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# Creating a Battery Hub In Africa's Graphite Triangle

Given China's overwhelming dominance in the production of all steps of the battery anode supply chain, diversifying global graphite production is essential to a secure global energy transition. Africa's Graphite Triangle (Mozambique, Madagascar, and Tanzania) is already the largest source of natural graphite outside of China and has potential to be developed further with U.S. engagement. Creating a sustainable relationship with the governments of Africa's Graphite Triangle (AGT) should, however, involve assisting these countries in developing downstream capacities beyond raw graphite extraction. Despite significant challenges, supporting the development of downstream added-value industries in the graphite triangle, would position the U.S. as a more appealing partner than China.

### **Lack of Suitable Regional & Friendly Graphite Reserves to Meet North American Demand**

Graphite by weight is the largest metal component of lithium-ion batteries, making control and provision of suitable graphite supplies central to both U.S. national security, and climate goals.<sup>1</sup>

Demand for graphite from growing North American battery manufacturing is, however, set to rapidly outpace the ability of the U.S. and its close allies to ramp up matching production from their reserves.<sup>2</sup> Planned battery manufacturing capacity in the U.S. and Canada is expected to grow by 438%, requiring based on current planned production ~ 1.5 million metric tons (Mt) per year of graphite by 2030.<sup>3</sup> Known major reserves of graphite in North America (located in Mexico) total only ~3.1 Mt.<sup>4</sup>

Total graphite resources in North America are significantly higher than 3.1 Mt (with ~30 million metric tons located in Canada), but the commercial viability of extraction is unknown. Even if all North American graphite resources prove to be commercially viable to extract, it is highly doubtful whether they can be scaled up at a pace sufficient to meet expected 2030 demand. Given that North American production of graphite in 2021 was only 14.1t, even if we assume a growth curve equivalent to the last commodity super cycle (1995-2010) with a CAGR of 2.8%, North American production only grows to 18.1t by 2030.<sup>5</sup> America’s sluggish pace of mining development, from exploration to extraction, is also a handicap.

	2021 US-CAN-MEX Production of Selected Mineral (t)	2030 US-CAN-MEX Production of Selected Mineral Commodity Supercycle Scenario, (t)	2030 Demand from North American Battery Production (t)	2030 North American Demand as a % of 2021 Production	2030 North American Demand as a % of Additional Production
Graphite <sup>3</sup>	14,100	18,078	1,676,818	11,892%	42,152%

Efforts to secure sufficient supplies of graphite should focus on increasing the pace of graphite resource development both domestically and in friendshored jurisdictions. It will, however, not be possible for the U.S. to meet the material needs of its planned battery manufacturing build out, without sourcing graphite from outside a close circle of U.S. allies.<sup>2</sup> The U.S. is going to have to make some new friends.

### **The Global Landscape of Graphite Extraction, Processing, and Relevance to U.S. National Security**

China holds the largest reserves of graphite globally at 78Mt (28%).<sup>4</sup> China has also been able to develop its reserves to a much greater extent proportionally than



the rest of the world. The majority of global graphite extraction (77%) is within China.<sup>4</sup> The majority of production of graphite into high-value downstream graphite products is also done in China, with 75% of natural graphite anodes produced in-country.<sup>6</sup> Even worse from a diversity of supply standpoint, China dominates the mid-stream step of graphite spheroidization converting natural flake graphite into coated purified spherical graphite (CPSG), with 99% of global production (See Annex I for the full graphite supply chain).<sup>6</sup> China also has been able to create synergies between its large coal base and graphite reserves. Coal derived needle coke can be used to create synthetic graphite, enabling China to lead in both synthetic and natural graphite production.<sup>7</sup> Combinations of both natural graphite and synthetic graphite are used in EV batteries.<sup>8</sup>

China's near total geographic control of graphite production is unique. Normally China operates a hub-spoke model of minerals production, with value added domestically, but raw materials extraction conducted in third countries. China's commanding lead in both extraction and processing therefore presents a challenge. Addressing Chinese dominance throughout the battery anode vertical, requires the development of entire alternate upstream supply chains down to the level of active anode materials (AAM's). Otherwise, in a business-as-usual scenario, the largest component in today's battery chemistries will continue to be supplied primarily by America's greatest geopolitical competitor.

Chinese dominance of graphite extraction is not pre-destined by geography, as the distribution of graphite reserves is heterogeneous across the Earth's surface.<sup>4</sup> Brazil is home to the 2<sup>nd</sup> largest global graphite reserves at 74 Mt and is 4<sup>th</sup> in extraction (4.6%).<sup>4</sup> While a joint industrial policy with Brazil focused on further developing the nation's graphite is worthy of further exploration, this is not the focus of this memo.

Mozambique and Madagascar hold the 3<sup>rd</sup> and 4<sup>th</sup> largest graphite deposits at 25 Mt and 24 Mt respectively. Both nations are the next largest producers of graphite after China (96kt and 100kt).<sup>4</sup> Alongside China, Mozambique and Madagascar are the only two countries with more than 5% of global production. In fact, global graphite mining can be more accurately described as a predominantly Chinese industry, with a small alternative production base in Mozambique (6%), and Madagascar (6.3%).<sup>4</sup> Rounding out the top 5 global graphite reserves is Tanzania, though the nation has been far less able to capitalize on its graphite reserves than its neighbors ranking 9<sup>th</sup> in production globally.<sup>4</sup>

If the democratic world wants to source sufficient graphite to meet the buildout of its battery infrastructure from Non-Chinese sources, it will need to engage deeply with the emerging African Graphite Triangle.



### Existing Graphite Economy in Madagascar, Mozambique, Tanzania

Africa's Graphite Triangle is a geography of opportunity to develop ex-China extraction to anode capacity.

Mozambique's total expected annual graphite output from all projects under-construction or onward, is ~36% of expected North American battery demand in 2030. Including active and near extraction projects in Madagascar and Tanzania, brings the region's projected output to ~59% of expected graphite demand from North American battery manufacturers.

Table 1. Advanced or Active Projects in the African Graphite Triangle<sup>9</sup>

Location	Project	Firm	National Origin	Stage	Grade	Tonnes Milled LOM	LOM	t/yr
MZ	Balama	Syrah	Australia	Production	16%	17,500,000	50	350,000
MZ	Ancuabe	Triton Minerals	Australia	Construction	6.20%	1,620,000	27	60,000
MZ	Montepuez	Tirupati Graphite	UK	Construction	9.27%	2,500,000	50	50,000
MZ	Nippe	DH Mining Development Limited	China	Construction	n/a	2,920,000	20	146,000
MD	Molo Mine	Next Source Materials	Canada	Production	7.10%	1,350,000	30	45,000
MD	Sahamamy/Vatomina	Tirupati Graphite	UK	Production/Construction	4.2%	3,240,000	40	81,000
MD	Antsirakambo/Marovintsy	Etablissements Gallois	France	Production	10%	n/a	n/a	140,000
MD	Loharano / Mahefedok	Bass metals	France	Production	4%	n/a	n/a	20,000
MD	Antisrabe	Unknown	Chinese	Production	n/a	n/a	n/a	n/a
MD	Maniry / lanapera	Envion Group	Australia	Construction	6.58%	1,184,400	21	56,400
TZ	Lindi Jumbo	Walkabout Resources	Australia	Construction	17.9%	960,000	24	40,000

Counting the total output of all projects for which data is available, including those in permitting and feasibility stages, provides a total regional output of graphite approximate to expected 2030 North American demand. Tanzania's significant number of early development projects makes it a very promising environment for the deployment of U.S. patient capital. U.S. public financing could allow for the development of additional ex-China graphite capacity, beyond that brought forward by market forces alone.



Table 2. Projects in the Exploration, Feasibility or Permitting Stage in the African Graphite Triangle<sup>9</sup>

Location	Project	Firm	National Origin	Stage	Grade	Tonnes Milled LOM	LOM	t/yr
MZ	Balama Central	Tirupati Graphite	UK	Permitting	11.06%	1,566,000	27	58,000
TZ	Bunyu Graphite	Volt Resources	Australia	Permitting	4.4%	2,380,000	14	170,000
TZ	Chilalo	Evolution Energy Minerals	Australia	Permitting	10.6%	884,000	17	52,000
TZ	Mahenge Liandu	Armadal Capital Plc	UK	Permitting	9.80%	1,488,000	15	109,000
TZ	Nachu	Magnis Energy Technologies	Australia	Permitting	4.6%	3,658,000	15.5	236,000
TZ	Epanko	EcoGraf	Australia	Feasibility	8.41%	960000	18	60,000
MZ	Nicanda Hill	Triton Minerals	Australia	Feasibility	11.1%	n/a	n/a	n/a
MD	Vohitsara/Marofody	DNI Metals	Canada	Exploration	5%	n/a	n/a	n/a
MZ	Nipacue	Frontier Rare Earths	Luxembourg	Exploration	n/a	n/a	n/a	n/a
MZ	Calua	New Energy Minerals	Australia	Exploration	13.40%	n/a	n/a	n/a
TZ	Kimoingan	Walkabout Resources	Australia	Exploration	8-12%	n/a	n/a	n/a
TZ	Merelani-Arusha	EcoGraf	Australia	Exploration	6.5%	n/a	n/a	n/a
TZ	Tanga	EcoGraf	Australia	Exploration	n/a	n/a	n/a	n/a

Not all extracted graphite can be shipped to North America, nor is such an outcome desirable from a national security perspective. Diversified offtake agreements by graphite suppliers, such as Syrah to the U.S. and South Korea, and Next Source Materials to Germany's Thyssenkrupp, are promising first steps of a global graphite supply chain diversifying from Chinese dependence.<sup>10</sup> Ensuring American non-dependency on Chinese production for key materials in battery anodes is essential. Also essential, to minimize the CCP's leverage, is supply diversification for U.S. allies and the international community.

Chinese firms, given their interest in Mozambique's coal resources, and Madagascar's other battery metals (cobalt and nickel), are already active in Southeastern Africa. Chinese firms have also already begun to engage with the region's emerging graphite economy. One Chinese firm is currently developing a graphite extraction project, and several are inking offtake agreements with Non-Chinese graphite miners.<sup>11</sup>

If the U.S. seeks to keep China out of the largest Non-Chinese natural graphite extractive base globally, it must accelerate the development of ex-China capacity in the AGT. However, to more effectively keep China out of the emerging Southeastern African graphite sector, the U.S. should engage in a deeper

relationship than just the financing of more raw-materials extraction. A deeper relationship between the U.S. and the countries of the AGT means helping the region develop downstream segments of what is currently a raw materials industry.

### **Rationale for the Development of Added Value Components of AAM Supply Chains in Southern Africa**

The US is already taking policy steps to further support ex-China extraction of graphite in Mozambique, though not yet in Madagascar. Australian firm Syrah Resources, received \$150 million in financing from the DFC to maintain and expand infrastructure at its Balama project.<sup>12</sup> Two separate streams of U.S. financing (a \$102.1mn DOE loan, and a \$220mn DOE grant) have also been approved to support the expansion of Syrah's Vidalia processing facility in Louisiana.<sup>13</sup>

However, the financing received by Syrah shows that the U.S. is following existing extractive patterns of development in regard to Southeastern Africa. It may make short term sense to outside powers from the standpoint of their economic interests, and their respective political economies, to export raw materials without investing in added value components in country. Perpetuating, extractive development models in Southern Africa, however, leaves an opening for the PRC to offer a better development relationship to the region's governments. Leadership of emerging economies don't want to be strip mined for raw materials and left with only the lowest value add industries. Leaders of emerging economies are seeking development partners that will help them add-value to their resources, and serve a growing market for complex green energy products.

The PRC, has already pursued development models with certain critical minerals suppliers (Indonesia, Chile), where it assists these nations in building domestic downstream manufacturing capacity.<sup>14</sup> China, so far though, has only pursued joint added-value industrial policies in nations that possesses leverage. China has no choice but to offer Chile or Indonesia investments more in line with their leadership's development visions, as these nations possesses commanding positions in the global minerals' economy (in lithium and nickel/cobalt respectively). Contrast China's relationship with Indonesia, and Chile, to that of Africa, where the CCP has been quick to repeat extractive, and borderline colonial, development patterns. One Chinese firm has even been caught in blatant violation of an African country's raw export ban, designed to add value to mineral resources domestically before their export.<sup>15</sup>

America and its allies have the opportunity to one-up the Chinese model of development when engaging with the nations of Southeastern Africa. Political



support of the African Graphite Triangle governments will go to the outside powers that can help them develop downstream industries reliant on their graphite.

IP required for Southeastern African countries to move up the value chain is also not so complex as to be out of reach. Canadian Next Source Materials has already indicated it plans to establish a CPSG production plant in neighboring Mauritius to process flake graphite from its Molo mine in Madagascar.<sup>16</sup> Other graphite firms such as Sarytogan, and Nouveau Monde Graphite, have plans to build spheroidization infrastructure in the country of extraction (Kazakhstan, and Canada respectively).<sup>17</sup> It would not be a far step to support greater graphite processing capacity in Southeastern African nations, and perhaps from there even AAM production, though the latter is a much harder lift.

### **Challenges to the Development of Downstream Added Value Components of AAM Supply Chains**

Developing the downstream industries of a battery anode cluster in Southeastern Africa is admittedly, easier said than done. All three nations score low on the Human Development Index.<sup>18</sup> However, Mozambique and Madagascar in particular face a challenging mix of infrastructure, security, and human capital deficits.

Madagascar lacks a national grid, with the nation instead primarily relying on localized grids.<sup>19</sup> Mozambique, as of 2021 had less than 1/3<sup>rd</sup> of its populace with access to electricity, less than but comparable to Madagascar.<sup>20</sup> New natural gas extraction in Mozambique is coming online with fields under development by Exxon, Total, and Eni.<sup>21</sup> Mozambique's natural gas deposits are, however, located ~5,000 km's away from existing graphite extraction, creating a resource mismatch challenge.<sup>21</sup>

If the energy picture is more promising in Mozambique, the security situation is worse. The active Al Shabab insurgency in the graphite mining region of Cabo Delgado remains a threat to development.<sup>22</sup> Graphite and other mining projects have already faced attacks from the militant Islamist group.<sup>23</sup>

The most significant roadblock impeding Mozambique and Madagascar from developing downstream graphite industries, however, is the lack of suitable human capital. Sufficient human capital is essential for any nation that wants to move not just one step up the value chain to CPSG production, but to the more technologically intensive step of AAM production. Graphite spheroidization is a technology that dates back to the 1970's, but the process used to convert graphite into AAM's currently used in Li-ion chemistries was only discovered as late as the 1990's by Sony.<sup>24</sup> Infrastructure can be built, insurgencies can be crushed, but



you can't instill an entire workforce with advanced manufacturing skills over a short timespan.

Aside from a nickel refinery, Madagascar has no major manufacturing domestically beyond textiles.<sup>25</sup> Mozambique, given its indigenous aluminum smelter Mozal, is in a slightly better position regarding necessary expertise in value-add manufacturing. Mozal was established in the 1990's, and is the 2<sup>nd</sup> largest aluminum smelter in Africa.<sup>26</sup> Of the three nations, however, Tanzania is best positioned in regards to human capital. Tanzania, possessing manufacturing capacity in chemicals, plastics, and steel, has the greatest chances of success in moving further into downstream industries of the battery anode supply chain.<sup>27</sup>

Given national infrastructure, security, and human capital deficits, if the U.S. wants to assist in the development of extraction to anode capacity in Africa's graphite triangle, a more regional strategy is advisable. Different nations, could pool relevant competencies, to address what others lack. Tanzania given its relative human capital advantage, could serve as a more senior partner to the US in the region, doing more of the heavy lifting in terms of industrial development. Consequently, it might make sense for the U.S. to support the development of an industrial park on the Tanzanian-Mozambique border, focused on processing locally mined graphite into AAM's. Graphite deposits are concentrated in the north of Mozambique and the South of Tanzania, making a transborder industrial cluster a logical geologic fit. The northern side of the Mozambique-Tanzania border also has a surplus of relevant infrastructure capacity. Shell invested heavily in infrastructure within the border region of Mtwara to serve a gas project that never went online.<sup>21</sup> Both sides of the Tanzanian-Mozambique Rovuma river border speak Swahili creating a shared language environment that could support joint industrial development.<sup>21</sup>

Alternatively, looking to Mozambique's Southern neighbor, South Africa could play the role of senior partner in the development of a regional battery anode supply chain. South Africa has the most advanced manufacturing sector on the continent, and the largest by economic valuation. Profoundly in the nation's favor for taking a larger role in a regional battery anode supply chain, South Africa is the only country in the region that has existing battery manufacturing infrastructure and plans to develop additional capacity.<sup>28</sup>

Beyond South Africa's ability to provide relevant, regional, human capital, it is also in the strategic interest of the US too engage more deeply with the nation given current geopolitical competition. Peer competitors such as China and Russia can be checked if emerging economies outside the traditional western camp can be brought into the economic fold of the global north as equals, or at the very least kept from further integration into a China-Russia axis. In the fallout from Russia's



invasion of Ukraine, South Africa's relatively neutral position, up to and including pursuing naval exercises with Russia and China, is increasingly at odds with the pro-western camp.<sup>29</sup> South Africa's stance is so deleterious, as given its size and political history, the nation has a disproportionate influence among the non-aligned middle powers the west seeks to court. Integrating South Africa into a regional battery supply chain and helping the nation's leadership meet their own added value manufacturing objectives for the energy transition, would go a long way towards tilting South Africa back towards the western camp.

### **What Tools Are Available to a U.S. Administration?**

An American Administration will likely want to recruit a senior regional partner like South Africa or Tanzania to assist in developing ex-China extraction to anode capacity. However, the U.S. is not without its own state tools and capacities that could be leveraged towards developing a regional battery-anode supply chain in Africa's graphite triangle.

The U.S. Development Finance Corporation (DFC) could be used to fund shovel ready mining, and added-value processing projects down the battery anode vertical. Already, the DFC has financed Syrah's expansion of its graphite project in Mozambique, and in the case of TechMet's Brazilian nickel mining operations, energy transition aligned raw materials projects elsewhere.<sup>30</sup> DFC, however, is not a magic fix all, as its funds are limited. Over the initial 4 years of its operation (FY 2020- FY 2023), ~\$26.3 billion of DFC's current \$60 billion cap have been committed.<sup>31</sup> A bi-partisan bill akin to the Americas Act currently sitting in the US Congress could increase capitalization for the DFC and Export-Import bank, specifically to address raw materials shortfalls facing the domestic battery industry.<sup>32</sup>

Another U.S. government (USG) tool to fund regional infrastructure needed to support the development of the AGT is the Millenium Challenge Corporation (MCC). MCC, has the remit to invest at both the national and regional level in infrastructure projects (transmission, power generation, ports, road, rail). MCC, while not suited to the investments in the extraction to anode supply chain, would be instrumental in addressing the regions infrastructure deficit.

It is unfeasible, however, to expect U.S. taxpayer dollars to fund the majority of mining and manufacturing projects necessary to buildout Non-Chinese capacity in Africa's Graphite Triangle. Good industrial policy, should be focused on leveraging public capital to draw in greater private investment. Least developed countries like Mozambique, Madagascar, and Tanzania, also don't face their first bottleneck in the availability of capital, but instead the availability of bankable projects.<sup>33</sup> More support is needed in early stage project development In Africa to attract suitable investment (private or public).<sup>33</sup> Africa's Graphite Triangle, already



the subject of a plethora of graphite extraction feasibility studies, needs more support in making the case to private capital for the feasibility of downstream manufacturing.

USG capacities that could support the early project development stage exist, though are underfunded. Currently, the U.S. Trade and Development Agency (USTDA) is the only organ within the U.S. government with a specific mandate to focus on the economic feasibility work, necessary to increase the pipeline of investable deals.<sup>33</sup> Hypothetically, the DOE could also have the capacity and potential remit to work on early-stage development work, given its stewarding of the Net-Zero World Initiative (NZWI).<sup>34</sup> Highlighted in the remit of the NZWI is support of "Cross-sector project pipelines and infrastructure modernization plans", the work necessary to develop decarbonization roadmaps for key sectors in foreign nations.<sup>34</sup> The NZWI also includes in its mandate, "workforce development training", potentially allowing the DOE to address the human capital gaps holding back the development of downstream industries in the AGT. USAID, could also serve a complimentary role in the delivery of any human capital training provided by the DOE. Development focused training initiatives have long been part of USAID's bread and butter. The NZWI does not, however, currently take the next step, providing the early stage deal due diligence akin to the work done by USTDA.

Regardless of the USG tools utilized, a coordinated all-of-government effort should be employed, to support the development of extraction to anode capacity in the AGT. USTDA's ability to provide early-stage deal feasibility should be beefed up and directed at the task of identifying more bankable deals in regional downstream capacity. DOE's potential to compliment the USTDA, through the provision of its own energy focused due diligence via the retooling of the NZWI should also be explored. A strategy of human capital development should also be worked out in tandem between the DOE and USAID, to determine how best to address the skills gaps holding back the development of a regional battery anode cluster. The DFC could be used to finance test case processing projects to attract private capital into similar deals, while the MCC finances the supporting physical infrastructure necessary to develop the region.

## **Conclusion**

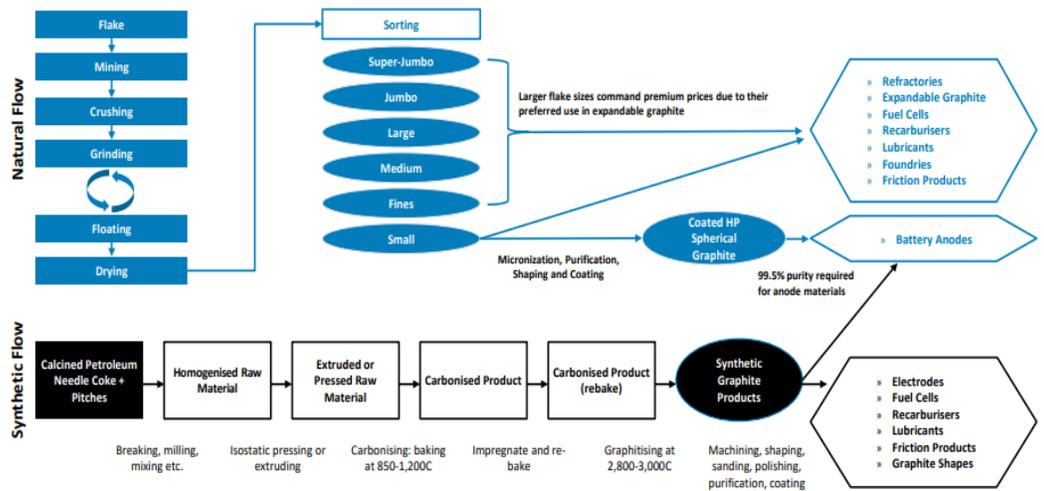
Whether it is a graphite triangle, of Mozambique, Madagascar, and Tanzania, or quadrangle bringing in South Africa, a diversified global battery anode supply chain runs through Southeastern Africa. US supported development of extraction to anode capacity in Southeastern Africa would in summary bring the Americans in, help the Africans raise themselves up, and keep the Chinese out. If the world wants a diversified Non-Chinese dominated battery mineral supply chain,



Southeastern Africa, despite its development challenges, is profoundly important towards unlocking that objective. If the U.S. also wants to one-up the development model China is offering the continent, positioning itself as a more appealing partner, it will assist the nations of Africa's Graphite Triangle in developing downstream industries reliant on their graphite resources.

## Annex I:

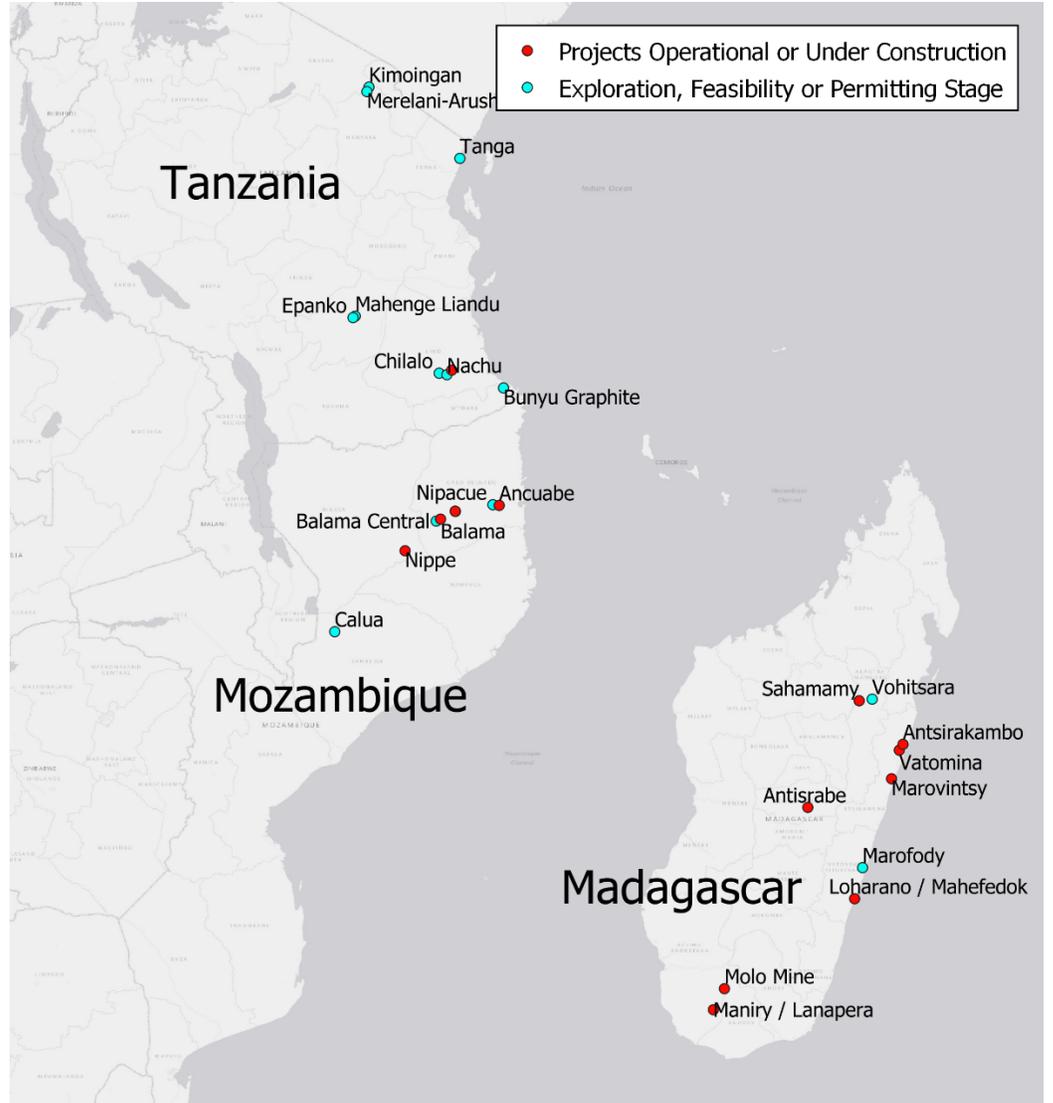
### + OVERVIEW OF GRAPHITE PRODUCTION, PROCESSING AND KEY USES



Source: Nouveau Monde Graphite. (2023). From Ore to Battery Materials a North American Integrated Source of Graphite-Based Solutions for the Energy Transition.

<https://nmg.com/wp-content/uploads/2023/03/NMG-Annual-Report-2022.pdf>

## Annex II:



Source: NZIPL

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- <sup>9</sup> Identification of graphite deposits used data from Mining-data-online, Digbee, and African Energy's Graphite Projects in Southeastern Africa Map. Company reports were used to provide expected mine production figures where available, when not figures from Mining-data-online or the British Geological Survey's report *Graphite Resources, and their Potential to Support Battery Supply Chains*, was used. Full list of sources available upon request.
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