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# Removing the volume & cost barriers to Economic Graphene commercialisation for coating applications

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12th International Surface Engineering, Paints & Coating Symposium and Expo 2015, Delhi India.

Mark Thompson, Managing Director



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# Executive Summary

- ▶ Talga Resources Ltd (“Talga”) ASX:TLG is an advanced materials production company with a unique, simple and cost effective process to liberate graphene directly from its large high quality graphite ore deposits.
- ▶ By removing cost and volume issues that have plagued uptake, Talga intends to enable widespread adoption of graphene in markets worth over \$700Bn.
- ▶ Owns five 100% owned high grade graphite mineral projects (including the world’s highest grade<sup>#</sup> graphite resource) located in Sweden.
- ▶ Owns processing IP to produce graphene direct from uncrushed, unmilled graphite ore which provides unique economic advantages compared to global peers.
- ▶ Growing team in Australia and Europe as development status advances rapidly (scoping study complete, trial mining complete and pilot plant commissioned).



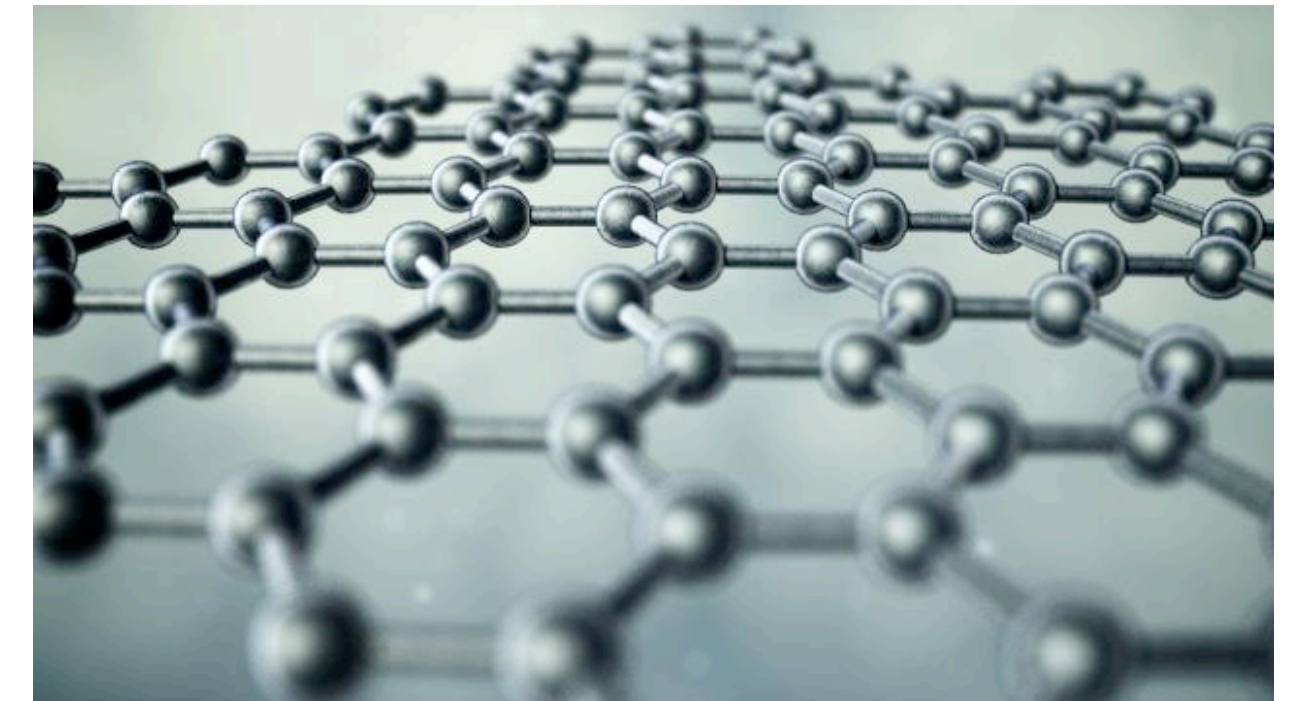
<sup>#</sup> see <http://www.techmetalsresearch.com/metrics-indices/tmr-advanced-graphite-projects-index/>



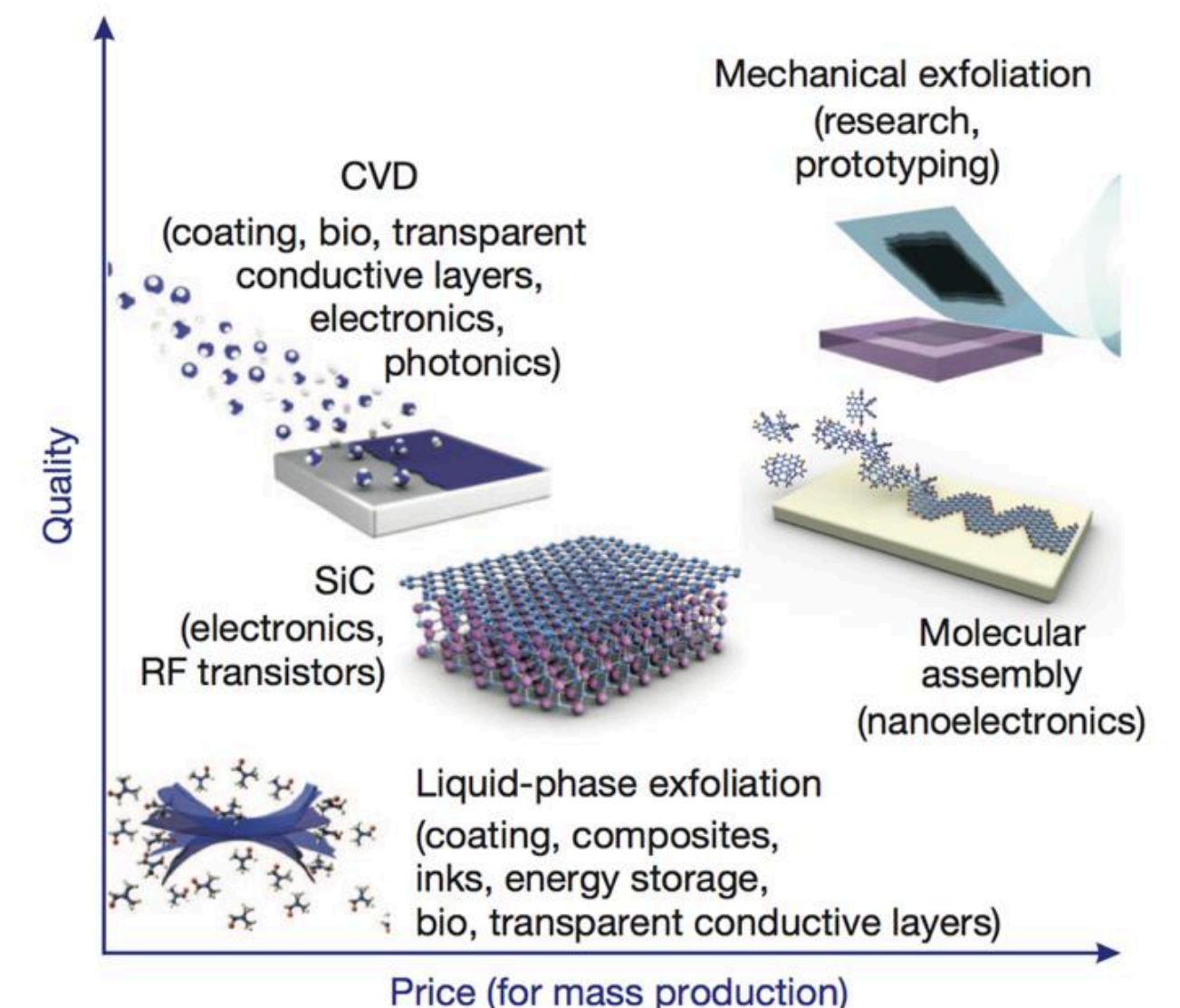
# Graphite vs Graphene?

- ▶ Graphite (the mineral) consists of multiple sheets of crystalline carbon atoms stacked together, which when isolated to one or few atom thick layers is called graphene.
- ▶ **1mm** of natural graphite contains about **3 million** layers of graphene.
- ▶ Natural graphite therefore is **already made** of graphene, but methods separating it to a few atoms thick has been **expensive** and **hard to scale** up.
- ▶ Different production methods exist but most suffer high costs due to high temperature/pressure/energy/precursor costs, and low scalability.
- ▶ There is an **advantage** using **natural** graphite as it already has the substantial temperature/pressure inputs completed by the earth's crust. It is also high density so can have high yields, but the liberation process must still be large scale to enable lowest cost and optimal enable industrial volume uptake.

Carbon atoms crystallising to form a graphene sheet



Different production methods for graphene; price vs quality (not to scale, or including scalability)



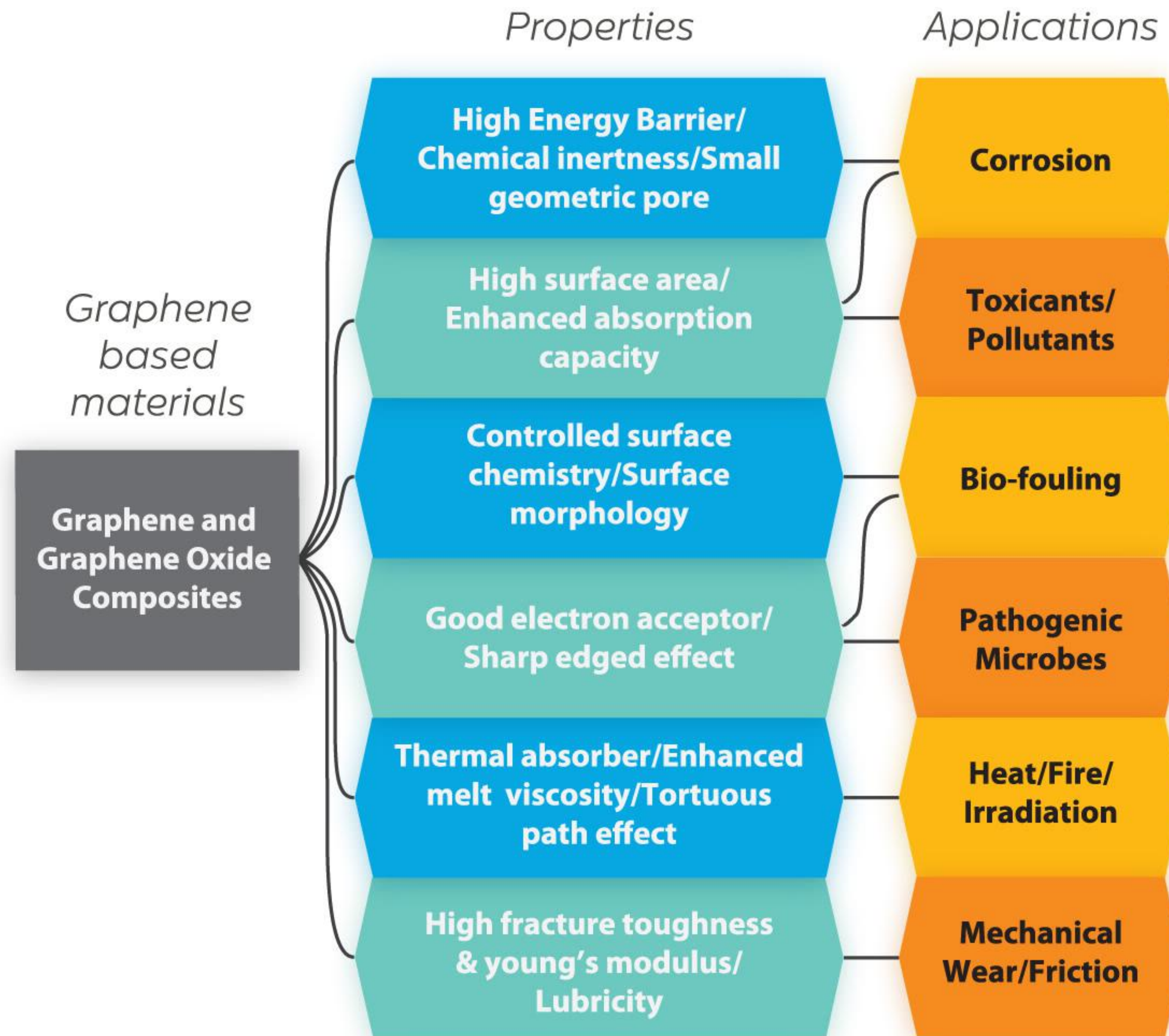
# Properties of Graphene Relevant to Coatings

Graphene additive coatings applications include:

- ▶ Nontoxic **alternative to hexavalent chromium** in coatings and electroplating\*.  
*“Graphene-based coatings showed an excellent corrosion inhibition capability when compared with current chromate-free anticorrosion technology, and comparable performance to chromate-based anticorrosion technology” S. Bohm, Nature Nanotechnology, Oct 2014 .*
- ▶ **Anti-corrosion and anti-fouling** barrier films
- ▶ **Electrically conductive** polymer compounds, inks, composite materials, elastomers and coatings. Single layer graphene has electrical conductivity  $2.5 \times 10^5 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$ .
- ▶ **Thermally conductive** polymer compounds, composite materials, elastomers and coatings. Single layer graphene has thermal conductivity  $3000 \text{ W m}^{-1} \text{ K}^{-1}$
- ▶ **Electromagnetic (EMI) shielding** composites and coatings
- ▶ General **strength** additive. Single layer graphene has Young's modulus of 1 TPa and intrinsic strength of 130 GPa.



# Protective applications for graphene based materials





# Disruptive potential in anti-corrosion applications

Annual cost of corrosion worldwide estimated to be **US\$2.2 trillion**, or ~3% of global GDP\*. **Graphene** incorporated in coating systems provides an environmental friendly solution towards protection against corrosion. This may be attributed to graphene's:

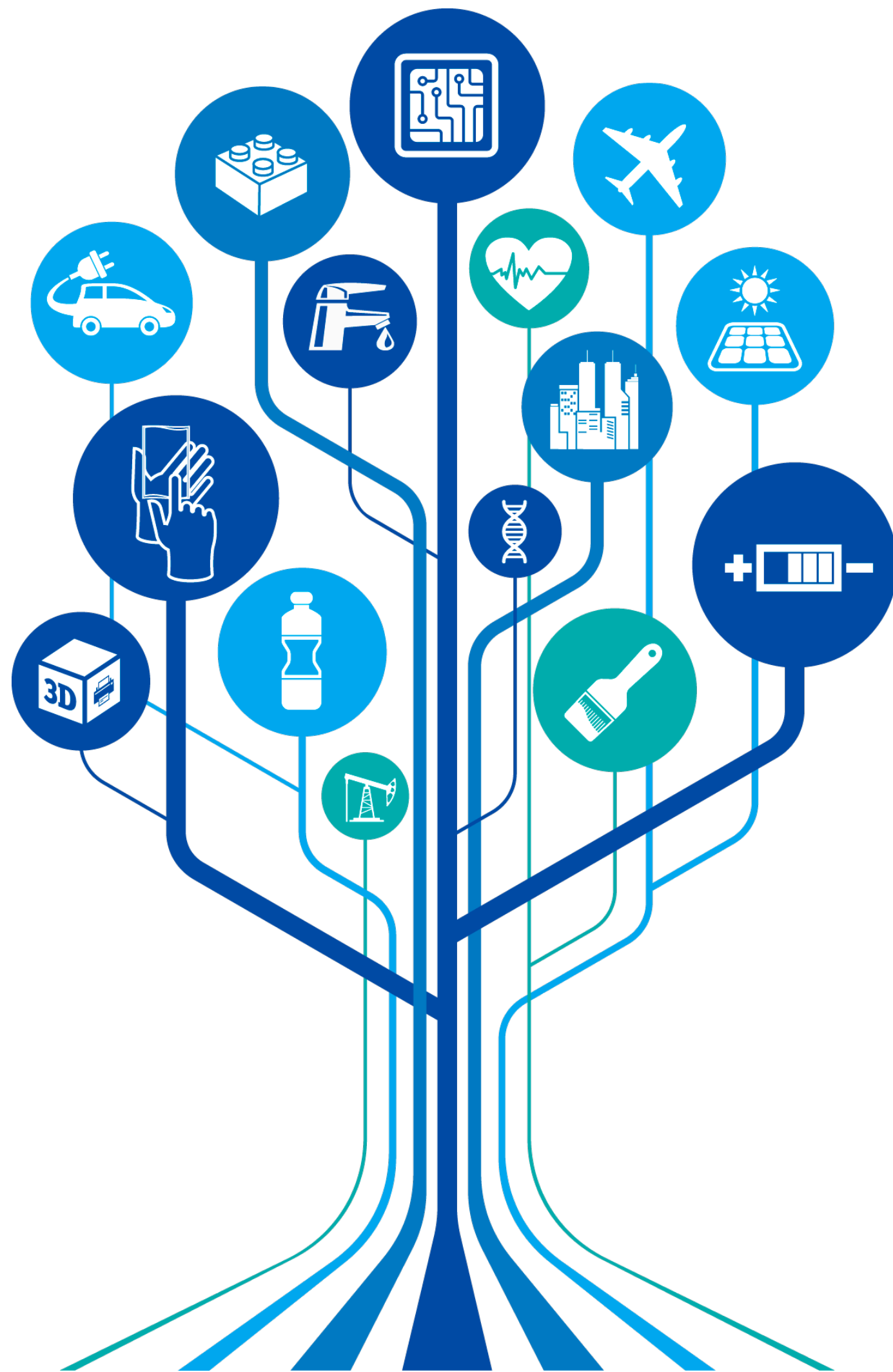
- ▶ **High surface area**  
Reduces liquid permeation by increasing tortuous path effect.
- ▶ **Impermeability**  
Barrier to water, oxygen and other corrosive materials such as chloride, sulphates, etc.
- ▶ **High conductivity**  
Provides alternative path for electrons to travel, other than the metal substrate, thereby retarding the overall corrosion process.



***“The use of graphene for anticorrosive applications provides an eco-friendly and industrially scalable replacement to chromium (VI) based coatings.”***



# Large Volume Additive Markets



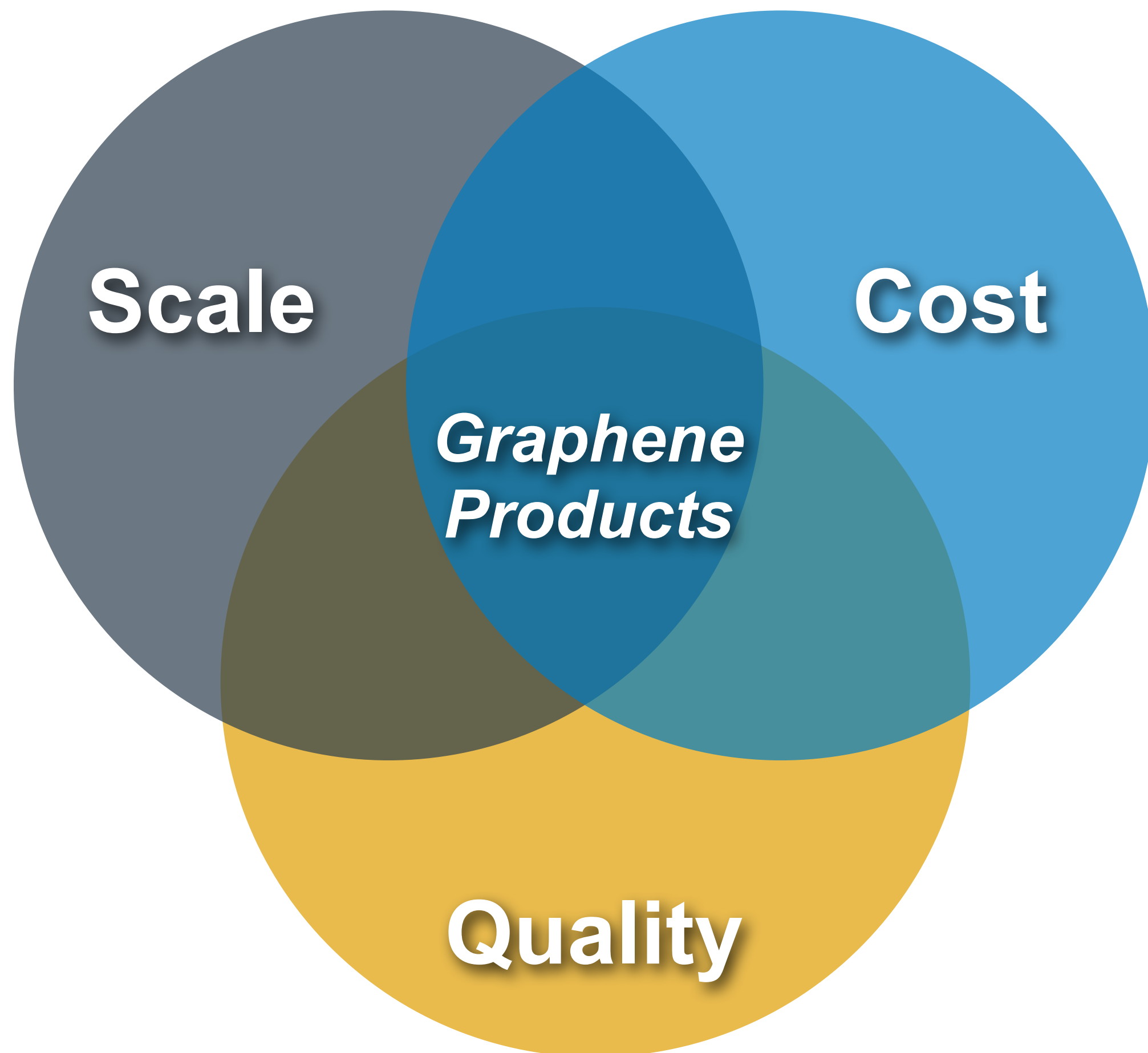
Graphene's combination of best-in-class strength, electrical and thermal conductivity, impermeability, flexibility and other properties make it an exciting new additive for a wide range of industrial applications.

Among the largest existing applications by volume, graphene can be used as an additive to increase performance:

- ▶ **Paint and Coatings:** current 40 million tonne annum market forecast to reach 52 million tonnes (2017) worth \$186 billion<sup>a</sup>.
- ▶ **Asphalt:** current use 101 million tonnes annum and projected to rise to 121 million metric tons as global population increasing pressure on demand for roads, paving and roofing<sup>b</sup>.
- ▶ **Cement and Concrete:** current additives market worth \$13.6B and projected to rise to \$21.2 billion in 2017.

# Commercialisation is held back by supply factors

Many applications have arisen from 10 years of graphene research but commercialisation is a question dominated by supply side factors



## Main factors delaying uptake of graphene:

- ▶ Lack of **scale**: most production methods are not scalable to the **large quantities** required to guarantee **long term** supply.
- ▶ High **costs**: costs are falling but are still vastly **expensive** compared to most material inputs.
- ▶ Low quality: most bulk methods have inherent limitations that **limit** applications/markets.
- ▶ **Scale and Cost are main constraints** as they have physical limitations while Quality can be manipulated to a degree by many methods.



# Graphite to Graphene: do you know the cost?



- ▶ Usually graphite ores require drill/blast mining, crushing, milling, flotation and purification stages to produce a graphite concentrate **prior** to the start of making graphene.
- ▶ This induces an environmental footprint from the energy, dust, chemicals and waste at each stage.
- ▶ The graphite is blended from different sources and may contain impurities that differ depending on source.
- ▶ At the point of commencing a graphene process, there has already been considerable commercial and environmental cost that increases costs or limits volume and quality.
- ▶ Large (brand name) companies demand cleaner supply chains and lower risk jurisdictions. Applications require consistency/homogenous sources.



# Processing Advantage Talga vs Others

## GRAPHITE PRODUCTION

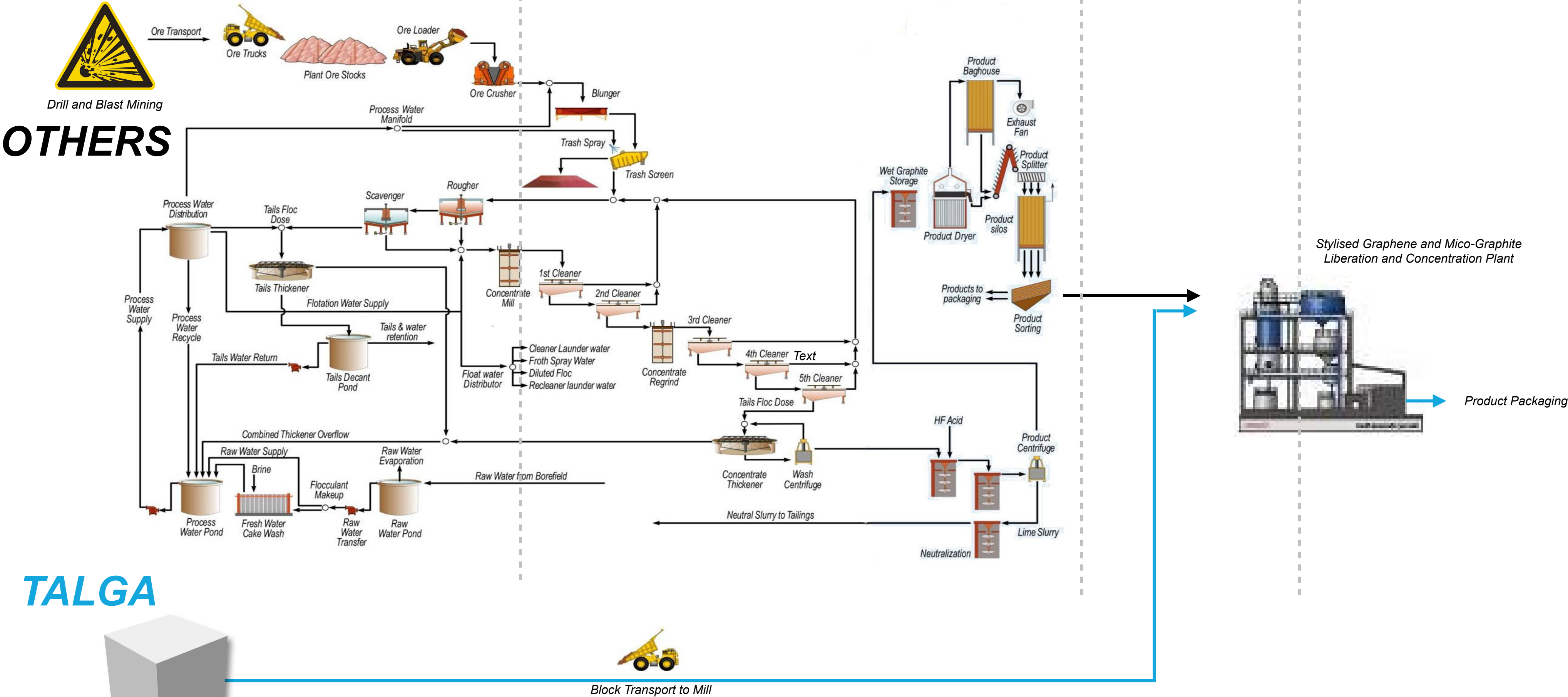
## GRAPHENE PRODUCTION

### Liberation

### Concentration

### Liberation

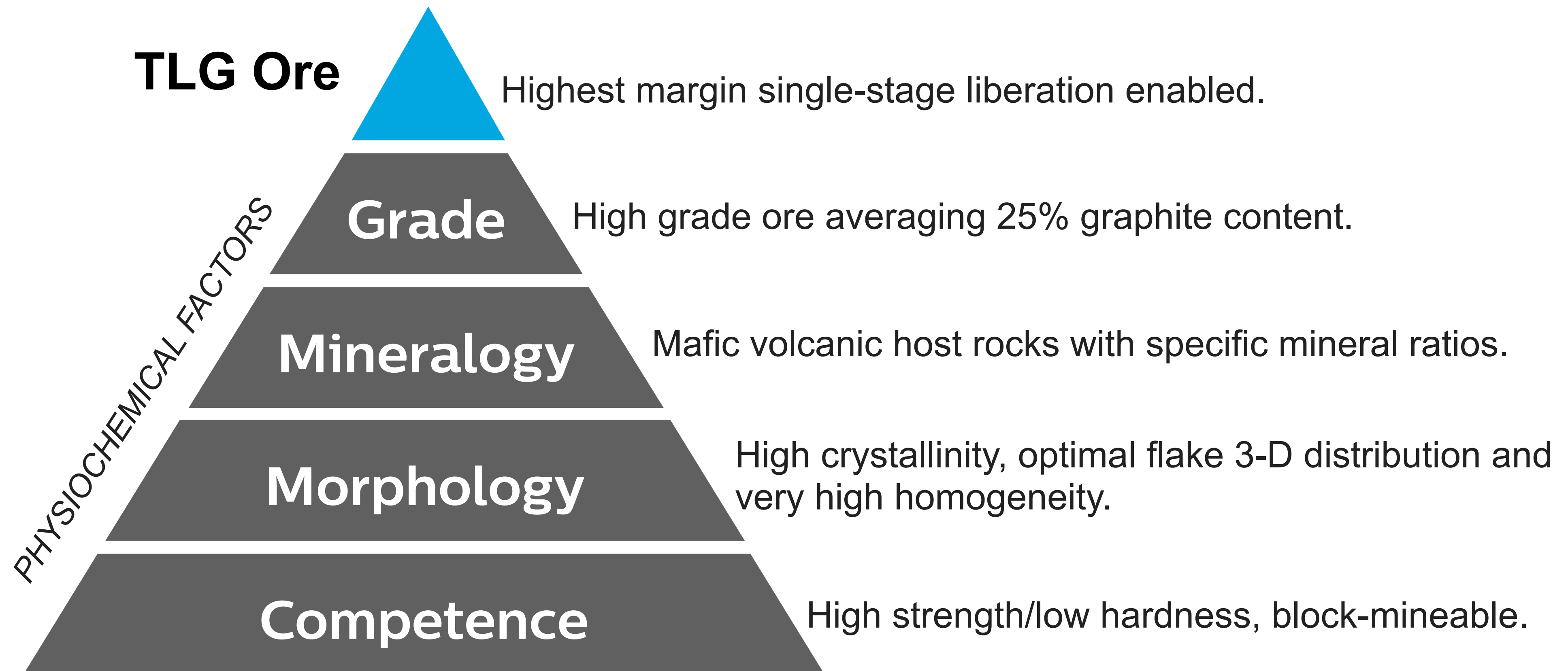
### Concentration



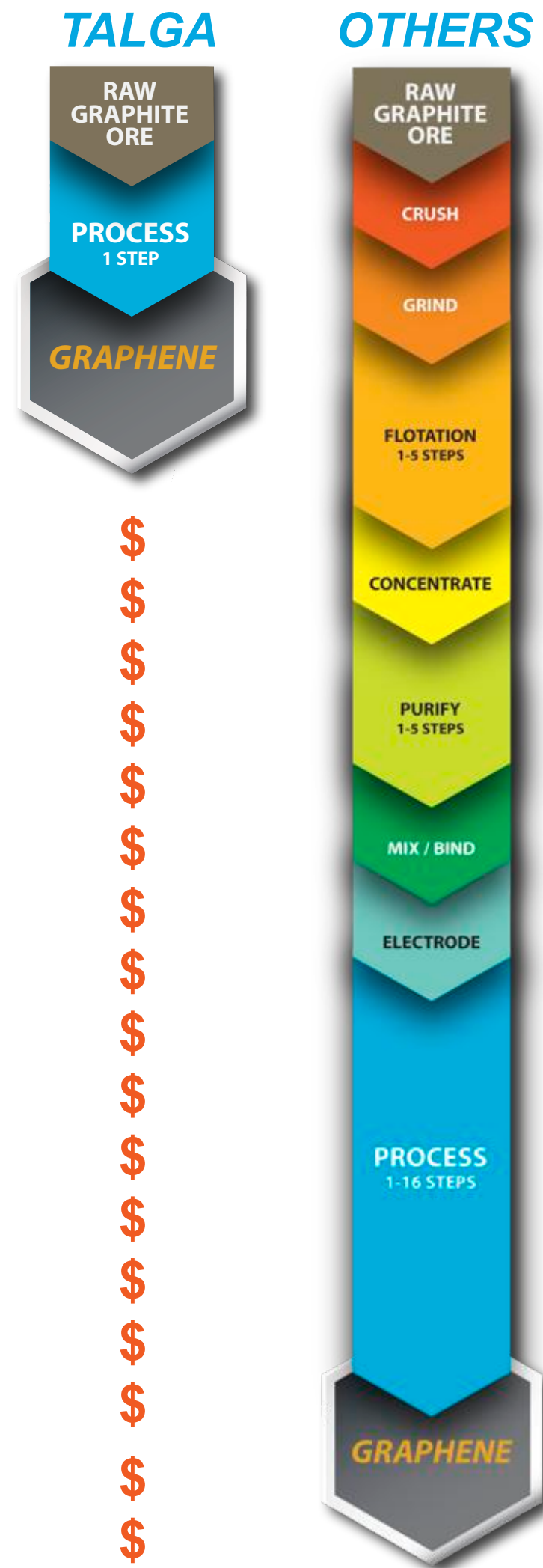


# Why Is The Talga Approach Unique

- ▶ Graphite is made from layers of graphene so in theory anyone can produce graphene in a laboratory - but at what volume and cost? Talga ore\* is differentiator.
- ▶ Talga's mining and processing method is designed to use natural multiple physio-chemical factors in the 100% owned orebody to liberate graphene without physical comminution.

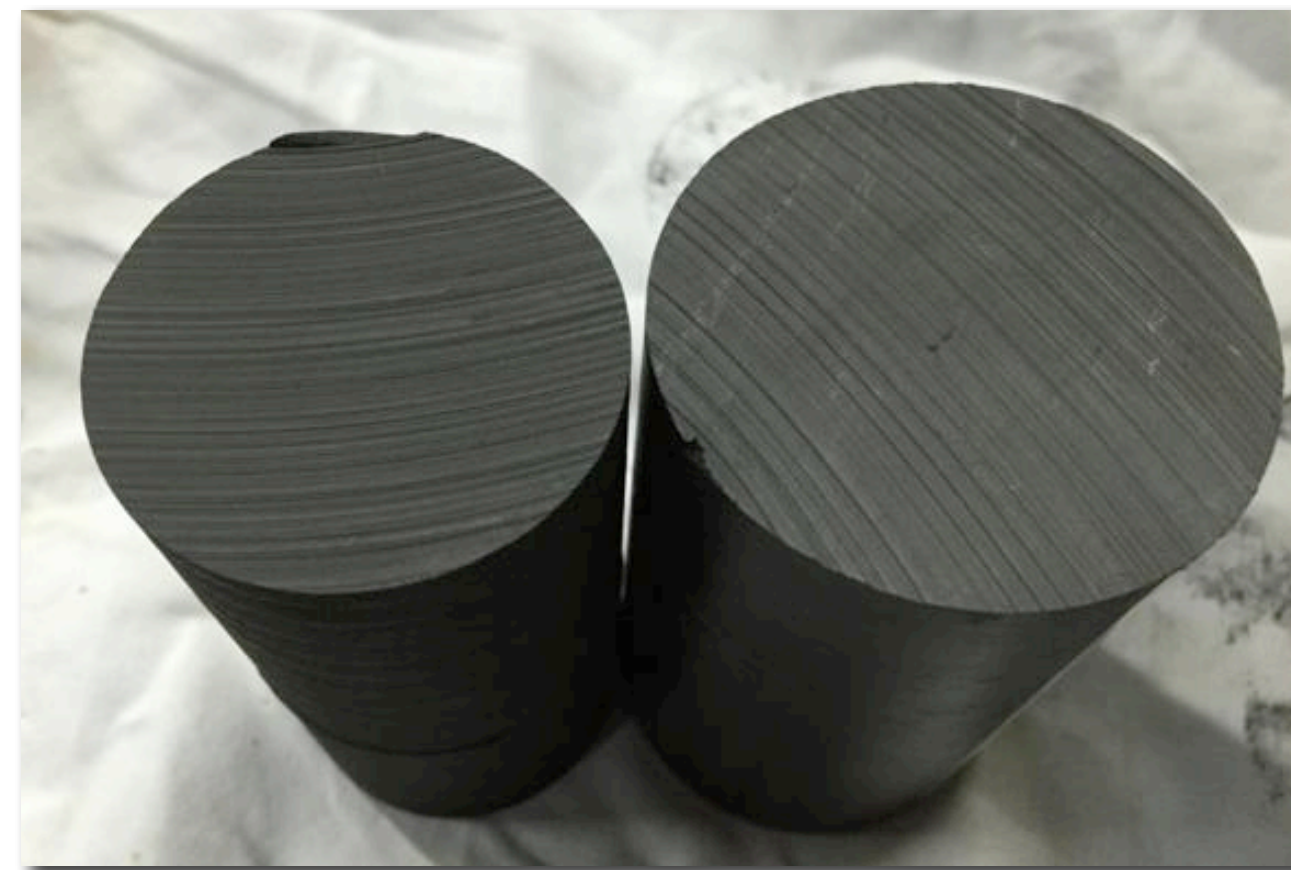


# Solution-Talga natural ore advantage



- ▶ Talga extracts graphene directly from natural microcrystalline graphite ore\* using low impact physio-chemical techniques. The benefits include:
  - No requirement for drill/blast, crushing, grinding and milling stages.
  - Entirely scalable to large industrial volumes
  - Lower environmental footprint and emissions
  - Unique unmilled graphite is also recovered for sale.
- ▶ Note the photo below - Talga's unprocessed natural ore\* (right) has similar characteristics to highly purified synthetic graphite (left), enabling a simpler, lower cost process to graphene.

*Processed  
Synthetic graphite  
99.9% Cg*

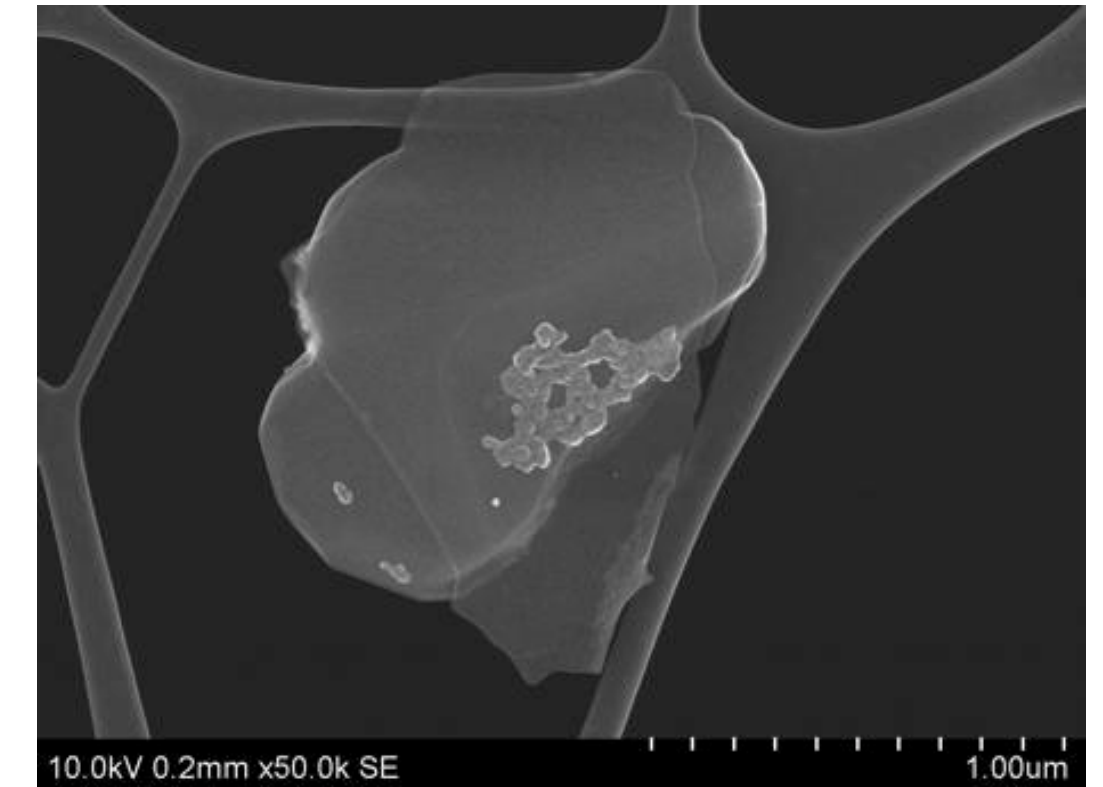


*Unprocessed  
Raw Vittangi ore  
24.4% Cg*



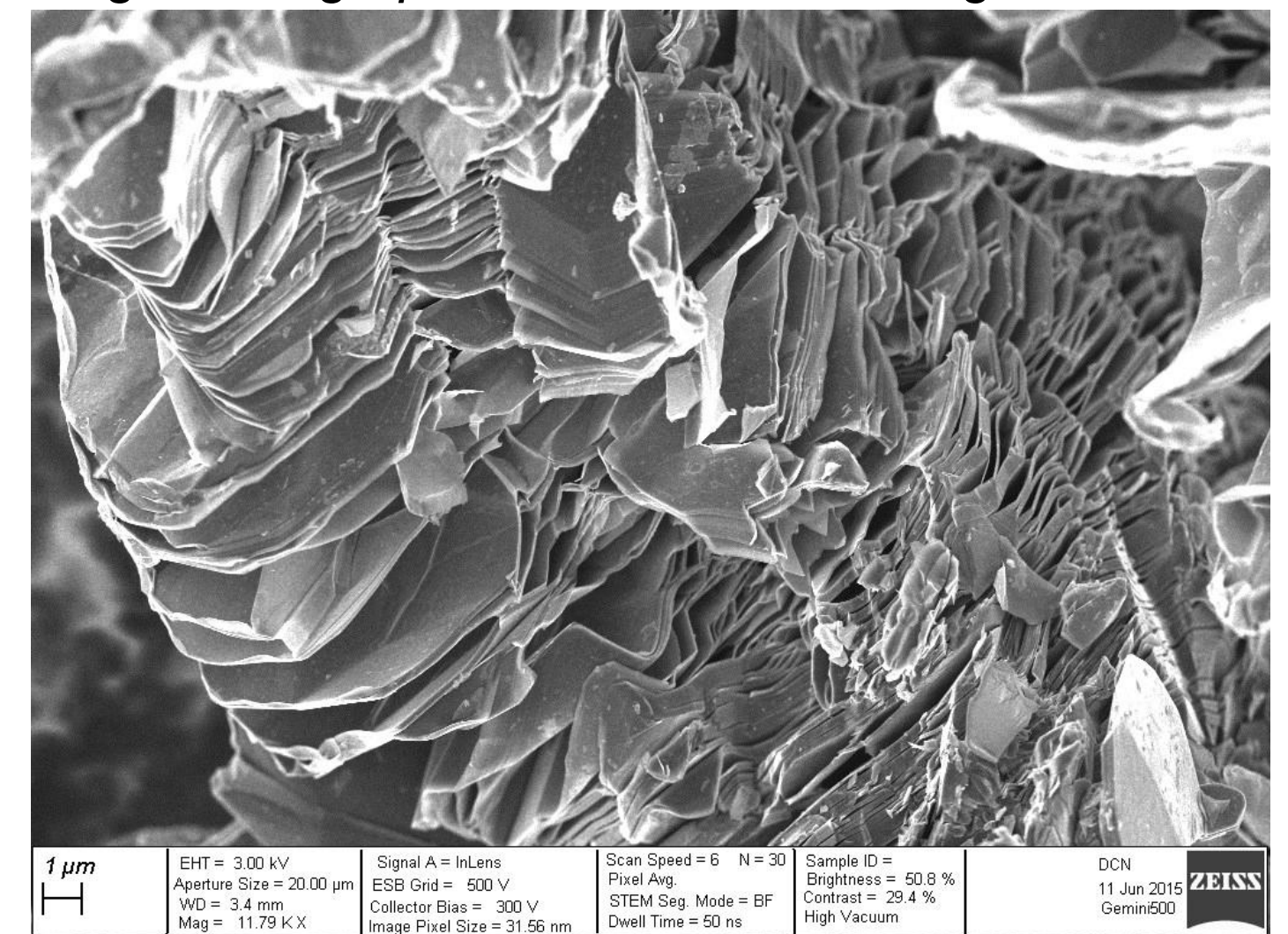
# Graphene direct from natural ore

- ▶ Three universities across two countries plus CSIRO work confirms Talga produces **high quality** 1-5 layer graphene (FLG) directly from raw natural rock (unprocessed ore\*).
- ▶ By not using 'Hummers' or Shear-based methods Talga graphene retains low defects ( $I_d/I_g \sim < 0.2$ ) and large particle size.
- ▶ Can be modified and optimised for different layer/quality specs to suit full range of current and future applications.
- ▶ Graphite flakes are uniquely micro-sized without milling and show expanded morphology of interest for battery materials.

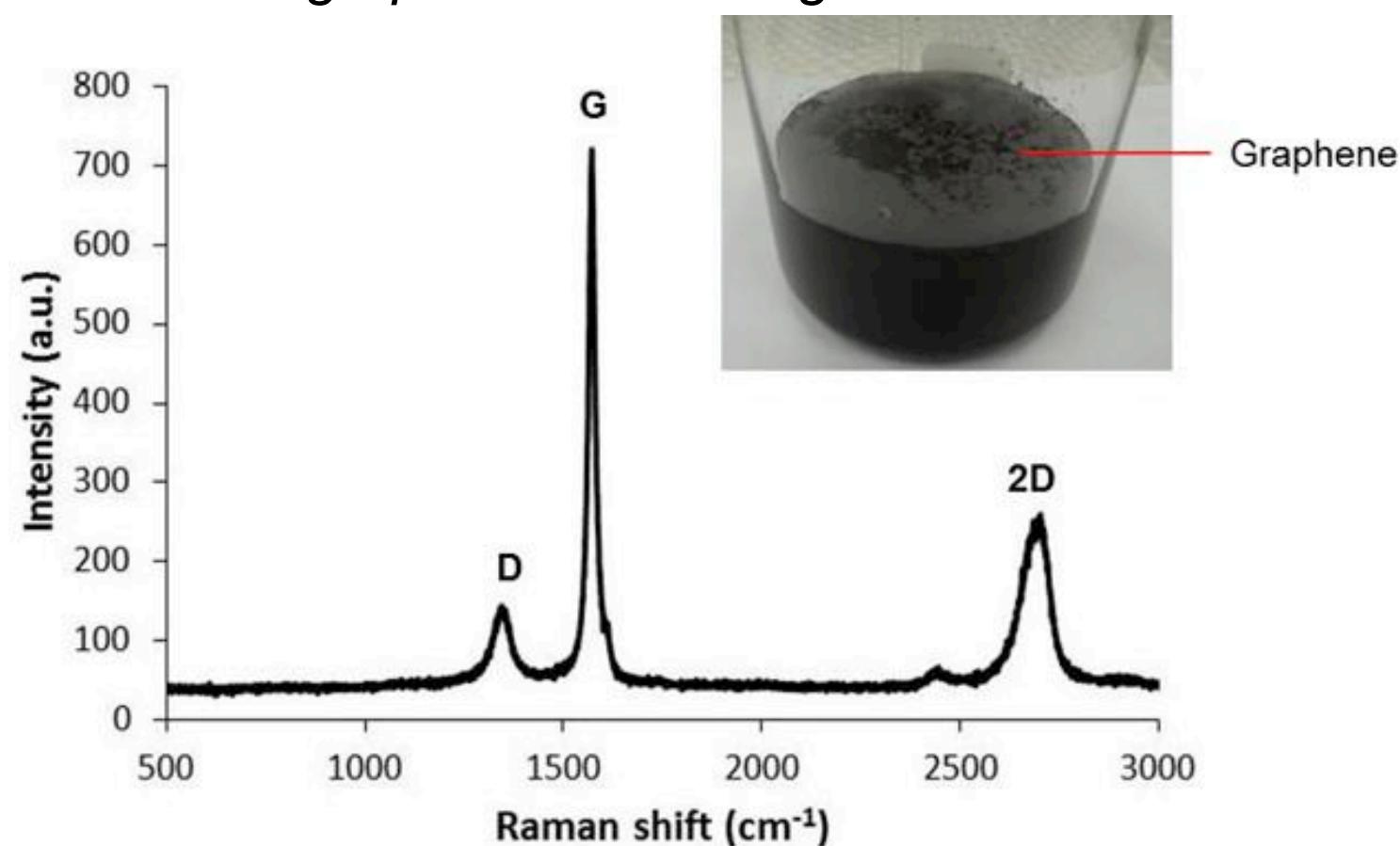


*Talga single layer graphene on multilayer stack*

*Talga micrographite. Note unmilled edges.*



*Initial graphene raman signature*





# Talga Europe Operations



## Research, Development and Analytics

- ▶ JV Uni of Dresden/Max Planck
- ▶ Friedrich-Schiller-University Jena

## Local Industry/End users

- ▶ Product testing/development
- ▶ Use research as interface



## German Operations

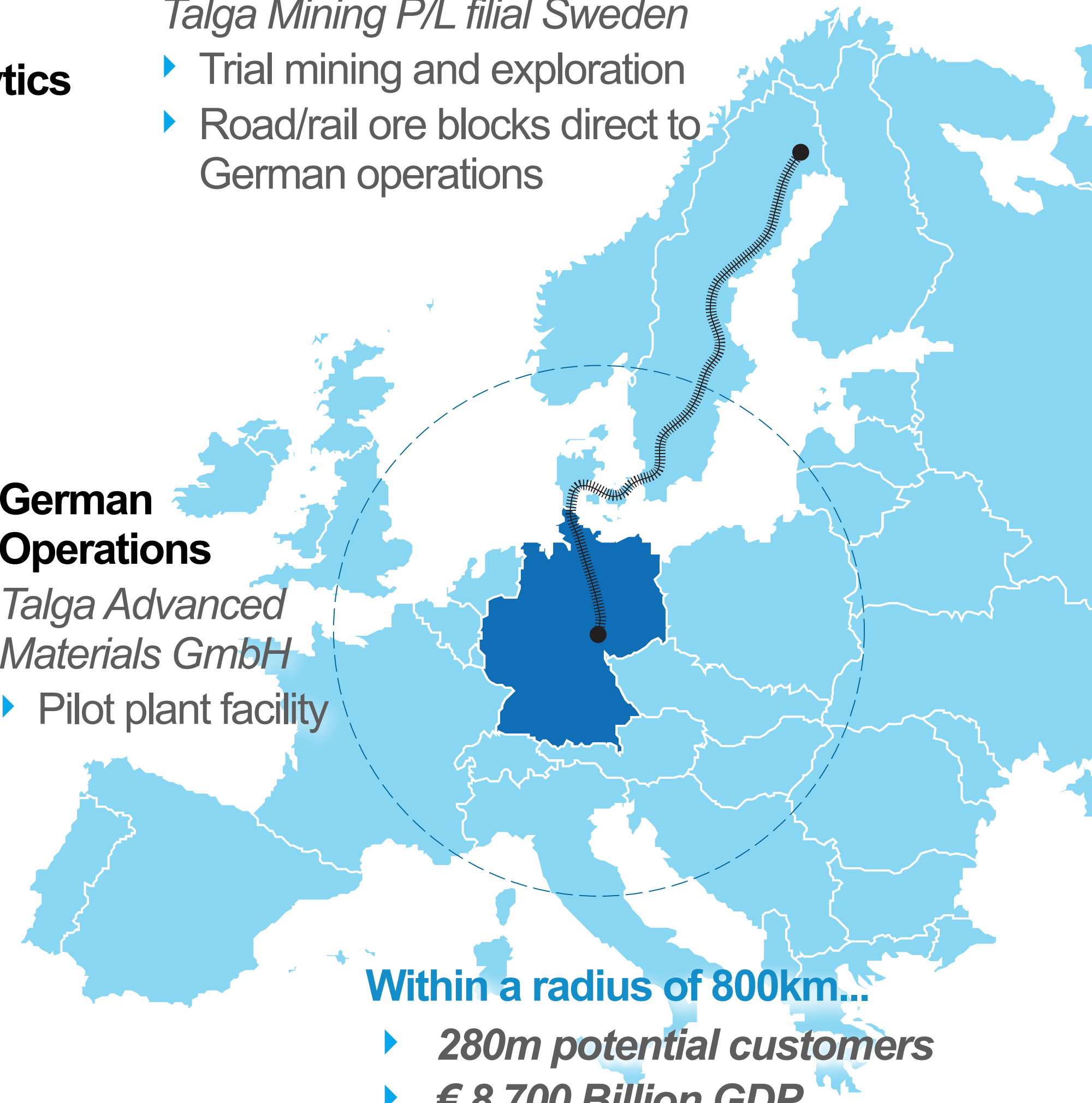
*Talga Advanced Materials GmbH*

- ▶ Pilot plant facility

## Sweden Operations

*Talga Mining P/L filial Sweden*

- ▶ Trial mining and exploration
- ▶ Road/rail ore blocks direct to German operations



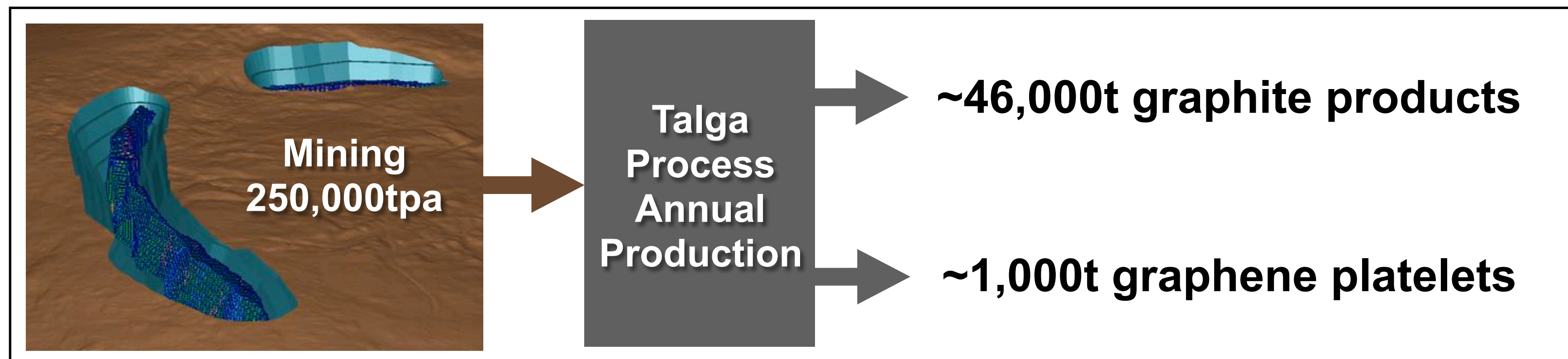
**Within a radius of 800km...**

- ▶ 280m potential customers
- ▶ € 8,700 Billion GDP



# Production/Business Model

- ▶ Talga uses innovative mining and manufacturing techniques aiming to disrupt the graphite and graphene supply chain in cost and performance, while minimising environmental footprint.
- ▶ Current aim to sell bulk graphene and graphite raw materials to large end users developing applications for nanoplatelets and micrographite (additives to coatings, inks, battery electrodes).
- ▶ Economic study\* shows Vittangi project:
  - **Capital cost** AUD\$29m
  - **Minelife** ~20yr





# Trial Mine (Video)





# Trial Mine (Video)





# Trial Mine (Video)





# Pilot Plant Site - Rudolstadt, Germany.





# Development Status

- ▶ Lab and Benchtop scale trials complete.
- ▶ Trial mining Campaign 1 complete.
- ▶ Pilot plant Phase 1 commissioned.
- ▶ Upscaling to produce commercial scale samples for product development and potential sales underway.
- ▶ 2016 trial mining to be expanded; permitting complete.
- ▶ Future full scale processing planned to take place in Sweden; permitting commenced.
- ▶ Focus now on commercial relationships and market development on path to being largest graphene raw material supplier.





# Appendices - Financial and Corporate Summary

## Capitalisation Summary 9 October 2015

Shares on issue (TLG Ordinary)	<b>138.6M</b>
Listed Opts (TLGO exp 30/11/15 @35c)	<b>7.7M</b>
Unlisted Options <sup>1</sup>	<b>15.6M</b>
Market Capitalisation ( <i>undiluted @ \$0.40</i> )	<b>A\$55.4M</b>

## Board

Managing Director - Mark Thompson

Chairman - Keith Coughlan

Non-Executive - Grant Mooney

Cash (end of June 2015) ~\$5.7 million. No Debt.

## Top 5 Shareholders

Lateral Minerals P/L ( <i>Mark Thompson</i> )	10.3%
Gregorach P/L and related entities	6.9%
HSBC Custody Nominees Australia P/L	5.7%
UBS Nominees P/L	3.0%
Yandal Inv P/L	2.8%

## ASX: TLG Share Price and Volume Year to Date



<sup>1</sup> Various expiry and strike prices with majority expiring 2016 at 50-60c

# Appendices- Graphite Resources and Targets

**Nunasvaara Mineral Resource<sup>1</sup>** (10% Cg low cut-off)

JORC Classification	Tonnes	Graphite (%Cg)
Indicated	5,600,000	24.6
Inferred	2,000,000	24.0
<b>Total</b>	<b>7,600,000</b>	<b>24.4</b>

**Jalkunen Mineral Resource** (5% Cg low cut-off)

JORC Classification	Tonnes	Graphite (%Cg)
Inferred	31,500,000	14.9

**Raitajärvi Mineral Resource<sup>1</sup>** (5% Cg low cut-off)

JORC Classification	Tonnes	Graphite (%Cg)
Indicated	3,400,000	7.3
Inferred	900,000	6.4
<b>Total</b>	<b>4,300,000</b>	<b>7.1</b>

**Talga Graphite Exploration Targets <sup>2</sup>**

Project	Exploration Target	Tonnes (0-100m Vertical Depth)		Graphite (% Cg)	
		Min.	Max.	Min.	Max.
Vittangi	Nunasvaara	62,400,000	93,600,000	20	30
	Kotajärvi	16,640,000	30,160,000	20	25
	Maltosrova	20,800,000	52,000,000	20	25
Jalkunen	Tiankijokki	2,600,000	5,200,000	15	25
	Nybrännan	5,200,000	10,400,000	20	30
	Suinavaara	2,600,000	5,720,000	15	25
	Lautakoski	26,000,000	52,000,000	15	25
Subtotal		136,240,000	249,080,000	19	27
<b>Rounded Total</b>		<b>136,000,000</b>	<b>250,000,000</b>	<b>18</b>	<b>25</b>

*1 Note: This information was prepared and first disclosed under the JORC code 2004. It has not been updated since to comply with the JORC code 2012 on the basis that the information has not materially changed since it was last reported. The Company is not aware of any new information or data that materially affects the information included in the previous announcement and that all of the previous assumptions and technical parameters underpinning the estimates in the previous announcement have not materially changed.*

*2 Note: The Exploration Target is based on a number of assumptions and limitations with the potential grade and quantity being conceptual in nature. There has been insufficient exploration to estimate a Mineral Resource Estimate in accordance with the JORC Code and it is uncertain if future exploration will result in the estimation of a Mineral Resource.*



## References

#) see <http://www.techmetalsresearch.com/metrics-indices/tmr-advanced-graphite-projects-index/>

NB) any data not specifically referenced is based on personal communications with industry participants where appropriate and/or unpublished technical research.

## Cautionary Statement

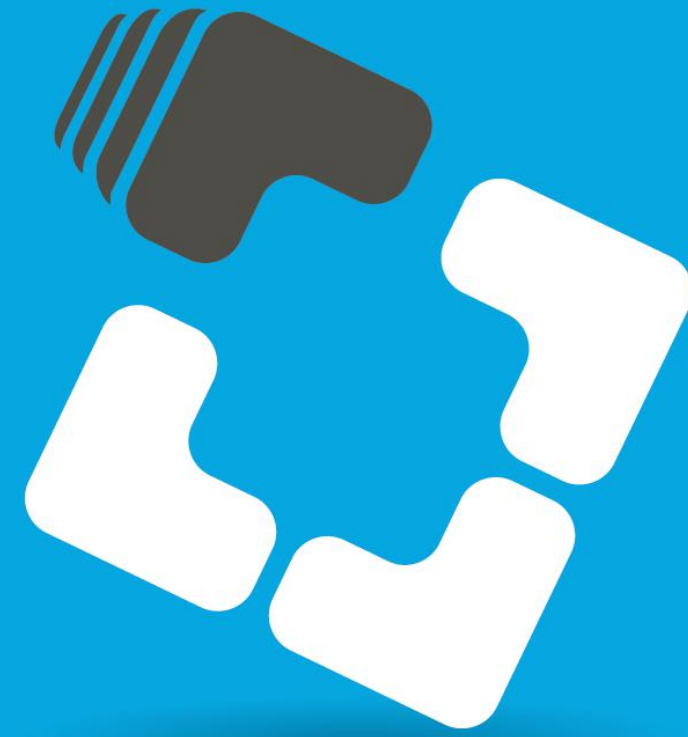
The scoping study referred to in this report is based on low level technical and economic assessments, and is insufficient to support estimation and economic assessments, and is insufficient to support estimation of Ore Reserves or to provide assurance of an economic development case at this stage, or to provide certainty that the conclusion of the scoping study will be realised. The Company confirms that all material assumptions and technical parameters underpinning the scoping study results and projections in this release continue to apply and have not materially changed. The use of the word "ore" in the context of this report does not support the definition of 'Ore Reserves' as defined by the 2012 Edition of the 'Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves'. The word 'ore' is used in this report to give an indication of quality and quantity of mineralised material that would be fed to the processing plant and is not to be assumed that 'ore' will provide assurance of an economic development case at this stage, or to provide certainty that the conclusion of the scoping study will be realised.

## Competent Person's Statement

The information in this report that relates to Exploration Results and Exploration Targets is based on information compiled and reviewed by Mr Simon Coxhell, a consultant to the Company and a member of the Australian Institute of Mining and Metallurgy and Mr Mark Thompson, who is an employee of the Company and a member of the Australian Institute of Geoscientists. Mr Thompson and Mr Coxhell have sufficient experience which is relevant to the activity which is being undertaken to qualify as a "Competent Person" as defined in the 2012 Edition of the "Australasian Code for Reporting of Exploration Results, mineral Resources and Ore Reserves" ("JORC Code"). Mr Thompson and Mr Coxhell consent to the inclusion in the report of the matters based on this information in the form and context in which it appears.

The information in this report that relates to Resource Estimation is based on information compiled and reviewed by Mr Simon Coxhell. Mr Coxhell is a consultant to the Company and a member of the Australian Institute of Mining and Metallurgy. Mr Coxhell has sufficient experience relevant to the styles of mineralisation and types of deposits which are covered in this document and to the activity which he is undertaking to qualify as a Competent Person as defined in the 2012 edition of the "Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves" ("JORC Code"). Mr Coxhell consents to the inclusion in this report of the Matters based on this information in the form and context in which it appears.





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