

HD Graphite: The six steps to striking success

BY Andrew Scogings

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This report aims to compare and contrast 21 listed graphite plays (13 ASX, seven TSX and one AIM) and shed some light on important factors to consider when assessing graphite (and indeed other industrial mineral) projects¹. Andrew Scogings, IM Consultant, and Jason Chesters, Resource Analyst at Patersons Securities, look into the listed companies using parameters set out by Patersons in August. The project list is by no means exhaustive, and should be seen as a general perspective on the current state of play.

The graphite sector remains highly topical and the share prices of most of the listed stocks continue to react positively, although they are well off the highs seen a few months ago. This is illustrated by the graph in Figure 1, which compares the price performance of the ASX-listed graphite sector relative to the ASX300 Resources index over the past 12 months.

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Speculation over the impact of Tesla Motors' planned 'Gigafactory', announcements by Dongfeng on their electric vehicle and hybrid electric vehicle (HEV) expansion ambitions, production closures and export taxes implemented in China, coupled with continued talk of M&A interest and the potential growth in applications for graphene serves to maintain interest in the sector.

There exists a growing window of opportunity for new supply to enter the market. That said, the extent of new discoveries and planned production globally is well in excess of this opportunity and it is looking increasingly likely that many projects will fail to reach production.

Many graphite explorers seem to be fixated on 'biggest is best' and, although resource tonnes and graphitic carbon content (grade) are key metrics in evaluating mining projects, the evaluation of graphite projects is more complex. Out of the myriad considerations, key attributes (in addition to size of deposit and grade) are flake size distribution, purity of the graphite and the extent to which the company has signed binding sales agreements.

With regard to graphite flake size and purity, attention is drawn to JORC 2012 (Clause 49), which requires that industrial mineral resources or reserves must be reported in terms of mineral specifications.

Furthermore, according to the Canadian Institute of Mining, Metallurgy and Petroleum guide to Best Practice (CIM 2003), "Market considerations incorporate not only the requirement for detailed market analyses and/or contracts of sale, but also recognition that markets for many industrial minerals are relatively small, may have a high degree of producer concentration, or may have very high technical barriers to entry, thus imposing limits or constraints on achievable market volumes."

Bearing the above in mind, we have compiled a quantitative matrix of six key factors that we consider important in ranking graphite plays in the current market. These are i) deposit size, contained graphite and enterprise value; ii) location (country risk); iii) flake size distribution; iv) product purity; v) product off take agreements and vi) timeframe to production (Tables 1, 2 and 3).

Table 1: ASX-listed graphite projects, as ranked in July 2014

Kibaran	Talga	Syrah	Valence	Triton	Lamboo
MRL		Archer		Sovereign	Lincoln
Code		Bora Bora	Uranex		
KNL		SYR	VXL	TON	LMB
	TLG		AXE	SVM	LML
MRF		BBR	UNX		

Project	Balama	Uley	Nicanda Hill	McIntosh
Epanko	Nunasvaara	Campoona & Wilclo	Duwi	Kookaburra
Gully	Warakapola	Matale	Nachu	
Country	Mozambique	Australia	Mozambique	Australia
Tanzania	Sweden	Australia	Malawi	Australia
Mineralisation	Sri Lanka	Sri Lanka	Tanzania	
Flake	Flake	Flake	Flake	Flake
Vein	Vein	Flake		
Factor 1	10	3	6	2
8	8	6	2	5
3	3	2		
Factor 2	3	8	3	9
3	10	8	2	8
2	2	3		
Factor 3	6	2		0
8	0		8	0
6		6		
Factor 4	8	6	6	2
4			2	4
4		4		
Factor 5	4	6	0	6
6		0		
4	6	10	4	8
Factor 6	2	2	2	2
4				
2	2	2		
Score	37	35	19	27
33	20	16	16	19
7	7	19		

1) Deposit size, contained graphite and enterprise value; 2) location (country risk); 3) flake size distribution; 4) product purity; 5) product off take agreements and 6) timeframe to production

Source: PSL, July 2014

Table 2: ASX-listed graphite projects ranked in November 2014

Kibaran	Syrah	Valence	Triton	Lambo
MRL	Talga	Archer	Sovereign	Lincoln
Code	Bora Bora	Magnis*	Buxton	
KNL	SYR	VXL	TON	LMB
MRF	TLG	AXE	SVM	LML
Project	BBR	MNS	BUX	
Epanko	Balama	Uley	Nicanda Hill	McIntosh
Gully	Nunasvaara	Campoona & Wilclo	Duwi	Kookaburra
Country	Mozambique	Australia	Yalbra	
Tanzania	Sweden	Australia	Mozambique	Australia
Mineralisation	Sri Lanka	Sri Lanka	Malawi	Australia
Flake	Flake	Flake	Flake	Flake
Vein	Vein	Flake	Flake	Flake
Factor 1	10	3	10	2
8	7	7	9	5
3	3	2	7	
Factor 2	3	8	3	9
3	10	8	2	8
2	2	3	9	
Factor 3	6	4	6	2
8	0	0	6	0
4		10		
Factor 4	8	6	8	2
4	2	6	4	4
		6		

Factor 5	4	2	0	8
6	0	0	0	0
		2		
Factor 6	6	10	4	2
4	2	4	2	2
2	2	2	2	
Score	37	33	31	25
33	21	25	23	19
7	7	25	18	

1) Deposit size, contained graphite and enterprise value; 2) location (country risk); 3) flake size distribution; 4) product purity; 5) product off take agreements and 6) timeframe to production

*Uranex now reported as Magnis

Table 3: TSX- and AIM-listed graphite projects ranked in November 2014

Mason	Alabama	Energizer	Flinders	Focus	
Code	Northern	Zenyatta	StratMin	FMS	LLG
	ALP	EGZ	FDR		
NGC	ZEN	STGR			
Project	Coosa	Molo	Woxna	Lac Knife	Lac
Guéret	Bissett Creek	Albany	Loharano		
Country	US	Madagascar	Sweden	Canada	
Canada	Canada	Canada	Madagascar		
Mineralisation	Flake	Flake	Flake	Flake	
Flake	Flake	Hydrothermal	Flake		
Factor 1	7	9	4	7	10
5		4	3		
Factor 2	6	1	10	7	7
7		7	1		
Factor 3	8	6	6	8	2
10			10		
Factor 4	8	6	2	8	4
6		10	4		
Factor 5	0	0	0	6	0
0		0	10		
Factor 6	2	2	10	4	2
4		2	10		
Score	31	24	32	40	25
32		23	38		

1) Deposit size, contained graphite and enterprise value; 2) location (country risk); 3) flake size distribution; 4) product purity; 5) product off take agreements and 6) timeframe to production

Each factor receives a maximum score of 10 points and we equally weight each compiled factor. This results in a maximum score for each listed stock under consideration out of 60. Naturally, earlier stage explorers may be detrimentally impacted by some of the quantitative factors (e.g., resource not yet estimated; no metallurgical results), however this partially compensates for some of the increased risk associated with the stage of development and illustrates the dynamics of the graphite space.

At this juncture, it should be noted that the graphite market is dynamic and that project rankings could be impacted in a number of ways, including:

- Changes in the political landscape of the region where the project is located;
- Fluctuating commodity prices, which could be exacerbated by foreign exchange variations;
- Non-availability of funding for exploration and development, or funding at a premium;
- An economic deposit (**ore** reserve) may or may not be delineated, especially when flake size, purity and processing characteristics are taken into account;
- The lab or pilot process test methods may or may not scale up to successful production and meet anticipated yields, flake size distribution or product purity.

The three highest ranked ASX graphite projects based on updated quantitative analysis continue to be those held by Syrah Resources (SYR), Valence Industries (VXL) and Kibaran Resources (KNL) as previously reported in July 2014 (Tables 1 and 2). The three most interesting TSX graphite projects are owned by Flinders (FDR) Focus Graphite (FMS) and Northern Graphite (NGC), while AIM-listed StratMin Global Resources (STGR) looks equally attractive with its Loharano project (Table 3).

However, given the recent spate of exploration updates, results and resource upgrades released to the markets since 20 July, e.g., Archer Exploration (AXE), Buxton Resources (BUX), Lamboo Resources (LMB), Kibaran Resources (KNL), Triton Minerals (TON) and Uranex (UNX), now known as Magnis (MNS) it is possible that the rankings will change as projects evolve.

Figure 1: Patersons Graphite Index (ASX listed stocks)

Source: PSL, Bloomberg

Factor 1 - Deposit size and quality

The first factor scores the size (20%) and grade (30%) of the deposit as well as the Enterprise Value per tonne (EV/t) of contained graphite (50%). This factor encompasses the traditional size and grade metrics of a 'normal' (non-industrial mineral) deposit (where bigger and higher is better) and adds an element of valuation to the mix with the EV/t metric. The size (tonnage) is given the lowest weighting of the three parameters, as this is considered to be less important than grade and that a resource of >20m tonnes is relatively academic given the present size of the global graphite market.

Syrah, Triton and Mason score the highest (10) on this factor, mainly as a result of significant size and/or grade of resource and commensurately a low EV/t, while Sovereign and Energizer (9) and Kibaran (8), also score well. The lowest scoring stocks are Lamboo and Magnis (2) (in the case of Magnis this is as a result of not having scores for size or EV/t, although we have assigned a value based on exploration target grades of 4-9%C at Nachu.). Figures 2-5 below show the results of this comparison. Figure 2 and 3 show bubble charts comparing deposit grade, size of deposit (in contained graphite) and enterprise value. As a result of the current size of the Syrah and Triton resources and the distortion that creates, we have excluded these companies from Figure 3.

Figure 2: Comparison of EV, Grade and Contained Graphite including Syrah and Triton

Figure 3: Comparison of EV, Grade and Contained Graphite excluding Syrah and Triton

Factor 2 - Location

The second factor scores the risk of project location using the Fraser Institute Annual Survey of **Mining** Companies 2013 (Policy Perception Index), supplemented with a subjective score for non-ranked countries. Country risk is often underestimated until the risk is realised, often with significant consequences for investors.

The top scoring stocks in this factor are Talga and Flinders (10), with deposits in Sweden (currently the top ranked country in the world according to the survey), while Lamboo and Buxton (9) scored well with their projects in Western Australia. Canadian and South Australian plays ranked fairly highly, well ahead of poor performers

with projects in Africa, Madagascar and Sri Lanka.

Factor 3 - Flake size distribution

The third factor scores the flake distribution (relevant only in flake graphite deposits as opposed to amorphous deposits) or suitability, of the graphite produced to be used in higher value applications. This is one of the more debated project factors as some stress its importance, while others play it down (usually those that do not have high proportions of larger flakes in their deposit).

However, a number of facts about flake size are true. Firstly, the larger the flake (in a given deposit) the higher the purity of the graphite and the higher the price (all else being equal). In addition, as certain end use applications require certain minimum specifications of graphite, the demand profile for different flake sizes (among other factors) is a key driver in project decisions. For that reason, projects with particularly

large proportions of ultrafine flake graphite may not proceed into development as this is the segment of the market most at risk of over supply.

Flake size is one of the more difficult factors to rank, given that not all explorers report comparable size fractions and also that many explorers have not progressed to the stage of detailed metallurgical testwork.

Figure 6 shows the flake size distribution based on our interpretation of information currently available. Magnis, Northern and StratMin score the highest on this factor (10), slightly ahead of Kibaran, Alabama and Focus (8) owing to their greater proportions of larger flake sizes relative to ultrafine graphite. Although Buxton reports coarse flake size based on petrographic evidence, this is insufficient to score this project. The two Tanzanian projects (Kibaran and Magnis) score higher than the two Mozambique plays (Syrah and Triton), suggesting an underlying difference in geological conditions. This may be related to original host rock composition and/or metamorphic grade. Archer has two projects: Campoona (fine flake less than 75 micron) and Wilco (medium to large flake). The current Archer score is based on a weighted value for the two projects; naturally this would change if based solely on Wilco.

Talga has two projects, Nunasvaara and Raitajärvi, of which Nunasvaara has, to date, been the **company's** main project. However, Raitajärvi is predominantly medium-to extra-large flake, hence this could change the Talga score as the projects progress.

It is also worth noting that Valence, which according to its market release dated 9 October 2014, has reportedly discovered material containing some of the largest flake sizes ever discovered (flake graphite exceeding 4 millimetres). The significance of this discovery to its Uley graphite project is still being quantified and therefore is not included in this analysis.

Figure 4: Total graphitic carbon (TGC %)

Figure 5: EV/t of contained graphite

Factor 4 - Product purity

The fourth factor scores the purity of the graphite after simple processing (ie., before acid or thermal upgrading). As with flake size, product purity is difficult to ascertain from public reports and we also draw attention to the potential difficulty of predicting the effect of scaling up from lab and trial testing to full-scale plant production.

Graphite purity is particularly important for the higher value end uses like lithium-ion batteries and is a key determinant in saleability of the product. It is also a key factor in the cost of production, as if further processing is required to make the product saleable, this could dramatically increase the operating cost. There is also an environmental consideration in whether acid leaching or thermal treatment is required in the product beneficiation and whether this may impact the attractiveness of the product for certain end use applications (eco-friendly applications may be particular about how the feedstock was produced).

Simple processing can be altered in certain cases by including further grinding and flotation to produce a purer concentrate (to a point), however this does decrease the proportion of larger flake sizes in the final concentrate and increase the cost of production. Some deposits such as Loharano (StratMin), Epanko (Kibaran), Duwi Sovereign and Coosa (Alabama) are deeply weathered; for example, Epanko, to 80 metres depth. Weathering causes oxidation and hydration, which softens the rock and breaks down gangue minerals such as entrained carbonates, sulphides and silicates; this may enhance flake liberation and hence purity.

Figure 7 shows the purity of the product after simple processing. Zenyatta (10) scores highest on this metric followed by Syrah, Triton, Alabama and Focus (8), while Lamboo, Talga and Flinders have the lowest scores (2). The high purity seen at the Zenyatta Albany project is probably related to the hydrothermal mineralisation style. Buxton could not be ranked as no metallurgical testwork has been done.

Although not included in Figure 7 the vein graphite projects in Sri Lanka (MRL Corp and Bora Bora) often have such high %C grades to start with, that simple sorting and processing is all that is required to produce a very high purity product.

Factor 5 - Product offtake

Given that an industrial mineral deposit without a market is merely a geological curiosity, the fifth factor scores the **company's** success in signing binding offtake agreements and memoranda of understanding (MoU) for substantial portions of intended production.

The graphite market is largely one of contracted sales agreements between buyers and sellers for product meeting the buyer's specific requirements. For this reason, a formal sales agreement with buyers for a substantial portion of the intended production is of particular importance (there have been cases of companies being forced to close because they could not sell a large enough portion of product produced). We have given greater weight in our scoring to binding off take agreements as opposed to MoU and have rewarded greater proportions of production covered by such agreements (although any agreement is better than none at all).

On this factor StratMin (10) and Lamboo (8) score the highest, followed by Kibaran and Focus (6).

Figure 6: Flake size distribution

Figure 7: Purity of concentrate

Factor 6 - Timeframe to production

The sixth factor scores the expected time to commercial production.

The interest in securing ex-**China** sources of supply coupled with **Chinese** closures and the growth in higher specification product demand has resulted in a window of opportunity to introduce new supply to the market. The race to bring the right product to the market and secure those sought-after offtake agreements means that those companies further advanced in their timeline to first commercial production have an advantage over those further behind (on the assumption that they have the required product specifications).

This factor scores Valence, Flinders and StratMin the highest (10) as they are either operational, or very shortly expected to be in commercial production. It is worth noting that Valence and Flinders are brownfield projects with a record of previous production, which is likely to shorten time to production. StratMin was also previously mined on a small scale prior to 1947, while the Alabama Coosa project was mined until the 1950s, which should assist timeframe to production.

Conclusions

Aside from the factors discussed above, it is worth bearing in mind the evolution of the graphite sector and the potential growth in the market for graphene applications, as many of the companies mentioned in this report either personally conduct or financially support R&D into future commercial applications using graphene. While the market is in its infancy (annual demand estimated at between 500-1,000 tonnes) the potential for growth in demand for this product stream is considerable. In this regard it should be highlighted that Talga (in its Vitangi scoping study) has highlighted its ability and intention to initially produce 1,000 tonnes (scalable) of graphene as part of its overall 47,000 tpa production rate.

In summary, while the graphite sector is dynamic, analytical problems exist in comparing companies based on publicly available information and the fact that new applications and product specifications are continually evolving, we believe the factors and analysis contained in this study correctly encapsulate the key drivers of a successful graphite project. While many of the projects discussed above may continue through to successful development and expansion, we ultimately believe that more will be disappointed.

1 This is an update on a previous report covering 12 graphite-focussed ASX-listed companies (Jason Chesters; Patersons Securities Ltd (PSL), 20 July 2014: Your Guide to the ASX Listed Graphite Sector Industry Report - Get Your Dose of Carbon), which was covered online in IM on 15 August 2014

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