

### Claudio Capiglia Ph.D. – Director of Battery Technology

- Based in Japan with over 20 years' experience in the battery industry, developing exclusive know-how relating to the research, development and industrialisation of advanced materials and electrodes for Li-ion battery manufacturing.
- Previous Professor and head of Battery Group/Italian Institute Technology
- Co-founder and Director of the original Li-ion cell manufacturer in Europe
- Former Senior Scientist for solid state battery technologies for HEVs at Toyota

#### **Sai Shivareddy Ph.D. – Manager – Energy storage**

- Heading Talga's UK development of advanced carbon products for energy storage, building on 7 years industrial experience focusing on early phase commercialisation of novel materials and energy technologies.
- Previously leading graphene research and commercialisation efforts at Tata Group in collaboration with the Cambridge Graphene Centre.

#### **Stephen Hutchins Ph.D. – Director of sales**

- Physicist with over 20 years developing new material technologies and engineering businesses.
- Previous Commercial Director, CTO and COO at Keronite Group.

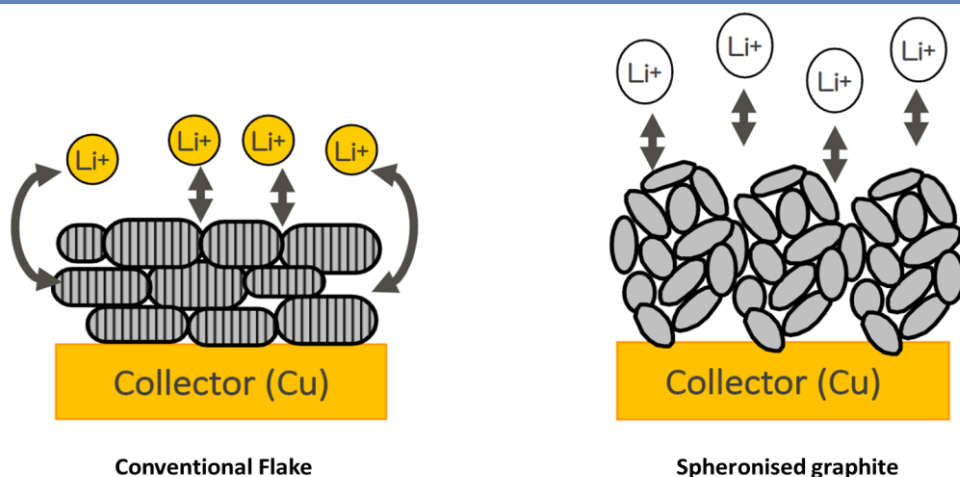
#### **Fengming Liu Ph.D. – Senior scientist – Batteries**

- Over 11 years industry experience with a focus on silicon and next generation battery anodes under the 'Safevolt' Talga-led project.
- Co-founder and former Senior Scientist for silicon anode specialist Nexeon.
- Responsible for 10 Li-ion battery anode patents to date.

#### **Optimal anode design**

- The strong commitment to research and development has yielded significant results for an optimal graphite anode design. The battery industry recognises 6 principal design criteria impacting the performance of graphite anodes; carbon source, particle size, shape, surface functional groups, coatings and orientation.
- Conventional flake graphite creates anisotropic particle orientation (below left) which inhibits performance in the intercalation of lithium ions due to packing and a high resistance to diffusion.
- The industry standard utilises mechanical spherodisation processing in a particle design mill, using impact and shear forces, to generate spherical graphite in the range 10-40 $\mu$ m depending on the intended product final performance. The action of spherodisation supports the breaking of crystal lattice to improve the penetration of lithium ions during intercalation (charging of lithium-ions).
- Further, spherodisation supports the formation of the solid electrolyte interface in the first cyclisation of LiB's. This chemical reaction between the electrolyte and anode material creates an interface a few nanometers thick, binding lithium ions and reducing the LiB capacity. Spheroids are associated with the greatest volume-to-surface ratio, and therefore minimise the capacity loss (source: Mundsinger et al<sup>1</sup>).

#### **Approach for optimal graphite anode particle design**

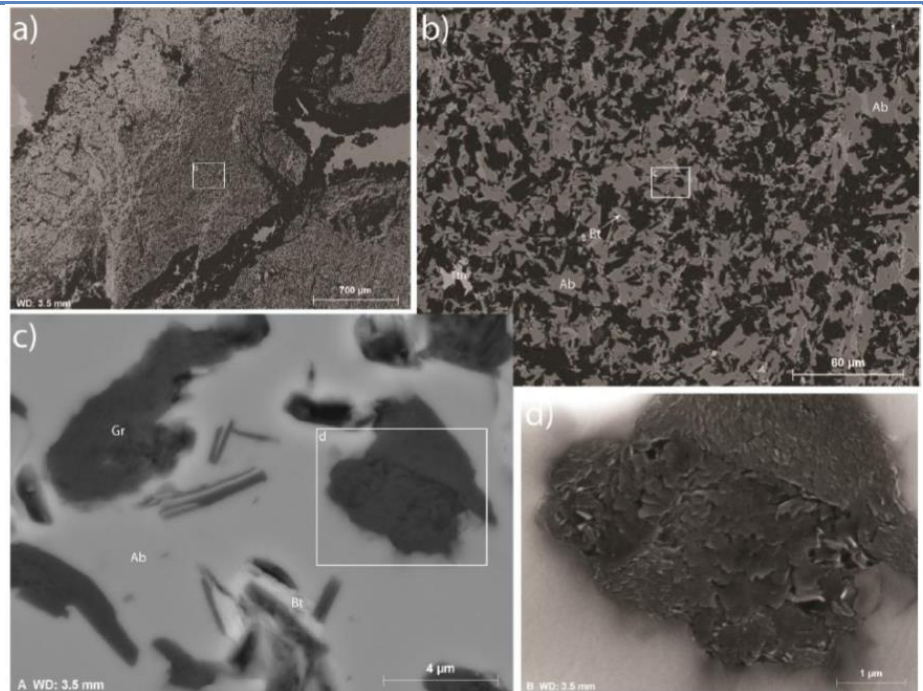


Source: Adapted from M Nisida (Hitachi)

<sup>1</sup> FIB-tomography of graphite anode particles for lithium ion batteries – Manuel Mundsinger et al.  
(<https://onlinelibrary.wiley.com/doi/abs/10.1002/9783527808465.EMC2016.6124>)

- Subsequent benefits also include enhanced porosity and permeability in the electrode, improvements in physical electrode swell and Li<sup>+</sup> resistance reduction.
- The action of mechanically milling from graphite concentrates >100μm to the desired spheroid diameters is associated with significant losses, with typically <50% of the initially introduced raw material recovered to the spherical phase.

#### Vittangi graphite micro-crystalline flake from CSIRO-Talga collaboration



Source: Talga Resources

- Talga Resources geological team formulate the Vittangi graphite was formed from a 2 billion year deposit of microbes, which were naturally crystallised at low temperatures and high pressures to generate micro-crystalline structures.
- Analysis of the Vittangi graphite indicates particle structure of the order desired (10-20μm), yielding significant cost savings in the processing of battery anode material. The excellent liberation from the host silica gangue and homogeneous graphite size distribution generates high process yields >85%, giving Talga Resources a major processing advantage against competitors (common yield ~50%).
- The purified, coated and functionalised active Talnode®-C powder has generated significant commercial qualifications against current industry-leading commercial benchmark cells.
- Talnode®-C is currently undergoing full-cell qualification with a range of new technical and commercial partners and independent battery institutes in Asia, USA and Europe as it progresses through the validation processes.

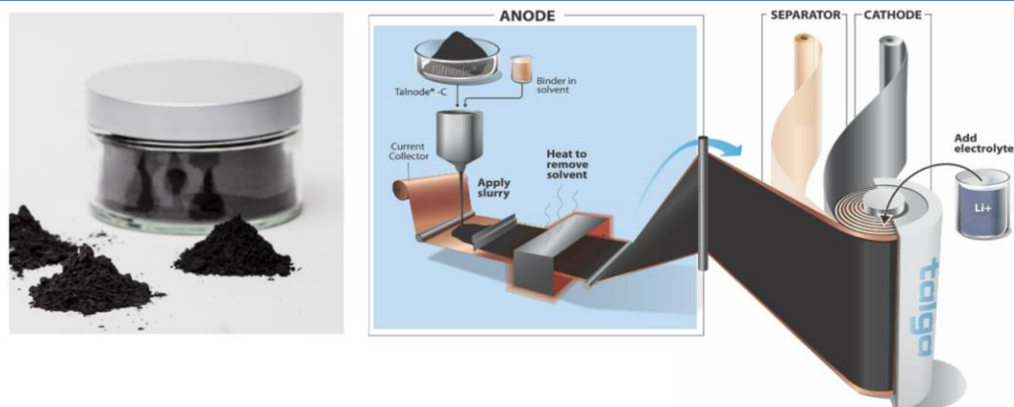
#### Industry leading results

- Breakthrough test results of the engineered active Li-ion anode product at the leading global independent facility Warwick Manufacturing Group (“WMG”), part of the University of Warwick’s Energy Innovation Centre, indicate significant performance enhancements of Talnode®-C against commercial benchmarks.
- Announced in May 2018, a range of Li-ion battery pouch cells were fabricated using Talga’s graphite anode and commercial nickel-manganese-cobalt (“NMC”) cathodes, utilising standard industrial roll to roll processing conditions to prepare large format (A5) cells.
- Following industry procedures, active material slurries with optimised rheology (flow properties) coat anode and cathode electrodes on copper and aluminium rolls

respectively. The coated electrodes are then calendered (finishing process to smooth coating) to attain higher electrode densities and required porosities.

- Electrodes are subsequently cut to the required size and stacked with a separator sandwiched between the electrodes to form the A5 pouch cell, which is finally filled with standard lithium salt electrolyte (LiPF<sub>6</sub>) dissolved in a carbonate solvent.
- The reference commercial anode cell was prepared under the same conditions, with identical weight inside the cells and paired with the same type of NMC cathode.

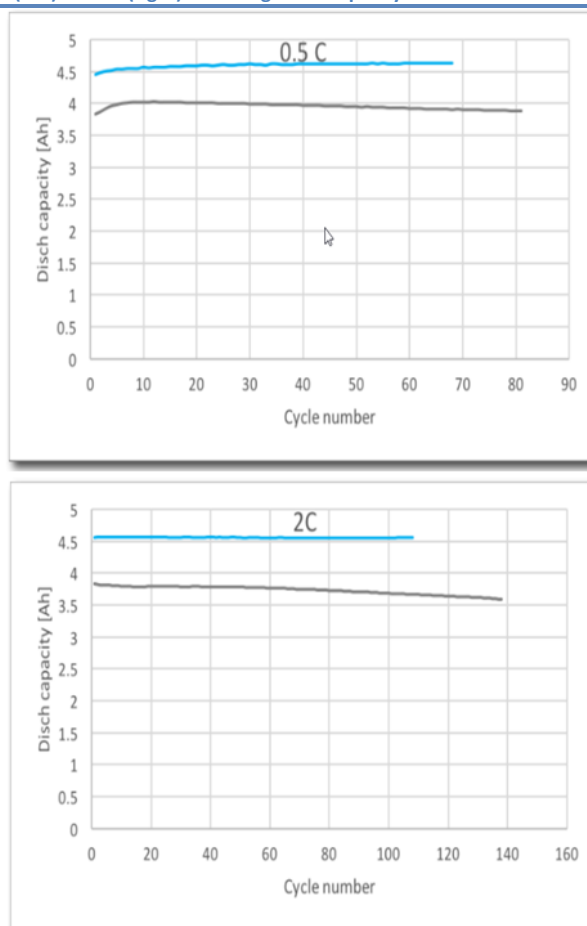
#### Preparation of Talnode®-C active anode material for commercial testing



Source: Talga Resources

- Relative measurements of the pouch cell performance at WMG indicates significant enhancements for Talga anodes:
  - Higher capacity – 20% higher capacity is observed for identical active material content at 0.5C and 2C rates respectively for cells with Talga anodes, with the first cycle loss in the full cell lower at 6%.

#### Talga full capacity at 0.5C (left) and 2C (right) achieving 100% capacity retention at 5.63Ah and 4.57Ah respectively



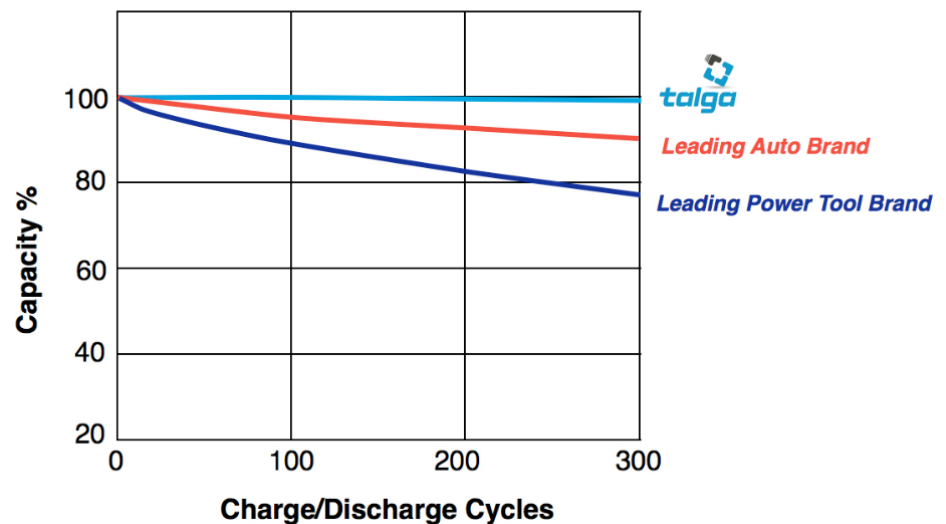
Source: Talga Resources



- Voltage charging profiles at the higher 2C rate also have enhanced performance using Talga anodes compared to reference graphite, retaining more than 99% of the initial capacity under accelerated tests to 300 cycles. Cycle stability is indicative of normal life greater than 4,000 cycles.

Battery capacity characteristics to available specification data from global leading electric vehicle and power tool battery makers over 300 cycles, normalised to the same start discharge capacity

### BATTERY CYCLE LIFE CHARACTERISTICS (@25°C)

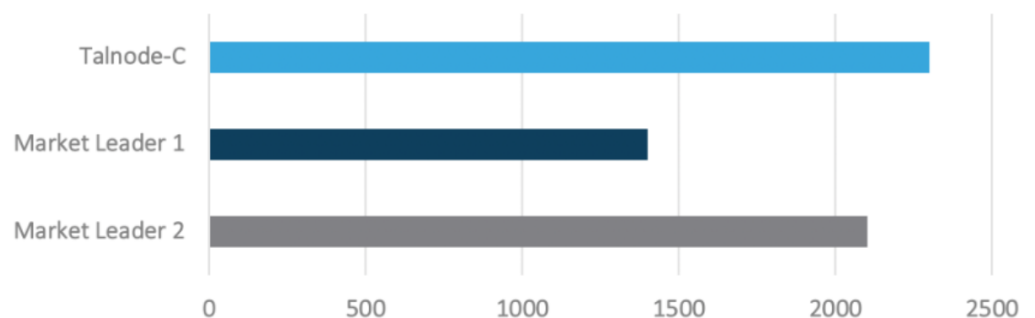


Source: Talga Resources

### Endurance test

- An engagement with IV Electrics (formerly Italian Volt) subjected benchtop tests designed to replicate extreme real world conditions of the “Stelvio” Italian Alpine mountain road to simulate high performance of the “Lacama” motorcycle battery pack.
- The cyclic test pressures the ability of a battery to efficiently collect fast charge regenerative current (from braking) following high-power discharge (acceleration) in low temperature conditions.
- Results focusing on the running time relate to battery cell performance before limits in voltage drop or cell temperature forced the end of the test.

Stelvio test – time (seconds) for cell voltage to fall below 3.2V at 14°C



Source: Talga Resources [Details – 3 second discharge at 3C, charge 1 second at 1C, rest 4 seconds and repeat]

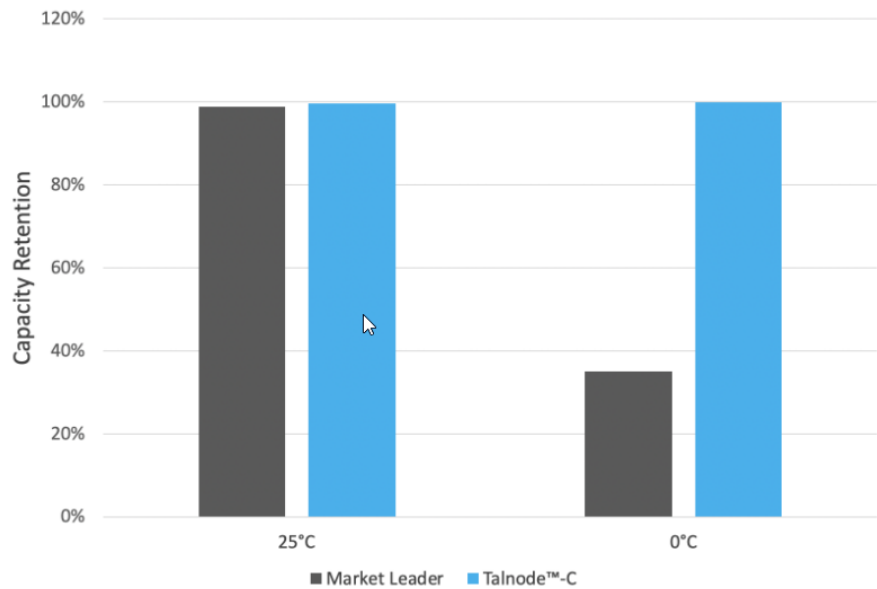
- Results indicate that Talnode®-C cells outperform the endurance of market leading commercial cells by up to 36%, also confirming the fast charge, high power and low temperature properties in real-world applications.
- Practically, Talnode®-C will require less thermal management and materials, reducing cost and weight, while increasing the energy density (range) and safety of battery packs.



### Extreme temperatures

- More recently, tests conducted at a leading Japanese battery institute examined performance under a range of temperatures including freezing conditions.
- Talnode®-C anode material supported retention of 100% capacity and 100% cycle efficiency at freezing conditions (0°C) to out-perform market leading commercial anode products.

Comparison of capacity retention between graphite anode market leader and Talnode®-C at 25°C after 30 charge-discharge cycles and at 0°C after 60 charge-discharge cycles



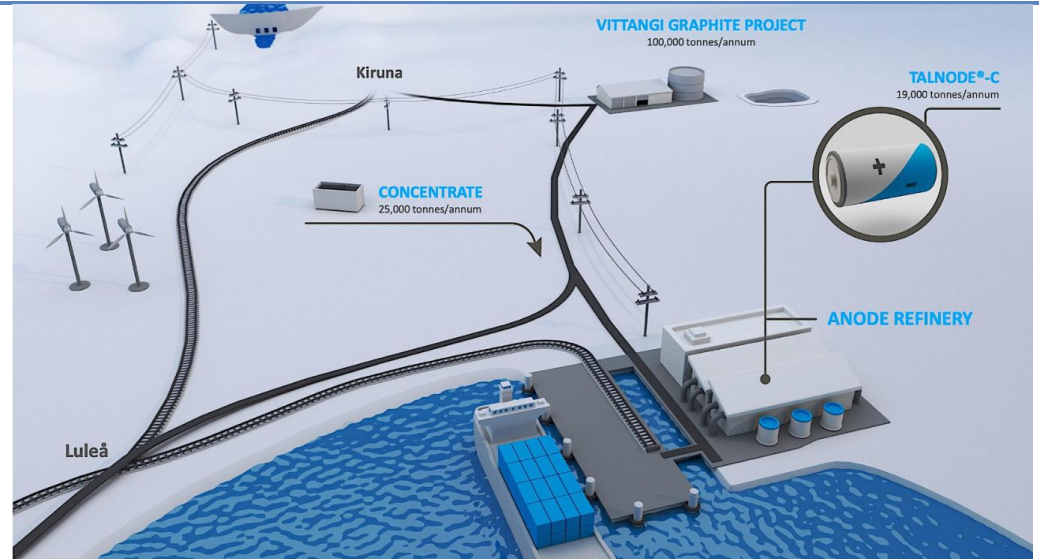
Source: Talga Resources

- Freezing conditions typically inhibit normal battery performance, forcing lower capacity retention and cycling efficiency, creating shorter runtimes for devices or shorter vehicle range. Under reduced temperature conditions, lithium plating occurs – the coating of electrode surfaces due to lithium ions reducing to a metallic phase.
- Practically speaking, the range of electric vehicles has been measurably impacted, falling up to 41% in cooler northern hemisphere countries (*source: American Automobile Association*).
- More significantly, cold temperatures can also cause dendritic deposits of lithium metal which perforate the protective separator, creating internal short circuiting or fire in the cell.
- A spate of electrical system failures across the Boeing 787 Dreamliner range in 2013 was traced back to cold winter overnight temperatures fostering lithium plating within the battery cells resulting in short circuits (*source: All Nippon Airways*).
- Cumulatively, validation indicates outstanding Talnode®-C performance against benchmark iterations.

## Robust Talnode®-C margins yield positive PFS development

- Talga Resources' Pre-Feasibility Study proposes a phased conventional open-pit mining operation with on-site concentrator and coastal anode refinery to produce, at final design, target 19,000tpa Talnode®-C.

### Swedish solution – Vittangi project anode production



Source: Talga Resources

- To lower initial capital expenditure and capitalise on near-term market opportunities, Talga will accelerate the commencement of Stage 1 with an expected output of approx. 5,000t Talnode®-C over the leading two years of development. Inaugurating in 2020, primary anode production is based on the trial mining of approx. 25,000t ore processed via toll milling-concentration and an early stage modular refinery operation.

### Ore Reserve Statement

- The portion of the Nunasvaara South MRE was selected for updating into Ore Reserve by Golders Associates mining consultants based on various impact preferences and defined Talnode®-C production targets. The Probable Ore Reserve Statement utilised totals 1.9Mt @ 23.5% Cg:

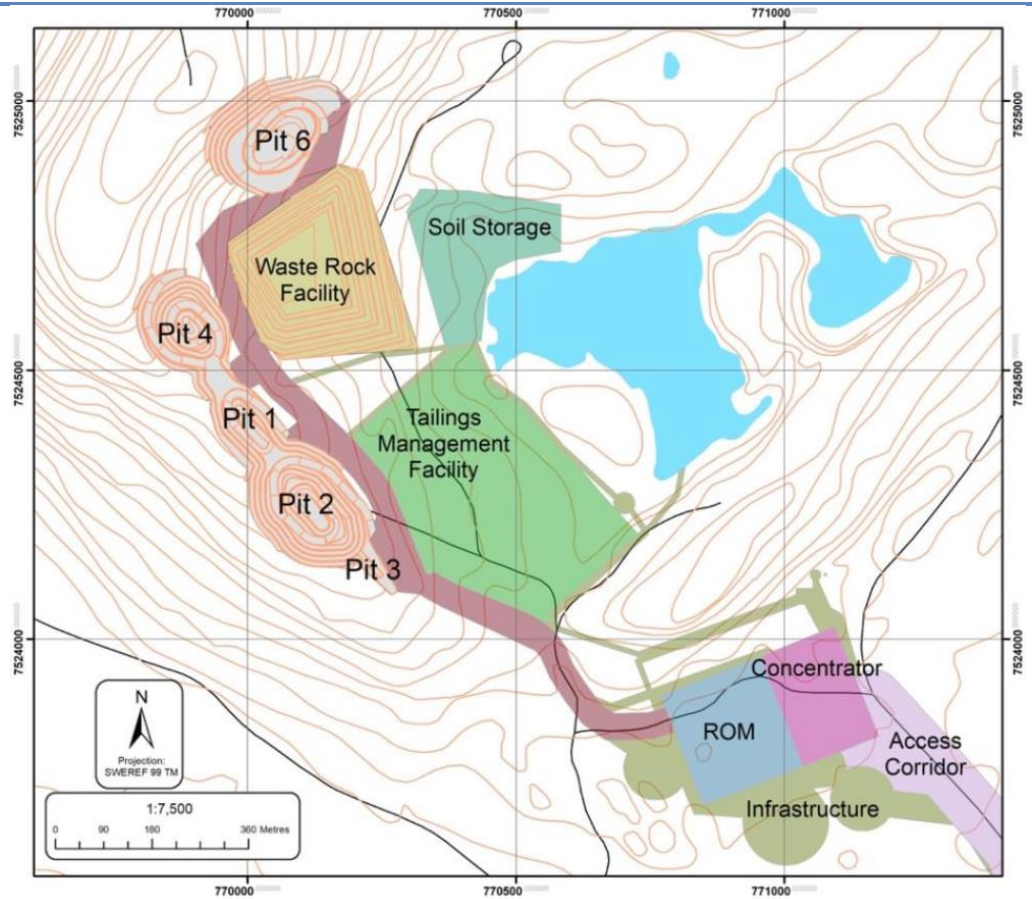
Vittangi Project Nunasvaara Ore Reserve				
Domain	Category	Tonnes (Mt)	Cg (%)	Contained Cg (t)
	Proven	0	0.0	0
	Probable	1.935	23.5	455,306
<b>Sub-total</b>		<b>1.935</b>	<b>23.5</b>	<b>455,306</b>

- The Ore Reserve is fully diluted for mining purposes with conservative parameters, having undergone optimisation to decrease early stage capital expenditure and lowered site impact. Ongoing optimisation targets high-grade components to raise early stage revenues.
- The Ore Reserve underpinning the current SP Angel valuation and Talga Pre-Feasibility Study was prepared by a Competent Person in accordance with the requirements in the JORC code.

### Mine design and production

- The Vittangi mining strategy proposes conventional open-cut mining, progressing from the southern-end northwards across five pits numbered 1, 2, 3, 4 and 5, presented below. Seasonal variations will allow the mining contractors to activate operations during the second and third quarter of the year.

### Summary layout of Vittangi mining and processing facilities



Source: Talga Resources

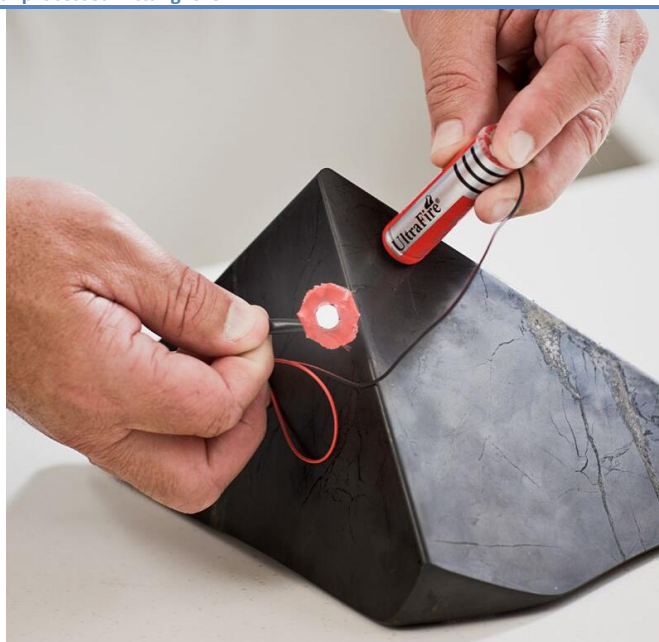
- The ultimate pit design focuses on multiple access points designed to minimise hauling distances to the dump, stockpiles, and crusher.
- The proposed annual rate of extraction of ore is approximately 100,000tpa life of mine, with the high-grade nature of Vittangi ore favourable to minimise mining volumes utilising 40-t articulated trucks.
- Drilling and blasting is proposed to take place on 5m bench heights, with estimated quantities of ore from each phase of development presented below. Ore recovery and dilution factors applied are 80% and 10% respectively.
- Cumulative waste extraction reached 6.9Mt with an average strip ratio across the 22 life of mine of 3.16, with the inherently high grade supporting stringent mining cost control.
- Talga also propose waste from pits 1, 2 and 3 to be used as construction material, with pits 4 and 6 backfilled into 1, 2 and 3. This strategy reduces hauling distances, waste dump footprints and reclamation expenses at the closure of the mine.

Vittangi Mining Profile				
Pit	Ore (Kt)	Waste (Kt)	Strip Ratio	Cg Grade (%)
1	306	754	2.47	24.98
2	754	2931	3.89	25.97
3	23	32	1.41	24.58
4	412	1547	3.76	27.32
6	704	1690	2.4	25.1
<b>Total</b>	<b>2199</b>	<b>6954</b>	<b>3.16</b>	<b>25.79</b>

### Metallurgical testwork

- Commencing 2017, Talga Resources have been proactively engaged in a comprehensive range of pilot and laboratory metallurgical programs, testing representative samples across the Vittangi project area.
- Vittangi ore comprises aggregates of microcrystalline graphite particles complexly intergrown with silicate and sulphide minerals. Ore mineralogy and characterisation has been derived from metallurgical programs:
  - High bulk density of ore and high-grade of graphite amenable to either crushing, or cutting of the ore into slabs;
  - High conductivity of ore as mined amenable to electro-chemical exfoliation methods; and
  - High crystallinity of aggregates amenable to ultra-fine grinding methods with excellent liberation and size distributions suitable for li-ion battery applications.

#### High conductivity of unprocessed Vittangi ore



Source: Talga Resources

- More recent metallurgical testing on 600kg sample of trial mined ore reveals successful anode material processing utilising industry standard crush-grind-flotation equipment for high recovery and purity:
  1. The first program conducted grinding tests on the Vittangi composite material to determine the grinding times needed to achieve P80 of 75  $\mu\text{m}$ , 150  $\mu\text{m}$  and 250  $\mu\text{m}$  in a laboratory scale rod mill ahead of flotation. Regrind and cleaner flotation was also tested. The test produced a high concentrate grade of 95.1% Cg at a high recovery rate of 91%, at premium sub-10 micron graphite flake size.
  2. A second program was completed with grinding and flotation test work on samples from the resource with the objective of producing high-grade graphitic carbon (Cg) samples and collect specific ultra-fine grind (UFG) regrinding energy requirements at different grind sizes. The energy requirement of 200kW/t was determined for the PFS design criteria which advantageously includes the micronisation stage normally achieved by separate jet attrition milling.

### Anode refinery testwork

- Characterised by microcrystalline flake graphite of <10 $\mu\text{m}$  concentrate via wet grinding techniques, the resultant anode processing phases for graphite micronisation using jet-milling and other grinding methods was not required in the flowsheet. This is critical

for Talga Resources in sustaining lowest quartile costs for anode material, while the process is not associated with >50% mass losses competitors are faced with.

- Testwork on alkali roasting and chemical purification has been finalised with successful refinement to >99.5%Cg purity anode products, with testwork underway on thermal purification to provide a lower eco-impact and use Sweden's sustainable hydro-power sources. The metallurgical test results confirmed graphite recovery of 88% from concentrate to final anode products.
- Total recovery applicable for the Pre-Feasibility Study focuses on 80%.
- Testwork also yields fully engineered coated li-ion battery anode material, Talnode®-C, via surface coating technology. Coated graphite powders offer higher initial discharge capacity with much improved rate performance, and enhanced cycle life compared directly to uncoated iterations.
- Talnode®-C product development and customer engagement focuses on chemical refining in a semi-continuous operation in Belgium. The value-add, battery-grade processing relies on Vittangi concentrates of varying grades and size distributions output from pilot concentrator at Core in Australia and Talga's Rudolstadt, Germany test facility. The pilot processing is in current use in 15kg batches and forms the basis for the PFS plant design.
- Talga will pilot thermal purification in the next phase of project development to provide a design basis for a thermal purification plant located in Luleå, Sweden.

## Processing facilities

### *Concentrator*

- The 25%Cg ore will be crushed in the pit during 6 months of the year with the crushed ore being trucked to a climate-controlled on-site concentrator building. The concentrator will operate year-round, where crushed ore is fed through a secondary crusher and to a ball mill until 80% passing 75µm.
- The ground ore is fed to rougher flotation circuit with selective reagents to collect a rougher concentrate in the froth and a gangue is collected in the tailings, which is sent to the thickener. The rougher concentrator is fed to regrinding mills and then further froth flotation cleaning to reduce the gangue minerals and produce a >92%Cg concentrate material.
- The cleaner tailings is combined with the rougher tailings in the thickener before being pumped to a filter for dewatering. The dry tails is trucked to a facility where it is stacked and stored above ground. The concentrate is filtered and stored in bags for trucking to the Refinery in Luleå.

### *Refinery*

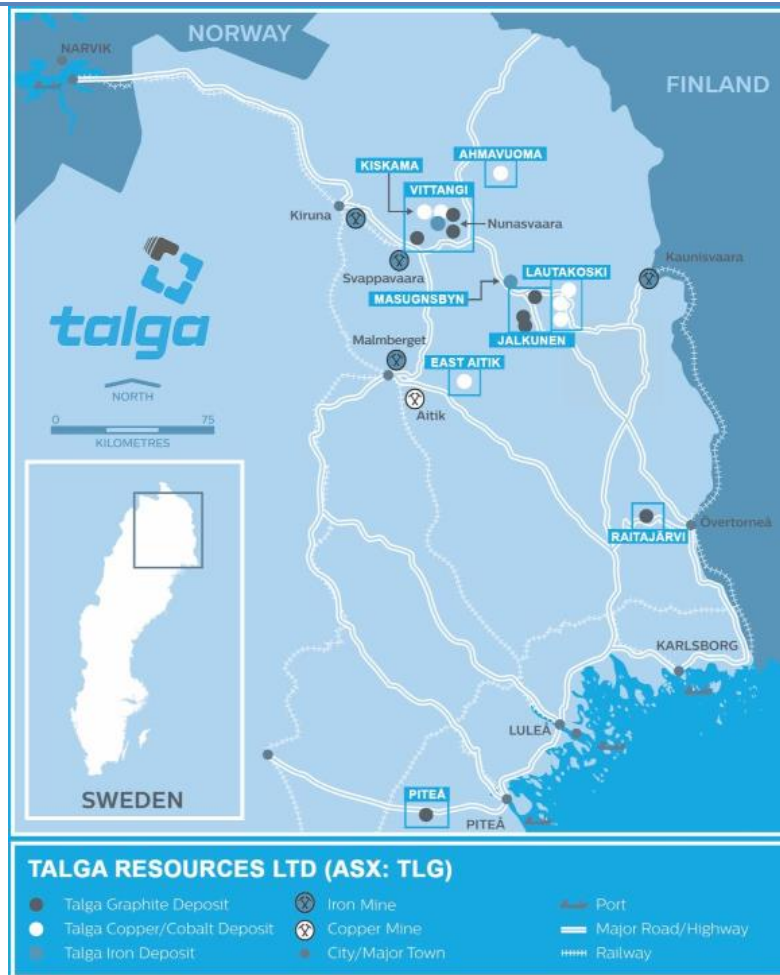
- The >92% Cg concentrate is then roasted together with alkali reagents to react with the graphite impurities. The impurities form salts during roasting and these are soluble in low pH solution and then washed from the graphite flakes using water.
- The filtrate wash water is collected and treated. The battery grade graphite product is then dried to produce uncoated, purified graphite material. All of the graphite material is made into coated anode material according to customer requirements by processing each batch through a range of shaping and coating equipment before being packaged and dispatched to customers in powder form.



### Nunasvaara Licence

- The Vittangi Graphite Project is located in northern Sweden, an experienced resource and investment jurisdiction with long-developed tradition of mineral extraction and processing. The Swedish government has signalled a high priority to develop every part of the value chain for “innovation minerals” in Sweden.
- Nunasvaara No. 2 is the exploration concession hosting the mine, being 100% owned by Talga’s Swedish subsidiary. The mineral exploration permit for Nunasvaara was issued by the Mining Inspectorate (Bergsstaten) in accordance with Swedish mineral law (Minerallag (1991:45)) and provides the holder rights to explore for minerals and first right to apply for an exploitation concession (mining lease) to mine identified mineral resources for 25-year period.
- The phased development allows Talga to apply for a second trial mine permit to extract 25,000t ore in Stage 1, followed by final-design exploitation at Nunasvaara South during Stage 2.

Map characterising the location of Nunasvaara mining area, and the coastal anode refinery location at the Port of Luleå



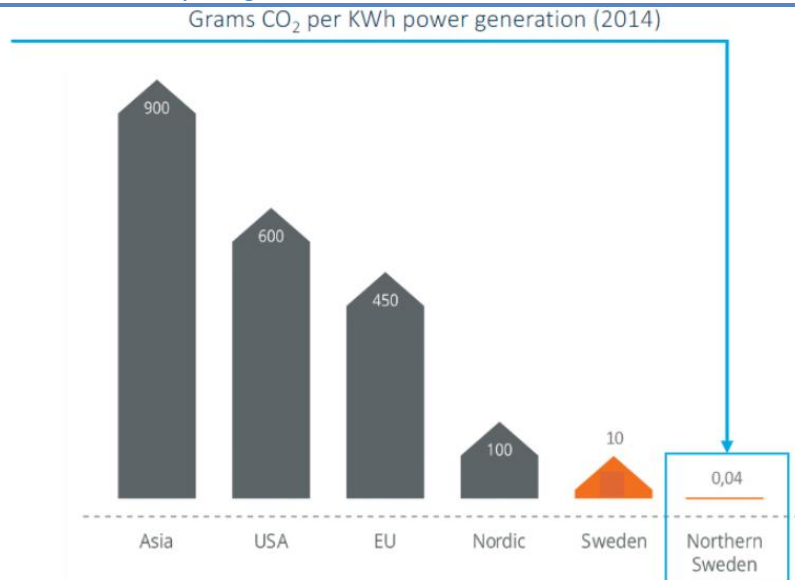
Source: Talga Resources

- Both the Mine and Refinery are located in areas well connected to relevant existing infrastructure such as an extensive highway network, a state-owned railway, nearby deep-sea ports allowing for container shipments, high quality optic fibre networks and accessible low-cost, low-CO<sub>2</sub> hydroelectrical power.
- Talga products will be packaged and containerised on-site at the Refinery for customer distribution, with the Port of Luleå located next to the Port of Piteå, the largest container port available for export with regular container shipments and year round weekly shipments to Germany (Hamburg) and the UK (Hull).



- The mine will be connected to the regional grid power, requiring installation of a new power line from Svappavaara, and operated by JBF (Jukkasjärvi Sockens Belysningsförening). At the refinery in Luleå, a connection will be made to the grid operated by Luleå Energi who are planning the installation of an additional substation for the new area development.
- The project will have access to low-cost and low-CO<sub>2</sub> sustainable power, with capacity of >18TW/annum hydroelectric and 12TW/annum wind. Access to clean, renewable energy is significant, with Volkswagen Group announcing it will place equal importance of CO<sub>2</sub>-neutral supply chain as procurement cost.

#### Low cost and low CO<sub>2</sub> renewable power generation



Source: Data and graphic courtesy of "Invest in Norrbotten"

#### Environmental and social responsibility

- Fundamental to the Vittangi project, Talga is coordinating efforts toward environmental approvals for Nunasvaara South submitting a detailed Environmental Impact Assessment (EIA). PFS parameters focus on developing a high-grade low-volume operation designed to minimise environmental footprint upon closure.
- The environmental studies to date, along with upcoming studies and the completion of the EIA, intends to ensure that environmental concerns are integrated into the proposed development, focusing on preventing, minimising, mitigating and/or compensating for possible adverse environmental impacts which may arise due to the proposed development. The required EIA is currently underway with planned timing for submission being Q3 2019, in conjunction with the planned exploitation (mining) permit application.
- Award of an exploitation concession (bearbetningskoncession) is derived under the Minerals Act, giving the holder the right to exploit a proven, extractable mineral deposit. Despite encouraging signals from the Swedish government proposing investment and development of a supportive domestic battery industry, prolonged lobbying of neighbours Beowulf Mining highlights potential delays to the PFS development plan. The protracted application and defence of the Country Administrative Board highlights the need for a more reactive Swedish government to support the swelling European battery industry.
- This become more relevant when combined with the growing capacity of start-up Northvolt, who intend to develop the first large-scale battery factory established in Skellefteå, northern Sweden, for 32GWh capacity.
- Talga demonstrated successful rehabilitation efforts following completion of trial mining operations in 2015 and 2016, approved by the relevant government agency, resulting in the timely return of paid mining bonds.

- Supplementary revegetation work is planned to support reindeer herding activity, emphasising the company's dedication to achieving sustainable outcomes that equally backs stakeholders, partners and the environment.
- The Company commitment focuses on operating responsibly with positive social integration, with Talga highlighting positive stakeholder and community relations on all levels – local, regional and national – are key to achieving and maintaining the legal and social licence necessary for the success of the project.
- The Company has been working proactively with the local community and other Project stakeholders since exploration commenced in 2011. Talga has already completed a socio-economic study, and is engaged closely with local community groups, regional and national government representatives to receive feedback and form economic co-operations.

#### **Talnode®-C product marketing**

- Determined evaluation tests and market qualification efforts over the last 12 months has demonstrated the suitability of Talnode®-C as a fully engineered, coated anode electrode powder, with ongoing testwork giving robust indication for premium electrochemical properties.
- Delivery of refined carbon materials offer competitive supply sources against dominating Chinese natural and synthetic raw material supply. As proposed by Benchmark Mineral Intelligence, the number of European Gigafactories is expected to increase from 22GWh in 2018 to 268GWh by 2028, with CAGR of 30%.
- Benchmark estimate that post-2020 the demand of natural graphite could reach 40% - 50% of the total demand. Therefore, it is reasonable to assume that the market for li-ion batteries will consume 400,000 - 500,000tpa of natural graphite, forecasting graphite consumption of >2M tpa by 2028.
- Through 2019, Talga has been scaling up capacity to supply larger quantities (20-50kg samples) of Talnode®-C to potential end-users. Engagements are supporting the development of product pricing, with current contracts often negotiated between consumers and producers based upon the performance of anodes relative to other materials, with ranges for pricing of the same material varying wildly.
- Talnode-C pricing in the PFS is based on a Talga commissioned report by Benchmark Mineral Intelligence, a globally recognised leader in research data specialising in independent price assessments of li-ion battery raw materials, including graphite anodes.
- The price assumed for Talnode-C, taking into account its high-performance specifications and applying a 20-30% discount to take account of long-term offtake pricing and other marketing costs, is US\$11,250 per tonne of product. This price is supported by li-ion battery market interactions and customer feedback received.

#### Value attributed across Li-ion battery supply chain

	Mining	Processing	Refining	Anode Production	Li-ion Cells
Quality	10% C	94-96% C Size:75um->350um	99.95+% C Micronised Shaped, Size:10-20um	99.95+% C Surface Treated, Coated or Si/Graphene Enhanced	Current collector
Product	Ore	Natural Flake Graphite Refractory or Steel Grade	Natural Spherical Battery Grade	Active Anode. Specialty Chemical Grade to Customer Spec*	Li-ion battery cell for Portable, Stationary Transport/EV packs
Prices	US\$	\$ 0.75 - 1.5/kg	\$ 3 - 4/kg	\$ 8 – 13/kg (Standard energy) \$ 15 – 20/kg (High energy) \$ 25 – 55/kg (Si/SiO energy)	\$ 127/kWhr (2018)

Source: Roskill, Benchmark Minerals, Bloomberg, Talga Analysis

- Cruising altitude full-scale production as a percentage of global demand gives ample surplus for production expansion to capture future growth. Accelerating European demand could theoretically absorb a Vittangi graphite project with scale 5x the proposed Pre-Feasibility Study to coordinate with Asian competitors.

Talnode®-C production as percentage of forecast Global (left) and European (right) LiB graphite anode material demand in 2028



Source: Benchmark Minerals Intelligence

- To stay relevant to Asian growth expectations, European manufacturing capacity and supporting value chain will require sustained investment. Chinese firms Shanshan Technology, BTR New Energy Materials and LuiMao Graphite (in association with BAIC Automotive) are building li-ion battery graphite anode megafactories with a total processing capacity of 260,000tpa of anode product. In Japan, Hitachi Chemical is planning another facility to process 100,000tpa to add to an estimated capacity of around 200,000tpa.

#### Development timeline

- The phased PFS has evaluated development plan with an initial smaller capital investment in Stage 1, focusing on trial mine permitting with toll processing and a smaller refinery operation to deliver Talnode®-C and capitalise on accelerating market opportunities.
- The subsequent phase 2 moves to full-scale production upon receipt of the Nunasvaara exploitation concession and environmental approval.

#### Vittangi project indicative development schedule

	2019	2020	2021	2022	2023	2024
<b>Stage 1 Development</b>						
Trial Mine Approval						
Definitive Feasibility Study						
Mining & Ore Processing						
Design & Construction						
Commissioning						
Talnode-C Production						
<b>Stage 2 Development</b>						
Mine Approvals						
Definitive Feasibility Study						
Mine Establishment						
Design & Construction						
Commissioning						
Talnode-C Production						

Source: Talga Resources

- The indicative schedule relies on coordinated funding, completion of the Definitive Feasibility Study, obtaining relevant permits and approvals, and the Company making the final development decision.

#### Stage 1 development plan

- The development plan for Stage 1 to install capacity to produce 2,500 tpa of Talnode®-C include:
  - Submitting a trial mine permit application for extraction of 25,000t of ore with approval targeted to be received in Q1 2020;
  - Submitting an application for construction of Stage 1 Refinery in Luleå and associated operating licences, including environmental permits. In parallel, completing the DFS along with preliminary mine development in Q1 2020;
  - Completing a detailed design and construction of the Stage 1 Refinery during 2020 while commencing trial mining and toll-processing of ore; and
  - Commissioning of Stage 1 Refinery at Luleå in 2021 and commence production of 2,500tpa Talnode®-C.

#### Panoramic detailing the trial mining method during 2015-2016 period



Source: Talga Resources

### Stage 2 development plan

- The development plan for Stage 2 to install capacity to produce 19,000 tpa of Talnode®-C include:
  - Submitting applications for a full-scale 100,000tpa mining and ore processing operation with approvals targeted to be received in Q1 2021 and completing the DFS in Q4 2020;
  - Completing the detailed mine design, and construction of the concentrator and the Stage 2 Refinery during 2021 while establishing the mine and associated infrastructure; and
  - Commissioning of the full-scale Stage 2 Refinery in 2023 and commence production of 19,000tpa of Talnode®-C.

### Financial evaluation

- SP Angel commercial assessment evaluates the Vittangi Graphite Project utilising key operational and financial parameters:

#### Vittangi Operational Summary - Phased

Operating Outcomes		Unit
Nunasvaara South Ore Reserve	1.9	Mt
Cg head grade	23.5%	%Cg
Cut-off head grade	12%	%Cg
Contained graphite	4,553	kt
Life of Mine (LoM)	22	yrs
Talnode®-C anode powder	99.5%	%Cg
Mining dilution	10%	%
Ore recovery	80%	%
Strip ratio (LoM)	3.16	x
<b>Phase 1</b>		
Phase 1 LoM	2	yrs
Trial ore processed	25,000	t
Talnode®-C capacity	2,500	tpa
<b>Phase 2</b>		
Phase 2 LoM	20	yrs
RoM ore feed	100,000	tpa
Process recovery	80%	%
Talnode®-C capacity	19,000	tpa

- Total capital costs for Stage 1 and Stage 2 are provided by the company, cumulatively incurring US\$174m. Capital costs have been prepared on the basis of ±25% and incorporate contingencies of 20% of direct costs.

#### Capital Cost Breakdown

Initial Capital		Phase 1	Phase 2	Unit
Mine & Ore Processing	Mining & Crushing	0	5	US\$m
	Concentrator	0	27.3	US\$m
Refinery Plant	Purification	10.8	29.5	US\$m
	Coating	3.2	11.2	US\$m
Indirect Costs	Purification	4.6	22.1	US\$m
	Coating	1.1	4.3	US\$m
Contingency (20%)		4.9	25	US\$m
Sub-total - Mine & Processing Plant		24.6	124.4	US\$m
Infrastructure		2.2	23.1	US\$m
Total project capex		26.8	147.5	US\$m
Working Capital (1.5% annual)		0.4	2.2	US\$m
Sustaining Capital (1.5% annual)		0.4	2.2	US\$m



- Operating costs have been prepared on the basis of  $\pm 30\%$ , with an additional 15% contingency applied to individual components of the operating costs for selective unforeseen undefined areas or elements of cost which will be incurred within the defined scope of operating costs.

Operating Cost Breakdown				
	Phase 1 (US\$m)	Phase 1 (US\$/t)	Phase 2 (US\$m)	Phase 2 (US\$/t)
Cash Costs				
Overburden	0.5	100	84	221
Mining	0.6	120	49.2	129
Mineral Processing	13.7	2,740	141.3	372
Anode Processing	13.2	2,640	389.1	1,024
Transport	1.1	220	47.8	126
C1	29.1	5,820	711.4	1,872
Rehabilitation cost		0.1	US\$/t waste	

- Vertical integration, phased-development, stringent cost controls and high margins for the premium high-performance fully engineered and coated lithium-ion battery anode product supports superior project economics for Vittangi Graphite Project, yielding post-tax NPV<sub>8</sub> of US\$767m with strong 51.0% IRR.**

Financial Outcomes	PFS	Unit
Graphite product	4,000	US\$ basket price/t
Talnode®-C capacity	11,250	US\$/t
Gross revenue	3947	US\$m
Project NPV8 (pre-tax)	1006	US\$m
Project NPV8 (pre-tax)	1341	AUD\$
Target Share Price (pre-tax)	6.10	AUD\$
Growth Factor (pre-tax)	13.6	x
IRR	60.6%	
<b>Project NPV8 (post-tax)</b>	<b>767</b>	<b>US\$m</b>
<b>Project NPV8 (post-tax)</b>	<b>1022</b>	<b>AUD\$</b>
<b>Target Share Price (post-tax)</b>	<b>4.65</b>	<b>AUD\$</b>
<b>Growth Factor (post-tax)</b>	<b>10.3</b>	<b>x</b>
<b>IRR</b>	<b>51.0%</b>	
Royalty	3.5%	
Corporate tax	22%	

- In deriving a 12-month price view for Talga Resources, SP Angel take a 40% risked valuation of the project in light of the early-phase of development and potentially protracted market growth opportunities within the nascent European lithium-ion battery industry. This is equivalent to approx. A\$1.80/share (~4.1x growth), and we fully expect the target price to appreciate with additional technical study.**

### Funding

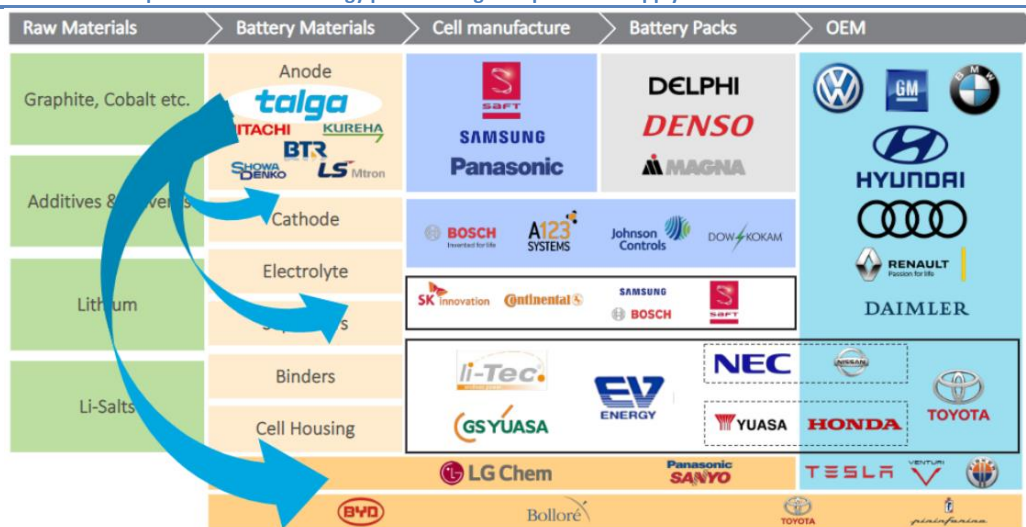
- The phased development schedule targets minimal capital investment risk, operating expenditures and funding requirements while capitalising on the accelerating li-ion battery industry to generate revenue prior to full-scale commercial production. The action provides an achievable avenue for rapid payback of 1.75 years following the commencement of Stage 2 commissioning.
- Decarbonisation targets are drawing significant investment focus on sustainable battery raw material supply across the energy mineral industry. Evident from the proactive investment strategy from VW Group, there is growing importance placed on sustainable



and ethical sources with traceability and auditing of supply chains evident e.g. Minespider blockchain technology.

- The trend is drawing partnerships, strategic and commercial models between industry players, which continue to offer more exotic funding opportunities and OEMs offering direct investment to secure long-term raw material supply.

#### Value-add anode products and technology position Talga deeper in the supply chain



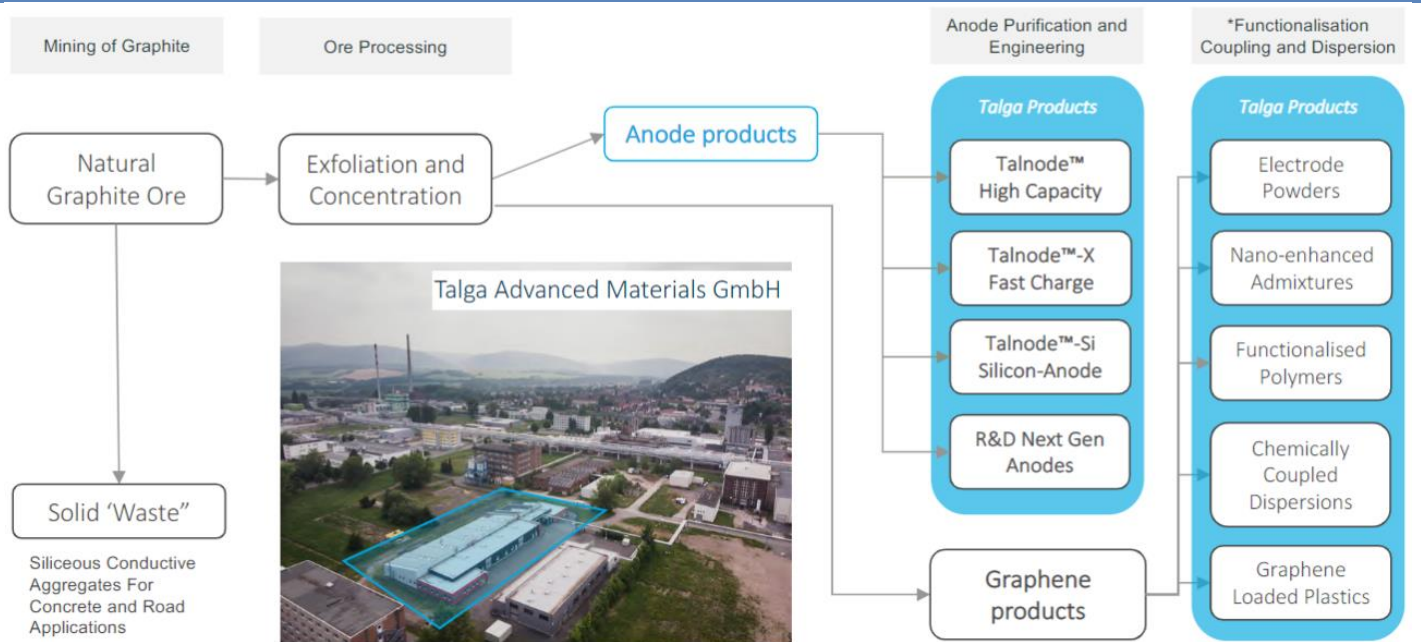
Source: Recruit, Avicenne

- Alongside funding initiatives, Talga will look to continue to optimise and reduce capital and operational cost requirements, including evaluating the option using thermal purification, further validation of Talnode®-C with potential customers and building the relevant qualified management team to ensure successful design and construction of the mine and processing facilities.
- To support the ongoing transition from explorer to developer, Talga Resources closed the March 2019 quarter with A\$10.9m cash-in-bank.

#### Technical upside

- The current SP Angel valuation and Pre-Feasibility Study is defined on the production and revenue potential from Talnode®-C active anode powers. Talga Resources are proactively engaged in the research and development of supplementary value-add products across the graphite and graphene suite presented below.

## Talga Resource suite of graphite and graphene derived value-add products



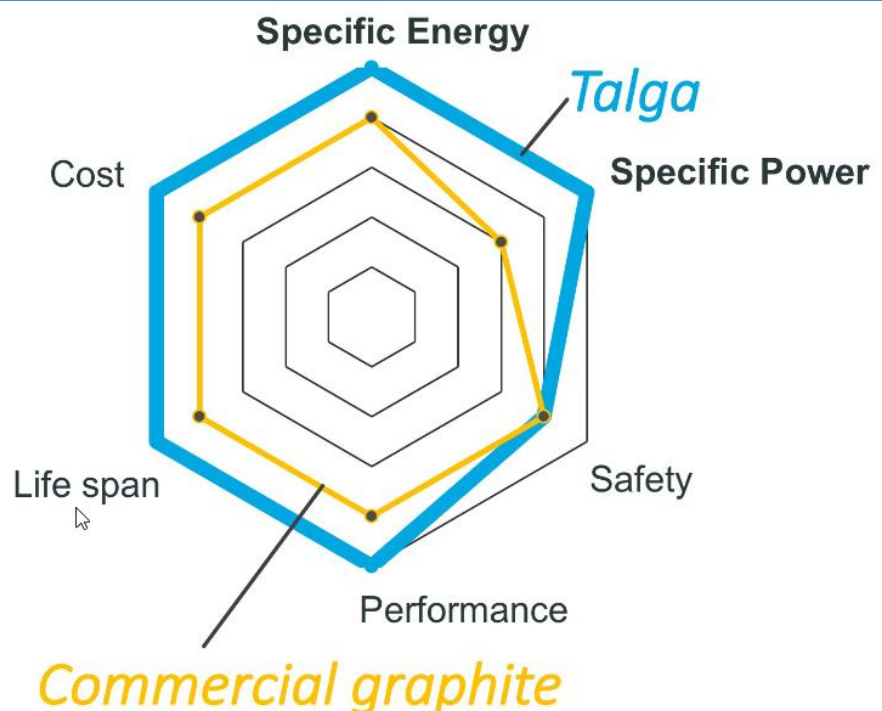
Source: Talga Resources

- SP Angel foresee Talga Resources' unlocking significant value upside from the commercialisation of graphite and graphene product suite into specialist advanced materials markets.

## Next generation compositions under development

- Meaningful performance and test results highlight the potential for Talga graphite anodes to represent premium products exceeding synthetic and natural standards of current commercial examples. The industry-beating results signify the higher performance, energy, power and life span potential at lower cost and no decrease in safety.
- The premium nature of the product also offers Talga commercial advantage of entering the Li-ion anode value chain at a more development point with higher prices associated.

### Illustrative summary of 'premium' Talga battery cell characteristics



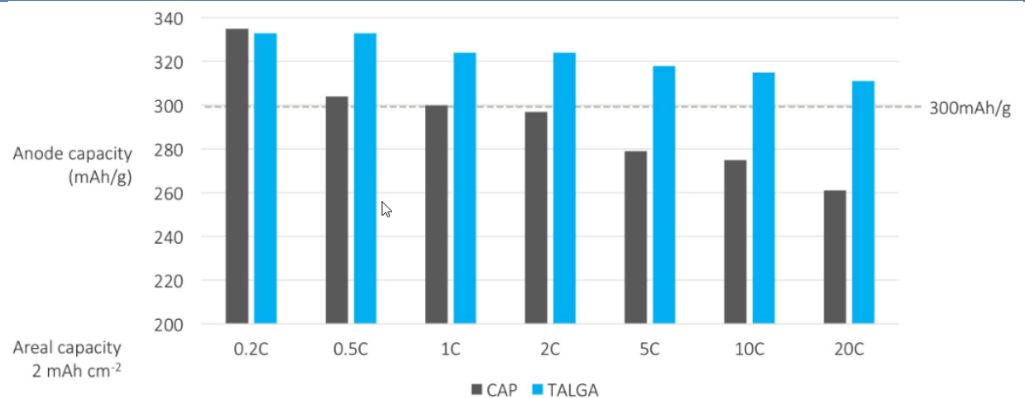
Source: Talga Resources

- Talga moved to trademark its range of Li-ion anode products as “Talnode™” products, with unique designation based on the formation and application.
- Development and testing of Talnode™ products continues across multiple battery test facilities, with parameters including customer protocols and specifications, with results benchmarked against current commercial anode materials.
- The company report a series of non-disclosure and sample transfer agreements have been executed with a range of European, Japanese and Korean automotive, electrical goods and Li-ion battery manufacturers to support continued technical and commercial discussions.
- Potential outcomes include technology and product development partnerships, off-take and distribution agreements, and project/manufacturing partnerships.

### Ultra-fast charging

- Accelerating development from May 2018, Talga has subsequently conducted high charge condition testing of a related but new anode product “Talnode-X” at a leading independent European battery test facility. The test results indicate active anode material outperforming the global leading commercial anode product (“CAP”) across a range of charge rates and achieved a very high charge capacity of >300mAh/g at an ultra-fast charge rate of 20C.
- In real world terms, the anode performance translates to 100% charging in 3 minutes without losing its capacity.
- By comparison, top-tier conventional graphite cells lose capacity when charged at a rate of only 5C.

**Battery capacity at increasing charge rates indicating higher capacity Talnode™-X, retaining over 300mAh/g at ultra-fast charge rates up to 20C or 3 minutes**



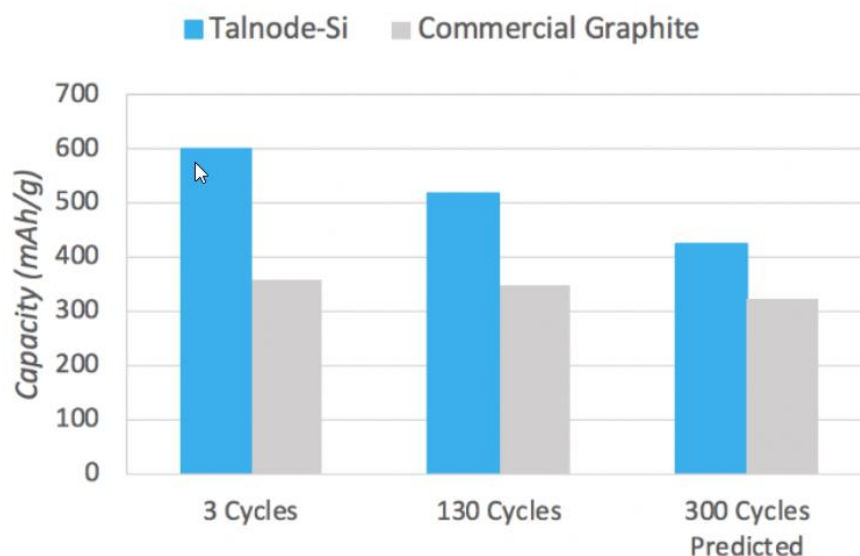
Source: Talga Resources

### Silicon anode

- Higher energy density requirements are drawing significant industry investment in research and development, with next-generation iterations offering enhanced performance (range) with minimised cost per unit energy.
- Battery engineers have suggested ‘secret sauce’ silicon for double-digit improvements to theoretical energy storage capacity; raising to 4,200Ah/kg compared to 372Ah/kg for graphite (*source: Sigma-Aldrich*).
- A broad range of technology development companies, including BTR, Panasonic, Hitachi and Maxell, are investigating the incorporation of higher concentrations of silicon into anode materials, with current graphite blending approximately 3-5% loadings.
- Inherently, silicon presents practical implications due to three significant issues:
  - Poor life-cycle: Resulting from pulverisation during large volumetric fluctuations (>300%) associated with lithium ion intercalation and deintercalation.

- Mechanical failure: can cause irreversible capacity loss and low coulombic efficiency.
- Solid electrolyte interphase breaking during delithiation (removal of lithium from the Li-ion battery electrolyte).
- Under the 'Faraday Challenge' initiative, Talga is developing a high-capacity silicon anode utilising in-house Talphene® graphene – dubbed 'Safevolt'.
- The 'Safevolt' program, run in conjunction with consortia partners Johnson Matthey (one of the UK's largest battery companies and leading global cathode material manufacturer), the University of Cambridge and manufacturing research group, TWI (The Welding Institute).
- The UK government has allocated funds of £246m to promote new battery technologies and establish local manufacturing and supply chains. Talga has been granted 70% rebates against eligible costs (~£830k) over a 2-year period.
- The 'Safevolt' project aims to achieve cells with 60% improved energy density and 30% reduced weight.
- Under 'Safevolt', Talga and TWI will develop and supply graphene-silicon hybrid and graphene-metal alloy anode materials to match high voltage cathode materials being developed by Johnson Matthey.
- Following initial test results in October 2018, further optimisation of Talnode®-Si with up to 15% silicon loading has generated significant enhancements from the battery material facility in the Maxwell Centre of Cambridge University, including:
  - ~70% higher reversible capacity (~600Ah/kg) against commercial graphite (~350Ah/kg)
  - Coulombic efficiency of 99.5%-99.9% with first cycle efficiency ~91%
  - Up to 94% reversible capacity (after >130 cycles across a range of silicon loadings)

[Capacity tests of Talnode®-Si versus commercial graphite reference](#)



Source: Talga Resources

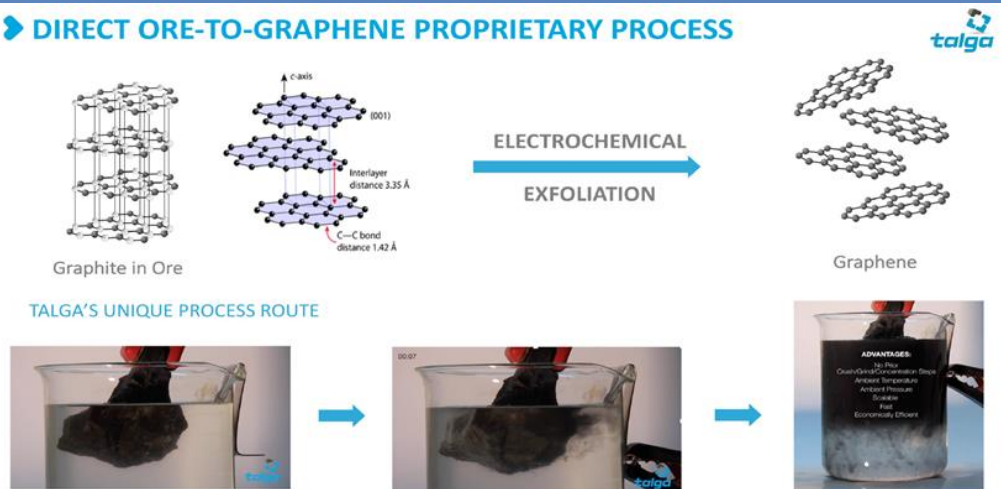
- Commercial samples have been prepared, under confidentiality and material transfer agreements, with delivery having commenced during February 2019. The company highlight recipients include some of the world's largest electronics companies.

### Conductive agent – Graphene

- Graphene applications within energy storage systems is developing organically, with Talga Resources principally focused on accelerating Talnode®-C products to commercialisation to capitalise on the swelling European battery markets.
- Breakthrough processing pathway developed for Nunasvaara graphite has demonstrated a simplified and effective method to extract graphene in bulk quantities utilising single-phase graphite liberation. Robust investment at the Advanced Materials GmbH test facility in Rudolstadt, Germany is yielding promising results for industrial-scale graphene production via electrochemical exfoliation.

#### Talga's unique graphite to graphene pathway

### ► DIRECT ORE-TO-GRAPHENE PROPRIETARY PROCESS



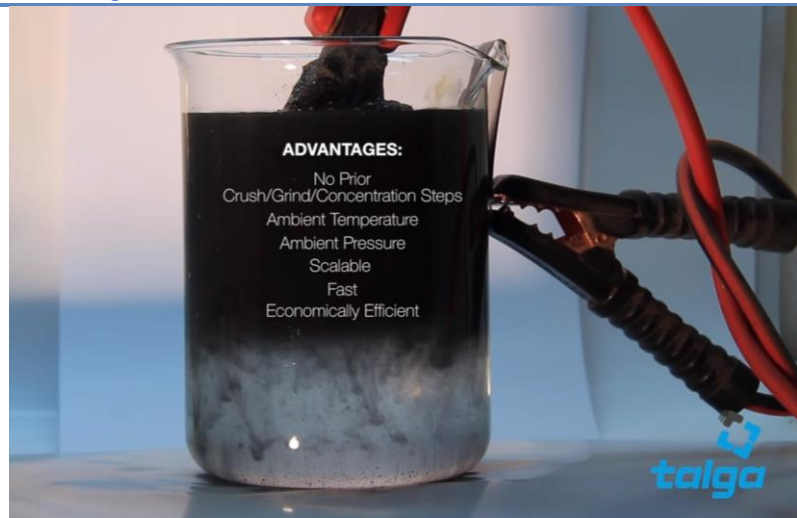
Source: Talga Resources

- Trial mining during 2016 extracted 5,000t graphite ore to demonstrate the scale-up of process test work, with significant stockpile remaining for ongoing research and development.
- The atomically thin layer of carbon atoms, graphene, exhibit remarkable material properties. The combination of high electrical conductivity, chemical and thermal stability, and excellent stretchability provides considerable advantages for the use of graphene in a broad number of end-use markets.
- Isolated graphene was found to exhibit a high charge carrier mobility ( $2 \times 10^5 \text{ cm}^2/\text{Vs}$ ), high thermal conductivity ( $\sim 5000 \text{ W/mK}$ ), exceptional Young's modulus ( $\sim 1.0 \text{ TPa}$ ) and large theoretical specific surface area ( $2630 \text{ m}^2/\text{g}$ ). Moreover, a single graphene layer absorbs only 2.3% of incident light and therefore has a transparency of 97.7%, according to an article exploring exfoliation process methods "*Exfoliation of graphene via wet chemical routes*".
- The microchemical cleavages within graphite can be utilised to extract pristine graphene, however previous methods fail to yield industrially significant high-quality production.
- The method of electrochemical exfoliation is an excellent approach to producing high-quality graphene, according to the above article (available <https://www.sciencedirect.com/science/article/abs/pii/S0379677915300229>). The utilisation of a conductive liquid electrolyte and direct electrical current to drive structural expansion within graphite to split off the graphene layers offers a number of advantages, including;
  - (1) low cost of operation (executable at ambient temperature and pressure) and high control over the synthesis process (functionalization and/or exfoliation can be tuned by varying the electrolysis parameters)
  - (2) scalable mass production potential and relatively fast synthesis rates



(3) liberation of graphene flakes without physical and chemical damage enables higher performance products with lower oxidation and higher conductivity

#### Talga's graphene advantages

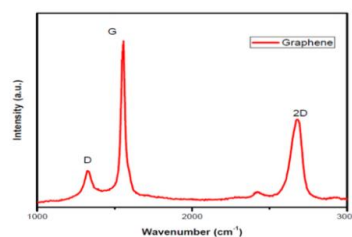


Source: Talga Resources

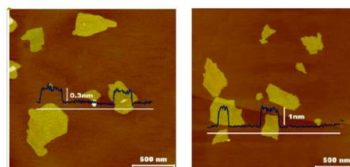
- The highly homogeneous nature of the raw graphite ore enables consistent manufacture of high-quality 1-5-layer graphene. First sale was completed in July 2014 to German group Microdrop Technologies, and more recently BASF and Haydale, with the company focusing on testing and engineering towards full scale production in Sweden.
- Phase 2 circuit stages have been completed since September 2016, expanding capacity and providing real world data. The production process begins by 'unzipping' layers of graphite at an atomic level from Talga's raw ore slabs in custom designed electrochemical exfoliation cells, followed by proprietary recovery, concentration and functionalisation stages. The company are focused on enhancing processing methodology with ~76% input graphitic carbon reporting to high-purity graphene products, verified by multiple industry measures including Raman spectroscopy and atomic-force microscopy.

#### Talga's graphene process delivers high quality, conductive products

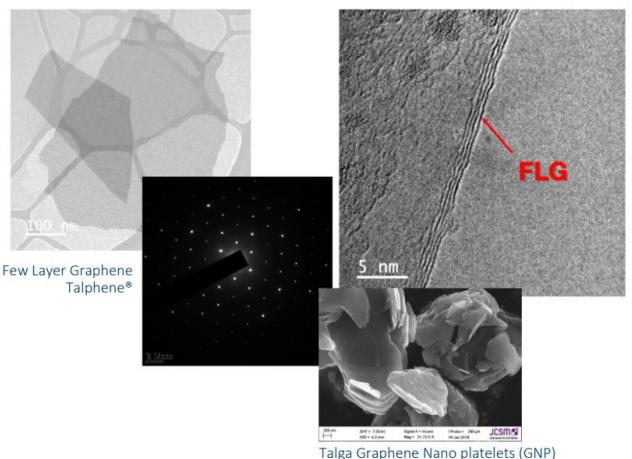
##### RAMAN SPECTROSCOPY



##### ATOMIC FORCE MICROSCOPY



##### TRANSMISSION AND SCANNING ELECTRON MICROSCOPY (TEM / SEM)



Source: Talga Resources

- Functionalised graphene, branded Talphene®, is undergoing stringent development as an additive for Li-ion battery cathodes. The "wonder material" graphene offers superior electrical conductivity, good chemical tolerance, layered structure (*two-dimensional material consisting of only carbon atomic layers of a honeycomb-like lattice*) and large surface area, which offers a highly conductive framework to be wrapped around cathode chemistries such as LiFePO<sub>4</sub>.

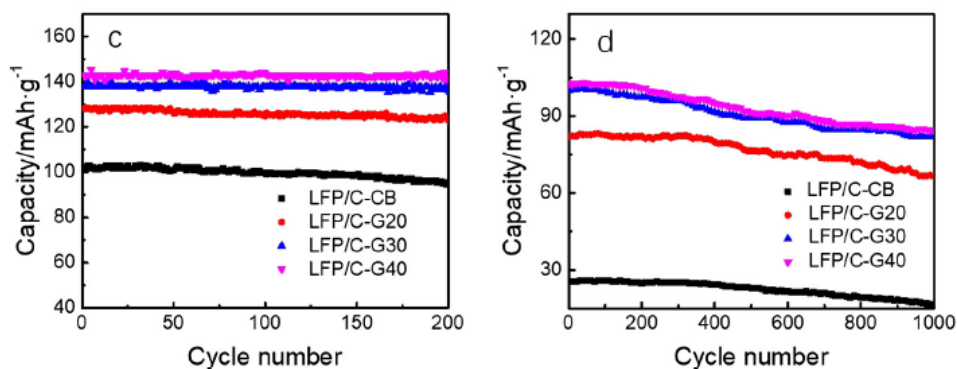




Source: Talga Resources

- The conductive carbon could construct a framework for high-speed electron transport, delivering enhanced electrochemical rate performance i.e. cathodes with high specific capacities at ultrahigh current densities for high-power lithium-ion batteries.
- Wei et al<sup>2</sup>, demonstrate electrodes with 30% wt. graphene loading (LFP/C-G30) exhibits discharge capacities of 152, 128 and 68Ah/kg at current rates of 1C, 10C and 50C, respectively.

Electrochemical performance of LiFePO<sub>4</sub> cathodes with different conductive agents: c) cycle stability at 5C for 200 cycles, d) cycle performance at 30C for 1000 cycles



Source: Wei et al., (2018)

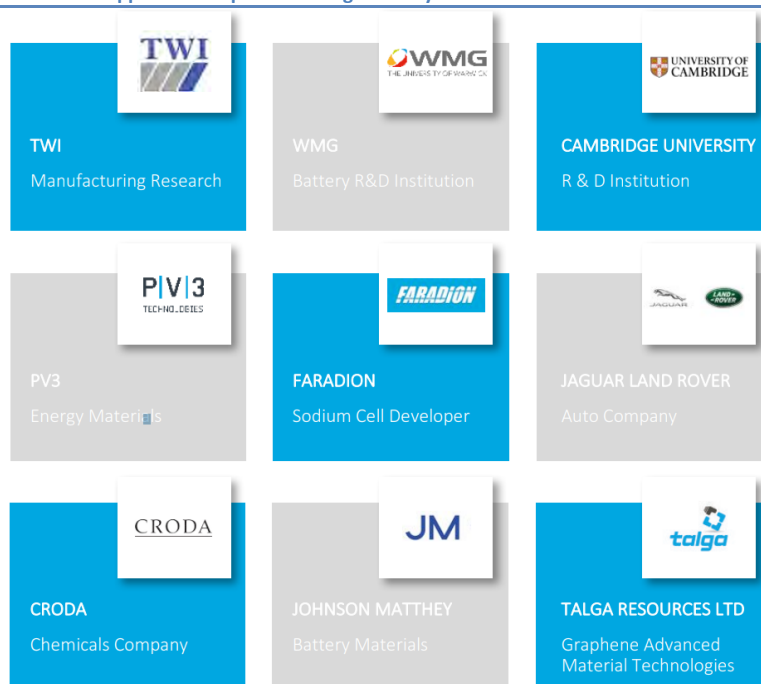
- While further down the development timeline for Talga Resources, the implications for high power next-generation Li-ion batteries are significant. Scalable, economically efficient production of exfoliated graphene could place Talga at the forefront of the future decarbonised economy, powering long-range electric vehicles and aviation.

<sup>2</sup> Improvement on high rate performance of LiFePO<sub>4</sub> cathodes using graphene as a conductive agent – Xufang Wei et al., (<https://www.sciencedirect.com/science/article/pii/S0169433218302198>)

### Collaborative partnerships

- Talga Resources have signed binding collaboration agreements to support the ongoing development and integration of battery technologies, including Jaguar-Land Rover, Johnson Matthey, Croda, Faradion, PV3, Cambridge University and Warwick Manufacturing Group.

#### Collaboration partners to support development of Talga battery materials



Source: Talga Resources

### Integrated advanced materials to unlock future of graphene

- While not incorporated within the released PFS in May 2019, the impact of industrial-scale graphene production cannot be understated for the growth potential of Talga Resources. Discovered in 2004 during Prof. Andre Geim and Prof. Kostya Novoselov's "Friday night experiments", the innovative advanced material has untold potential to disrupt future industries.
- The two-dimensional atomic layer of graphite displays properties favourable for innovative technology markets. Graphene is more robust than diamond, measuring the strongest discovered material equivalent to 40x gemstone strength. The material is also flexible, thin (1mm = 3 million sheets of graphene), lightweight, transparent and an excellent conductor of electricity and heat.
- McKinsey Global Institute identified 12 potentially economically disruptive technologies, where advances will transform life, business and the global economy. Properties of graphite and graphene are expected to support at least 8 of these segments (indicated by Talga Resources symbol), giving robust outlook for consumption.
- Graphene's superlative properties encourage broad use with applications in energy, electronics, high-strength bulk materials, carbon fibres, coatings, sensors and membranes for purifying water and many more (source: Talga Resources). However, the majority of potential products are currently in early development phases and due to high production costs and/or lack of scalability, have not yet been commercialised outside sporting goods and specialist composites.
- In 2017, 58% of the world's graphene patent applications were from China, according to a Ministry of Industry and Information Technology report. Growth across the future material markets is expected to accelerate as China lifts investments in clean technologies to reduce pollution, driving increasing demand for electrification (batteries) and lighter,

stronger, multi-functional materials, providing a boon for the upstream graphene industry.

- Graphene as a commercial product is typically marketed as either bulk powder, dispersion in solution or small areas of continuous thin film, with variable extraction methods such as chemical vapour deposition (CVD), mechanical or electrochemical exfoliation and epitaxial growth. While no universal standards exist for graphene materials, some organisations such as ISO have begun publishing standards terms and definitions. Generally classification can be defined by the number of sheets in the particle:




#### Graphene definition and approximate offer price (2016)

	# sheets	Offer price (US\$/kg)
- Graphene (monolayer)	1	~\$750
- Few layer graphene (FLG)	2 - 5	~\$100 - \$250
- Multilayer graphene (MLG)	2 - 10	~\$40 - \$60
- Exfoliated graphite "graphene nanoplatelets" (GNP)	> 10	~\$30 - \$50

Source: Carbon Journal, fullerex

- While nanomaterials broker Fullerex foresee the principal industrial segment as composites, consuming almost half bulk graphene market by 2024, the rapidly advancing electric economy is the major driver for the advanced material.
- Gradually falling graphene costs, declining by approximately 8% per year to \$165/kg by 2020 (source: Goldman Sachs), is leading to adoption by primary consumers of Lithium iron Phosphate (LFP) technology such as BYD and Guoxuan High-Tech. As a conductive additive, graphene LFP cathode demand could reach 164,400 tonnes by 2025 (source: Goldman Sachs).
- Talga's approach focuses on 'fit for purpose' products for application across markets with large volume capacity whose graphene usages either already exist (enhanced with Talga material) or new purposes with short pathways to commercialisation. Principally, four prime industrial sectors are; enhanced coatings, polymer composites, construction and energy storage.

#### Talga graphene target sectors

			
<b>ENHANCED COATINGS</b>	<b>COMPOSITES &amp; RESINS</b>	<b>ENERGY STORAGE</b>	<b>CONSTRUCTION</b>
Protective, High Performance, Functional & Nano Coatings Eco-friendly Cr(VI)-free based pre-treatment coatings for multi metals Pre-fabrication and post fabrication primers & anti-corrosion coatings Marine anti-fouling systems Low friction coatings	High Strength, Low weight & Conductive CFRC & two pack Resins chemistry High strength carbon fibre reinforced plastic systems Conductive plastics and polymers composites Lightning strike protection and EM shielding Thermal Interface Materials, Conducting adhesive & Inks	Batteries, Conductive Inks & Fuel Cells Next generation higher performance lithium-ion battery anodes Conductive additives Flexible, printable batteries for 'IoT' and 'Wearable' devices PEM-FC-BPP coatings & membrane	High strength, thermal & electrically conductive building materials Combined graphite and graphene mixtures for high strength building materials Thermally conductive screeds for de-icing systems Electrical conductive flooring, wall panel systems combined with heating or cooling systems

Source: Talga Resources

- End-use markets are receiving significant R&D funding, with the 'Graphene Flagship' initiative delivering Europe's largest-ever research enterprise of €1 billion in a joint, coordinated research consortium. The group consists of over 150 academic and industrial research parties across 23 nations taking graphene from the realms of academic laboratories to market. In addition, the UK government are also funding £246 million into the 'Faraday Challenge' initiative targeting superior battery technologies and promoting local supply chains.
- Talga completed commissioning of Phase 3 construction of modules to increase parallel output as planned in 2018. Phase 3 provides further important process and design data

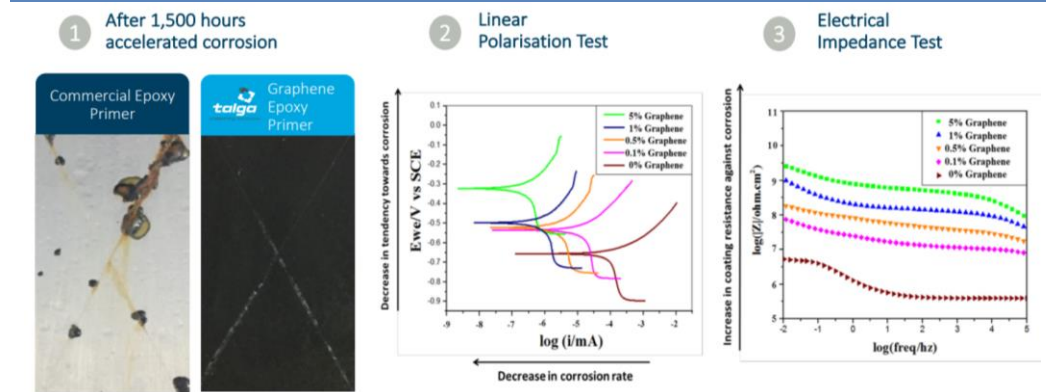
for the upcoming feasibility studies, project and product planning and permitting applications towards full-scale development in Sweden.

- Motivation for enhancing the Talga exfoliation method is to drive production costs below existing carbon materials, such as carbon nanotubes and synthetic carbon, to provide a strong incentive to adopt this new material. Pricing today for graphene powders ranges between US\$50-200/kg, with Goldman Sachs estimating that graphene would be competitive at a cost of US\$25/kg.
- Throughout 2018, Talga advanced product development programmes, with material and product engagements with Chemetall Group (subsidiary of BASF), Bosch, Heidelberg Cement AG, Haydale and Zinergy UK Ltd., amongst other undergoing partner programs.
- The company are proactively accelerating industry partnerships, expanding the pipeline of market opportunities as product development and supply programs are underway with over 125 companies.

### Coatings

- Proprietary chemical functionalisation tailor's graphene into higher performance surface treatments and coatings focusing on enhancing tensile strength, abrasion resistance and corrosion rates.
- Test work emphasises that the addition of low loadings of graphene can provide major increases in anti-corrosion performance and mechanical properties.

#### Talphen® enhanced epoxy-based primer with increased corrosion protection at increased loadings



Source: Talga Resources

- Further mechanical improvements indicate enhancements to abrasion resistance by 82%, tensile strength by 160% and elongation by 95%.
- The primary focus appears to be increasing volumes of engagements with the world's largest coatings companies in marine and industrial markets to offer eco-friendly Cr(VI)-free based pre-treatment coatings for multi metals.
- The company have also commenced on innovate electrically conductive film and ink programmes with numerous companies.

### Composites and resins

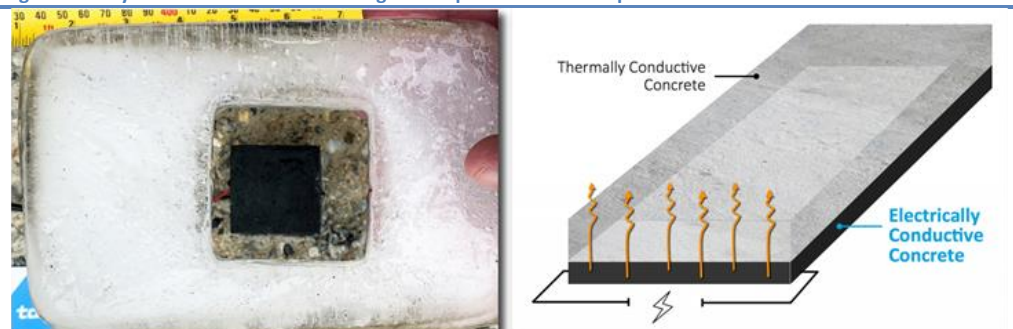
- The integration of graphene into composite materials can enhance the conductivity and strength of bulk materials, which are also resistant to heat and pressure.
- Graphene-info note applications for graphene-composite seem endless, as "one graphene-polymer proves to be light, flexible and an excellent electrical conductor, while another dioxide-graphene composite was found to be of interesting photocatalytic efficiencies, with many other possible couplings of materials to someday make all kinds of composites".

- The potential of graphene composites includes medical implants and engineering materials for aerospace and renewables.
- Talga have commenced a test programme at the leading R&D institute TWI (The Welding Institute) in Cambridge, covering multiple graphene product developments including de-icing and lightning strike protection for aircraft.

### Construction

- Impregnating cement with graphene has the potential to generate greener building materials with enhanced strength, impermeability, resistance to surface abrasion, and electrically and thermally conductive.
- The technology represents an opportunity to disrupt an industry valued over US\$450bn/annum (source: World cement & concrete additives market). Speciality concretes form a subset of this, and while no formal volume that may be attributed to the new products, we recognise the market opportunity is significant.
- Breakthroughs from the company's graphite-graphene research and development lab offer substantial improvements in existing and emerging applications, particularly as concrete is the world's largest construction material by volume; exceeding 5 billion tonnes/year (source: Cement Market Forecast). A MoU with the world's second largest concrete manufacturer, Heidelberg Cement, focussing on thermally conductive concrete gives significant indication on the technological potential of Talga graphene-impregnated concrete.
- Recent study from the University of Exeter (ultrahigh performance nanoengineered graphene-concrete composites for multifunctional applications) suggests the nanotechnology enhances concrete strength by 146% with four-times more water resistance than existing iterations.
- Greenhouse gas emissions associated with concrete and cement-making remains stubbornly high, accounting for ~8% global emissions in 2015, according to reporting by PBL Netherlands Environmental Assessment Agency. The minor addition of graphene minimises the volumes of concrete required, limiting the chemical process involved in the break-up of limestone and associated carbon dioxide release. The study suggests an estimated 50% reduction of cement consumed would result in a 446kg/t reduction in carbon emissions.

### Talga thermally conductive concrete melting 5cm depth of ice from 9v power



Specimen	Conductivity (Siemen/cm)	Resistivity (Ohm.cm)
Talga Concrete	20	0.05
Standard Mortar	0.000001	1000000

Source: Talga Resources

- Initial tests at Talga's German process test facility and Betotech (Heidelberg Cement Q&C) laboratory with the addition of pristine graphene targeted high electrical percolation at low material concentrations and with potentially lower cost factors.



- Sample measurements undertaken by Professor Ian Kinloch's group at the University of Manchester recorded significant reduction in electrical resistivity from ~1,000,000 ohm-cm for the reference mortar to 0.05 ohm-cm.
- Current iterations significantly improve on historical performance of attempts relying on the addition of high loadings of magnetite (iron), steel fibres, synthetic and natural carbons. In addition to the large relative quantities, active materials tend to cause negative effects on cost, strength, corrosion and abrasion resistance, maintenance costs and weight.
- Electrically conductive 'graphene concrete' has broad applications across underfloor heating, anti-static flooring, EMI shielding (radio frequency interference), and 'solid state heater' offering rapid and environmentally-friendly ice and snow clearing of key transport routes.

#### Idealised concept of inductive charging technologies for electric vehicles



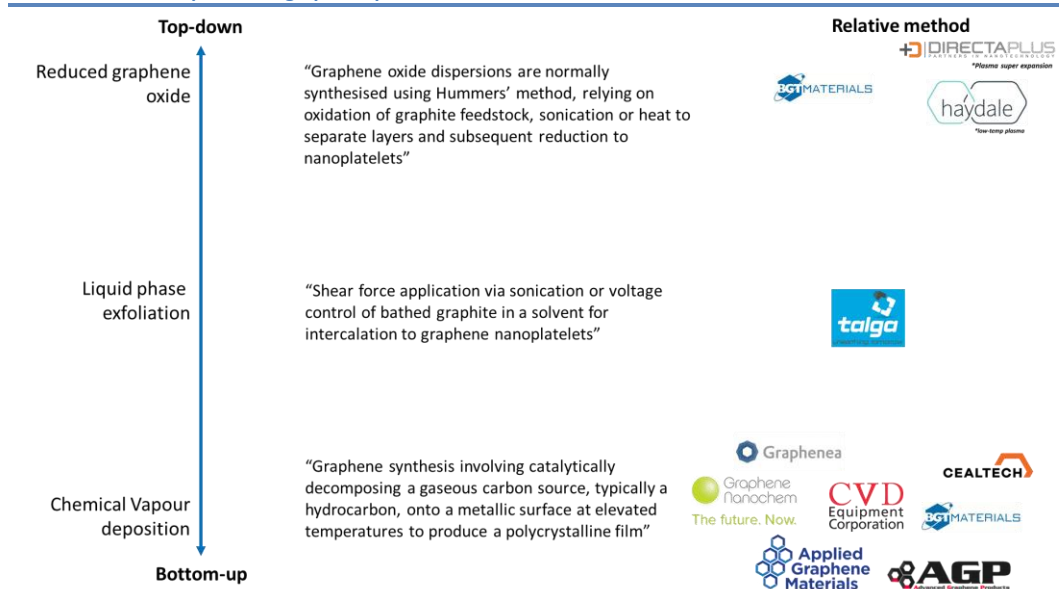
Source: Talga Resources

- Future capability also investigates electrically conductive concrete for a cost-effective role in enabling inductive (wireless) charging technologies for electric vehicles under dynamic (driving) as well as stationary (parking) conditions.
- Wireless charging roads are receiving major global interest to support usability and mass adoption of electric vehicles, and are becoming closer to reality in the UK under a new £40m government proposal.
- The Department for Transport foresee electromagnetic induction charging could be positioned at service stations and car parks as well as during mobility in dedicated charging lanes. Chargemaster add "wireless charging will make driving an electric vehicle as similar as possible to driving a petrol or diesel car but without frequent trips to the petrol station".
- A partnership between Renault, Qualcomm Technologies and Vedecom are developing dynamic electric vehicle charging (DEVIC) at a €9m project 100m test track capable of charging up to 20kw at practical motorway speeds.
- Successful implementation of dynamic charging is expected to significantly boost the global requirement for inductive concrete, while electric vehicle developments will also support the desire for Talga graphite and graphene product suite.

#### Talga unique graphene process flow

- Innovative manufacturing methods are competing against Talga electrochemical exfoliation technology and vertically integrated carbon supply, with the aim of providing the market cost competitive products against existing leading carbon materials.
- Nanomaterial fabrication target either bottom-up techniques relying on synthetic graphene sources or top-down focus on downstream reprocessing of graphite; each offering distinct advantages, disadvantages, scales and costs.

## Non-exhaustive comparison of graphene production methods



Source: Talga Resources

- Expanding application of graphene across growing markets means that Talga has entered its pioneering processing methods in direct competition to incumbents. The high-quality graphite ore feedstock from the Vittangi project lends itself to ambient temperature electrochemical exfoliation, with the process yielding a high proportion of graphene at industrially scalable volumes and low costs, while a higher proportion of global manufacture focus on higher energy synthesis from purchased pre-purified carbon sources.

**Advanced Graphene Products** – Owns a unique but low volume production method of large High Strength Metallurgical Graphene (HSMG) based on the growth of graphene on a liquid metal substrate, originating from the Institute of Materials Engineering at the Lodz University of Technology in Poland. The graphene layer can be applied as a coverage to any surface, with standard substrates including PMMA (polymethyl methacrylate), quartz and silicon wafers. The process improves on the CVD (Chemical Vapour Deposition) process to minimise the overlapping effect resulting in common defects.

**Graphenea** – Chemical Vapour Deposition offers graphene monolayers by combining carrier gas molecules hosting disassociated carbon atoms with the substrate to create a material film on the surface. While the method produces coatings with high purity, impervious, fine grained characteristics, the gaseous by-products are typically very toxic and require extreme temperatures. As documented by Graphenea, deposition methods onto substrates create an issue upon separation or exfoliation of graphene from the substrate without damaging the graphene. Current solutions focus on a copper substrate, which then requires dissolving in toxic acids to remove the graphene. Another major hurdle focuses on creating a completely uniform layer due to the kinetic transport dynamics of the gases, resulting in inconsistencies in the final graphene sheet.

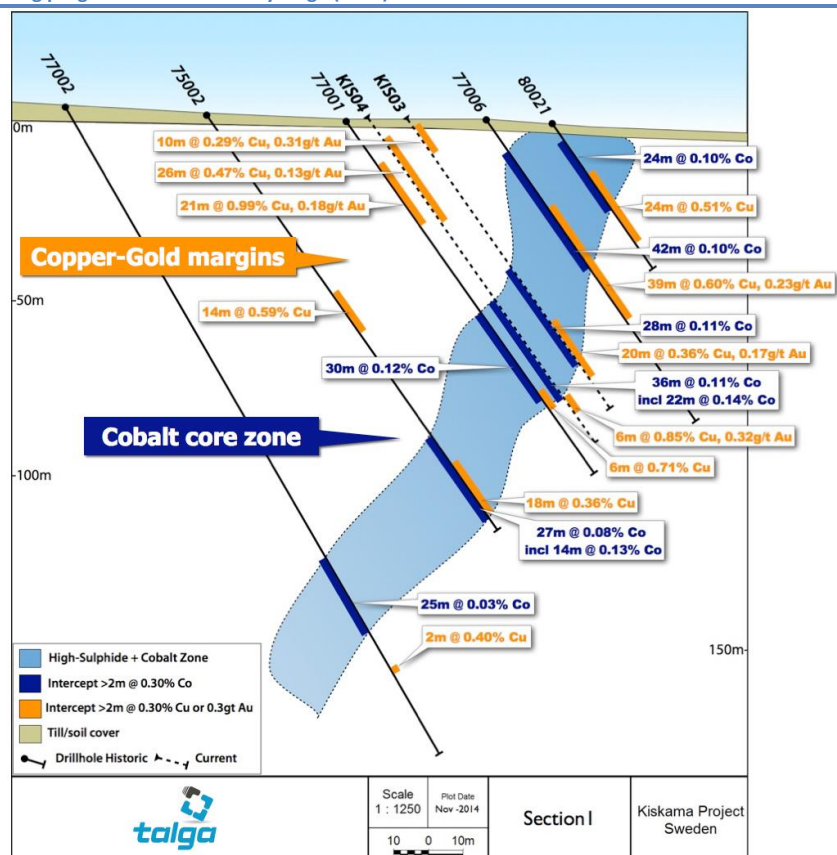
**Applied Graphene Materials** – Relying on a unique multiple dispersion technique, the lack of graphite feedstock or any oxidation procedures generates graphene with limited graphitic impurities, graphene oxide or transition metals.

**Directa Plus** – After launching 'The Graphene Factory' in 2014, the company have been expanding capacity to 30tpa pristine graphene nanoplatelets using patented technology. Using 'super plasma expansion' high purity graphite feedstock is exposed to temperatures of 10,000°C where it becomes possible to separate into a collection of graphene platelets. While costs associated with drawing the process to extreme temperatures are high, the process relies on no chemical toxicity preserving the characteristics of the graphene.

## Complementary cobalt exploration enhanced Talga battery exposure

- As part of the purchased Teck Sweden package in 2012, Talga Resources inherited battery metals exposure through a wholly owned suite of highly prospective cobalt minerals assets, focusing on the Kiskama project. The company announced the incorporation of 100%-owned Swedish subsidiary – Talga Battery Metals AB – to support the advance of the project.
- Acquisition targeted Kiskama, Sweden's largest cobalt deposit, with current Talga exploration efforts enhancing 101 historic drill holes for 13,836m which test only 1km strike of a 7km cobalt-copper-gold zone.
- Encouraging drill intercepts highlight; 36m @ 0.11% Co, 0.27% Cu & 0.13g/t Au, 33.1m @ 0.10% Co & 0.56% Cu and 28.1m @ 0.11% Co & 0.51% Cu.

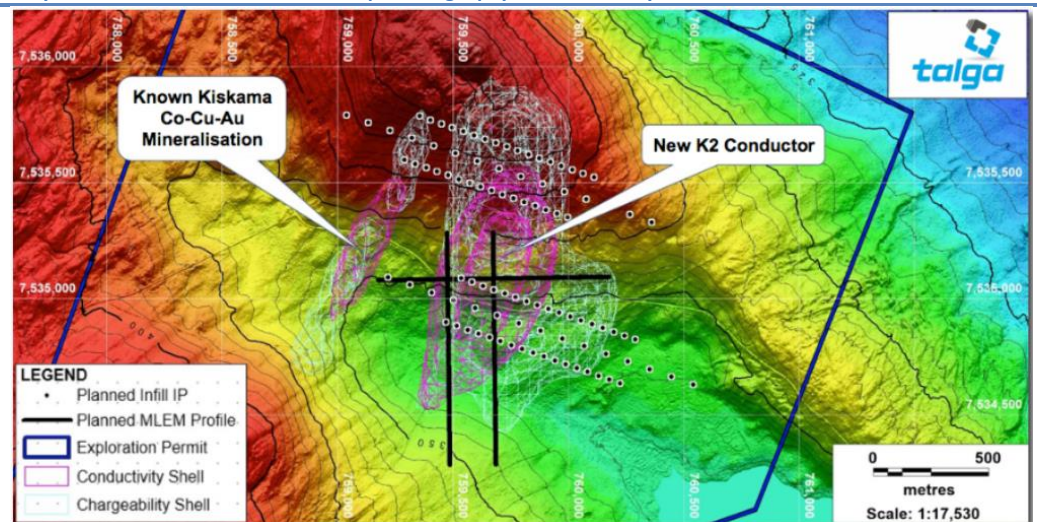
Kiskama drilling programme conducted by Talga (2014)



Source: Talga Resources

- First pass metallurgical results in 2017 demonstrated positive recoveries including up to 91% Cobalt, 86% Copper and 77% Gold.
- The company have recently (Oct 2018) obtained all necessary permitting to commence a diamond drilling as part of a maiden JORC-compliant resource. During the period under review, Talga completed geophysical surveys comprising Induced Polarisation ("IP") and Moving Loop Electromagnetic ("MLEM"). First-pass exploration yielded a new, large geophysical conductor, K2, which is double the size and strength of the existing defined Kiskama deposit signature, and its located around 500-1000m to the east.
- In early 2019, a subsequent program of infill IP and MLEM targets further processing, modelling and interpretation to better define the K2 conductor. Analysis will form the basis of a comprehensive drill campaign towards a maiden JORC Co-Cu-Au mineral resource at Kiskama.

#### Newly identified Kiskama conductors and planned geophysical infill surveys



Source: Talga Resources

- The suite of cobalt licences also incorporates Lautakoski, Ahmavuoma and East Aitik projects which host vital mineralisation, including 'wildcat' drill core sampling intercepting 91.8m @ 0.18% Cu and 147ppm Co at Lautakoski and 52m @ 0.24% Co, 0.59% Cu, 0.17g/t Au including 21m @ 0.38% Co, 1.12% Cu, 0.42g/t Au from Ahmavuoma.
- Talga's management recognise the strategic priority remains Vittangi, however the new broader Kiskama cobalt opportunity will further add value to the burgeoning European battery metal industry.

## The Board of Directors

- Talga is a vertically integrated advanced material company corporately headquartered in Perth, Western Australia, and listed on the Australian Stock Exchange since July 2010. The Company's main focus is enabling stronger, lighter and more functional graphite and graphene enhanced products for the global coatings, battery, construction and polymer composites markets.
- The Company's wholly owned subsidiaries Talga Battery Metals AB and Talga Graphene AB operate the Company's natural mineral resource assets in Sweden. Talga Advanced Materials GmbH operates the Company's processing technology test facility and graphene plant operations in Germany. Product research and development is undertaken at Talga Technologies Ltd in Cambridge, UK.

### Terry Stinson – Non-executive Chairman

- Mr. Stinson has over 35 years of international experience in engineering and technology commercialisation and management across the automotive, aerospace, defence, maritime, industrial products, mining and manufacturing sectors. Previous roles include Vice-President and General Manager Siemens VDO, former CEO and Board Member Synerject LLC and Vice-President Manufacturing for Outboard Marine.
- Mr. Stinson has a Bachelor of Business Administration, majoring in Operations Management from Marian University in Wisconsin, US and is a former National Young Manufacturing Engineer of the Year for the North American-based Society of Manufacturing Engineers. He is a Fellow of the Australian Institute of Company Directors and currently serves as a Non-Executive Director of Orbital Corporation Ltd.

### Mark Thompson – Managing Director

- Mr. Thompson has more than 20 years industry experience in mineral exploration and mining management, working extensively on major resource projects throughout Australia, Africa and South America. He is a member of the Australian Institute of Geoscientists and the Society of Economic Geologists and holds the position of Guest



Professor in Mineral Exploration Technology at both the Chengdu University of Technology and the Southwest University of Science and Technology in China.

- Mr. Thompson founded and served on the Board of ASX listed Catalyst Metals Ltd and is a Non-Executive Director of Gibb River Diamonds Limited.

#### **Grant Mooney – Non-executive Director**

- Mr. Mooney has a background in corporate advisory with a wealth of experience in resources and technology markets that will benefit Talga as it proceeds with the Company's dual graphene/graphite project development at its world-class deposits in Sweden.
- Mr. Mooney serves as Director to several ASX listed companies including renewable energy, battery storage and micro-grid developer, Carnegie Clean Energy Ltd and Director of ASX-listed resource companies, Barra Resources Ltd and Gibb River Diamonds Limited. Mr Mooney is a member of the Institute of Chartered Accountants in Australia.

#### **Stephen Lowe – Non-executive Director**

- Mr. Lowe's background is in business management and taxation and he has over 18 years' experience consulting to a range of corporate and high-wealth clients.
- Mr. Lowe is currently a non-executive director of Coziron Resources Ltd and a former Chairman and non-executive director of ASX 200 company Sirius Resources NL, a position he held during the discovery and partial development of the Nova/Bollinger deposits. He was also a former director of the Perth based specialist taxation firm MKT - Taxation Advisors.
- Mr. Lowe holds a Bachelor of Business (Accounting) and a Post Graduate Diploma in Advanced Taxation and a Masters of Taxation from the UNSW. Mr Lowe is a Fellow of the Taxation Institute of Australia and a Member of the Australian Institute of Company Directors.

#### **Ola Mørkved Rinnan – Non-executive Director**

- Mr. Rinnan has extensive commercialisation and management experience covering Europe and predominantly Scandinavia. Previous roles include CEO at Eidsiva Energi AS, CEO at Norgeskreditt AS, CFO for Moelven Industrier AS and regional MD for DNB ASA along with further previous positions as CFO and Board member to a number of European listed companies and financial institutions.
- Mr. Rinnan holds a Masters' degree in Construction and Materials Technology, as well as a Bachelors Degree in Economics, and his current board positions include Non-Executive directorships in Smedvig group (Talga's largest shareholder) companies, Nordavind DC Sites AS and DFCU Bank (where he represents the largest shareholder Norfund). Mr Rinnan also serves as the Chairman of Avinor AS and he is a member of the advisory board for DLA Piper in Norway.

#### **Andrew Willis – Non-executive Director**

- Mr. Willis, an experienced finance executive and investment manager, is the Co-Managing Partner of London-based The Pallinghurst Group, a leading strategic investor in the global metals and mining sector with significant development operational and financial expertise in mining.
- Mr. Willis has 20 years' experience in international finance, structuring and private equity, including roles at European private equity investment manager Candover Investments plc and as Finance Director of Pallinghurst Resources Limited (since renamed Gemfields Group Limited), a leading mining investment company. Mr Willis is an ACCA accountant and he holds an MBA from INSEAD.



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Recommendations are based on a 12-month time horizon as follows:

Buy - Expected return >15%

Hold - Expected return range -15% to +15%

Sell - Expected return < 15%

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