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Visit to Zambia and the United Arab Emirates, 30/10 to 17/11 2022

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CJ Mitchell

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British Geological Survey offices

Nicker Hill, Keyworth, Nottingham NG12 5GG
Tel 0115 936 3100

BGS Central Enquiries Desk
Tel 0115 936 3143
email enquiries@bgs.ac.uk

BGS Sales
Tel 0115 936 3241
email sales@bgs.ac.uk

The Lyell Centre, Research Avenue South, Edinburgh EH14 4AP
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email scotsales@bgs.ac.uk

Natural History Museum, Cromwell Road, London SW7 5BD
Tel 020 7589 4090
Tel 020 7942 5344/45
email bgslondon@bgs.ac.uk

Cardiff University, Main Building, Park Place, Cardiff CF10 3AT
Tel 029 2167 4280

Maclean Building, Crowmarsh Gifford, Wallingford OX10 8BB
Tel 01491 838800

Geological Survey of Northern Ireland, Department for the Economy, Dundonald House, Upper Newtownards Road, Ballymiscaw, Belfast, BT4 3SB
Tel 0289 038 8462
www2.bgs.ac.uk/gsni/

Natural Environment Research Council, Polaris House, North Star Avenue, Swindon SN2 1EU
Tel 01793 411500 Fax 01793 411501
www.nerc.ac.uk

UK Research and Innovation, Polaris House, Swindon SN2 1FL
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Foreword

This report summarises the visit from 30th October to 17th November 2022 by Clive Mitchell, Industrial Minerals Geologist, British Geological Survey (BGS) to Zambia and the United Arab Emirates (UAE) as part of BGS research on African graphite resources for use as a battery raw material.

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Securing the supply of battery raw materials, such as graphite, is a key focus for global economies in their drive to decarbonise. Diversification of available graphite resources has lead to a resurgence of mineral exploration in Africa, particularly eastern Africa. There are many other countries in Africa, such as Zambia, where graphite resources are known to occur but where there are no modern classification compliant resource estimates or mineral exploration data.

As part of the International Geoscience Research & Development (IGRD) programme of the British Geological Survey (BGS), a research project on graphite resources in Africa is being conducted with an initial focus on resources in Zambia. This report describes the visit to Zambia and the United Arab Emirates (UAE) carried out by Clive Mitchell, Industrial Minerals Geologist from the BGS in November 2022 as part of this research.

A presentation on graphite in Africa was given at the 10th Zambia International Mining and Energy Conference and exhibition (ZIMEC) which took place in Kitwe, Zambia on 1st and 2nd November 2022. Attendance at the conference was pivotal in re-establishing contact with key research collaboration partners in Zambia. The presentation drew attention to the presence of the largely unexplored flake graphite resources in Zambia. The presentation is available here: Graphite in Africa: Carbon for Decarbonisation.

Planning for a PhD research project in collaboration with the Copperbelt University (CBU) was initiated. The research will be fully funded and supported by the CBU African Centre of Excellence in Sustainable Mining with researchers from the CBU Schools of Mines & Mineral Sciences and the School of Mathematics & Natural Resources. Several PhD candidates have already expressed interest. Discussions were also held with the Zambian Geological Survey Department (GSD) and the School of Mines, University of Zambia (UNZA) who both expressed their interest in participating in the research collaboration.

A presentation on graphite resources in Africa was given, as well as participation in a discussion panel on battery raw materials, at The Mining Show in Dubai, United Arab Emirates on 15th and 16th November 2022. Attendance at The Mining Show was important to maintain contact with key research collaborators and make new contacts with potential research collaborators in the Middle East and North Africa (MENA) region.

1 Introduction

Battery raw materials, such as graphite, are a key focus for global economies in their drive towards Net Zero and decarbonisation to combat global warming. Graphite is the primary anode material used in batteries for electric vehicles, energy storage and other technologies. Demand for graphite is expected to outpace supply by 2030 and is seen as a critical risk to industrial supply chains. Global graphite production and processing is dominated by China. Diversification of production is seen as critical in protecting the resilience of the global supply of graphite.

Africa has significant graphite resources especially in eastern Africa where countries such as Madagascar and Mozambique have significant graphite production. Mineral exploration for, and development of, graphite resources in Africa is taking place at a rapid rate with approximately 40 mineral exploration and development projects across the continent including projects in Botswana, Ghana, Guinea, Madagascar, Malawi, Mozambique, Namibia, Tanzania and Uganda (Mitchell & Deady, 2021).

The main source of graphite in eastern Africa is the Mozambique Belt which is a Pan-African orogenic belt consisting of high-grade metamorphic rocks (mainly gneiss, marble and schist) of Meso- to Neoproterozoic age. The southwestern extent of the Mozambique Belt occurs in the Eastern Province of Zambia where graphite-bearing deposits are known at Njoka (10–13% graphite) near Lundazi, and Mkonda (6–7% graphite) and Mvuvye (6–12% graphite) near Petauke (Drysdall, 1959, 1960a, 1960b; Simpson, 1965; Mitchell, 1993). However there has been no exploration activity for almost 60 years and there is no modern classification compliant graphite resource estimates or mineral exploration data for graphite in Zambia.

In May 2022 a small team from the BGS visited the Copperbelt University Africa Centre of Excellence for Sustainable Mining (CBU-ACESM) in Kitwe, Zambia (Figure 1) as part of ongoing research collaboration and to explore the potential for a joint research project on graphite resources in Zambia (Hamilton & Mitchell, 2022). This visit coincided with the recent signing on 29th April 2022 of the “Zambia and Democratic Republic of the Congo (DRC) Cooperation Agreement on the Establishment of a Value Chain in the Electric Vehicle and Clean Energy Sectors”. The aim being to manufacture electric vehicle batteries using the mineral resources of Zambia and the DRC (Nachalwe-Mbao, 2022). CBU and other universities in Zambia have been tasked to create a research programme to address the challenges posed by the cooperation agreement.

A follow up visit to Zambia was undertaken in November 2022 (this report) with the first objective being to take part in the 10th Zambia International Mining and Energy Conference and exhibition (ZIMEC) to present on graphite resources in Africa (Mitchell, 2023). The second objective of the visit to Zambia was to initiate planning for a Zambian PhD student, fully funded by CBU-ACESM, to focus on Zambian battery raw materials with an emphasis on graphite resources in the Eastern Province of Zambia. As part of this visit, discussions were also held with the Zambian Geological Survey Department (GSD) and the School of Mines, University of Zambia (UNZA). It is envisaged that BGS will collaborate with CBU-ACESM, the GSD and UNZA on an initial battery raw material research project on graphite resources, with the potential to extend the collaboration into lithium-bearing pegmatites which primarily occur in the Southern Province, as well as the Central and Eastern provinces, of Zambia.

In addition, the third objective of the visit was to participate in The Mining Show 2022 in Dubai, United Arab Emirates (UAE) to take part in a panel on battery raw materials and present on graphite resources in Africa.

Figure 1. Copperbelt University, Kitwe, Zambia.

2 Visit itinerary

Date	Activity
30th to 31st October 2022	Travel from the UK to Kitwe, Zambia (3 flights; Birmingham to Dubai; Dubai to Lusaka; Lusaka to Ndola)
1st & 2nd November 2022	10th Zambia International Mining and Energy Conference and Exhibition (ZIMEC 2022), Garden Court Hotel, Kitwe.
3rd to 8th November 2022	Copperbelt University, Kitwe
9th November 2022	Travel from Kitwe to Lusaka, Zambia
10th & 11th November 2022	Geological Survey Department and School of Mines, University of Zambia, Lusaka
12th & 13th November 2022	Travel from Lusaka to Dubai, United Arab Emirates (UAE)
14th to 16th November 2022	The Mining Show 2022, Festival City Arena, Dubai
17th November 2022	Travel from Dubai to the UK

3 10th Zambia International Mining and Energy Conference

The 10th Zambia International Mining and Energy Conference and exhibition (ZIMEC) was supported by the Zambian Ministry of Mines and Mineral Development and the Ministry of Energy (Figure 2). The theme of the conference was "The synergy between mining and energy: Developing sufficient sustainable energy to satisfy Zambia's mineral production goals" Other expert industry stakeholders who supported ZIMEC were the Chamber of Mines, Zambia and AZMEC (Association of Zambian Mineral Exploration Companies). The conference was held at the Edgar Chagwa Lungu Convention Centre, Garden Court Hotel in Kitwe, Zambia on the 1st and 2nd November 2022 and was attended by 300 delegates from 25 countries. This was the first time that the conference had been held in the Copperbelt (it will be back in Kitwe 1st to 2nd November 2023).

The conference was opened by the Minister of Mines Hon. Paul Chansa Kabuswe MP, part of the 'New Dawn' government of the United Party for National Development (UPND) in Zambia lead by HE Hakainde Hichilema the 7th President of Zambia. As part of his welcome speech, the Minister said: "Value addition is the song – we want to take advantage of the EV industry", "We are going to be predictable and stable to ensure investors have certainty and confidence" and "The social licence is critical you must respect it" and "Let the local people feel your presence".

Zambia aims to increase its copper production to 3 million tonnes per annum within 10 years and energy production will need to keep pace with the planned number of new mines being opened. This is an ambitious 'stretch' target as current production is around 800,000 tonnes per year of finished copper (blister and cathode). Mining currently contributes 17.5% to GDP, 27% of Government revenues and 70% of foreign exchange earnings in Zambia.

Clive Mitchell gave a presentation, "Graphite in Africa: Carbon for Decarbonisation" which highlighted the dramatic increase in exploration for, and production of, flake graphite in eastern Africa and drew attention to the presence of the largely unexplored flake graphite resources in Zambia (Mitchell, 2023).

Other highlights of the ZIMEC conference included:

- The Zambian Geological Survey Department (GSD) is currently undertaking a GeoData programme to digitise Zambian geological reports and maps to make them more accessible online. This will continue to the end of 2023 and is currently 80% completed. The GSD has a strategic plan for mineral exploration which includes increasing geological map coverage to 70% (currently only on 55%) and an ambition for an aerial geophysical survey of Zambia,
- The Zambian emerald producer, Kagem Mining Ltd, has been successful in taking Zambian emeralds to global auctions and bringing their full value back to Zambia. Kagem, which owns the Mbuva-Chibolele emerald mine and the Kamakanga emerald deposit, is believed to be the largest producer in the world and has contributed to Zambia becoming the No.1 emerald producer in the world.
- Mopani Copper Mines is looking to transition to purely renewable energy aiming to produce "green copper" which it hopes to sell at a premium price.

Figure 2. 10th Zambia International Mining and Energy Conference and exhibition (ZIMEC)

4 Copperbelt University (CBU)

Research collaboration between BGS and CBU will be enhanced with the likely addition of at least one PhD research project focusing on graphite resources in Zambia. The research will be supported by the CBU African Centre of Excellence in Sustainable Mining (ACE-SM) with researchers from the CBU School of Mines & Mineral Sciences and School of Mathematics & Natural Resources. The proposed PhD research at CBU would involve a reconnaissance assessment and technical evaluation of Zambian graphite. This research would act as an important source of information for promotion of inward investment for the assessment of the feasibility of the development of economic extraction and production of flake graphite concentrate. Flake graphite is used to produce spherical graphite which is the precursor material for the manufacture of graphite anodes used in Lithium-ion batteries. Production of flake graphite in Zambia would help to alleviate the global concerns regards the risk to the graphite supply chain. It would also diversify the Zambian mineral production portfolio and increase revenues. The proposed research is timely as it coincides with the Zambian-DRC technical co-operation agreement to develop a battery manufacturing capacity using indigenous mineral resources.

Planning for a reconnaissance field trip to Eastern Province is underway with the involvement of CBU and the GSD (and potentially the University of Zambia, UNZA). This will take place in June 2023 which is a drier, cooler part of the year for field work. An initial trip was mooted for this current trip but the rainy season started two weeks early (it is usually mid-November to April). The graphite deposits occur mainly in Eastern Province, in the vicinity of Petauke and Lundazi.

One potential constraint is the presence of National Parks and Game Management Areas (GMA) which are an important part of the tourism industry in this part of Zambia.

A PhD research project on the environmental impact of copper refinery slag is underway as part of BGS-CBU collaboration. A consignment of laboratory equipment, for this research project, sent by BGS to CBU was inspected. This included an Inductively Coupled Plasma - Mass Spectrometer (ICP-MS), drying oven, muffle furnace, jaw crusher and Tema mill. A sample of the copper refinery slag was brought back to the BGS for further analysis.

5 Geological Survey Department (GSD)

A meeting was held at the GSD with the Director, Gerald Mwila, as well as David Mupika (GSD Information Management) and Lawrence Kalaba (Senior Geologist). The Director is keen to foster further collaboration between the GSD and BGS. A thorough tour of the GSD revealed the poor state of the buildings and a large proportion of equipment that no longer functions. The GSD staff are well motivated and eager to engage with the renewed interest in Zambian resources. As a follow-up to the visit, the Director of the GSD has requested support from the BGS for equipment, with the highest priority being given to petrological microscope and thin section making equipment.

Figure 3. Geological Survey Department (GSD), Lusaka, Zambia

6 University of Zambia (UNZA)

A meeting was held at the School of Mines, University of Zambia (UNZA) with the Dean, Dr Bunda Besa and the Head of the Geology Department, Cryton Phiri. The School of Mines is keen to be involved in the Zambian graphite research and will be in touch with CBU and the GSD to initiate discussions.

Figure 4. School of Mines, University of Zambia (UNZA), Lusaka, Zambia.

7 The Mining Show 2022

The Mining Show 2022 was organised by Terrapin Middle East with the support of the UAE Ministry of Energy and Industry (MOEI) plus many commercial sponsors. The Mining Show 2022 was held at the Dubai Festival City Arena in Dubai, United Arab Emirates on Tuesday 15th and Wednesday 16th November 2022. A total of 3808 attendees were registered to attend from 118 countries mainly from the Middle East and North African (MENA) region. It was in two parts with a mining, quarrying and mineral exploration exhibition forming the main part of the show and a conference which was split in two parallel sessions. Clive Mitchell took part in a panel discussion on battery raw materials and reprised his presentation, "Graphite in Africa: Carbon for Decarbonisation" (Mitchell, 2023).

Keynote and notable presentations at The Mining Show:

- "The Mineral Future in Saudi Arabia" by Hassan Al Marzouki Director General – Planning & Development, Saudi Geological Survey outlined the 2030 Mining Vision that aims to

increase the contribution of the mining sector to US$75 Billion by 2035. This will involve a significant increase in mineral exploration and acquisition of geological data.

- “Industrial Resources Assessment in UAE” by Khaled Mohammed, Head of Minerals Wealth, MOEI outlined the resources of construction aggregate, dimension stone and high-purity limestone and dolomite in the UAE. This was based on the BGS resource reports published in 2012.
- “Exploring the long-term strategy for mineral resources in the UAE” by Yousef Jawabreh, Mining Advisor, MOEI outlined the ongoing development of a mining strategy for the UAE.
- “Geological exploration potential and opportunities in Zambia” by Hon. Paul Kabuswe MP, Minister of Mines and Minerals Development, Zambia emphasized the attractiveness of Zambia as a peaceful and stable country that is ideal for mining investments.
- “Mining investment opportunities in Fujairah, UAE” by Sikander Khan Durrani, Geologist, Fujairah Natural Resources Corporation (FNRC), UAE gave a thorough assessment of the potential investment opportunities including basalt composite fibres, dimension stone, high-purity limestone for precipitated calcium carbonate, quick lime and hydrated lime, magnesium extraction plants and calcined clay for Supplementary Cementitious Materials.

Discussions were held with MOEI to explore areas for research collaboration including contribution to the new strategic programme for MOEI due to be launched in 2023.

Figure 5. Clive Mitchell presenting at The Mining Show 2022, Dubai, United Arab Emirates

8 Conclusions

The visit to Zambia and the UAE was carried out for the ongoing research project on African graphite resources for use as a battery raw material as part of the BGS International Geoscience Research & Development (IGRD) programme.

Attendance at the 10th Zambia International Mining and Energy Conference and exhibition was pivotal in re-establishing contact with key research collaboration partners at the Geological Survey Department and School of Mines, UNZA. The presentation by Clive Mitchell on "Graphite in Africa: Carbon for Decarbonisation" highlighted the dramatic increase in exploration for, and production of, flake graphite in eastern Africa and drew attention to the presence of the largely unexplored flake graphite resources in Zambia.

Research collaboration between BGS and CBU will be enhanced with the likely addition of at least one PhD research project focusing on graphite resources in Zambia. The research will be fully funded and supported by the CBU African Centre of Excellence in Sustainable Mining with researchers from the CBU Schools of Mines & Mineral Sciences and School of Mathematics & Natural Resources. Several PhD candidates have already expressed interest. Planning for a reconnaissance field trip to Eastern Province is underway with the involvement of CBU and the GSD (and potentially the University of Zambia, UNZA). This will take place in June 2023, which is a drier, cooler part of the year for field work. The Geological Survey Department and the School of Mines, UNZA both expressed support for the research collaboration on graphite resources in Zambia.

Attendance at The Mining Show 2022 in Dubai, UAE was important to maintain contact with key research collaborators and make new contacts with potential research collaborators in the Middle East and North Africa (MENA) region.

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