Preliminary assessment of graphite resources in Turkey

A. Özarslan[1], L. Krebbers[2], M. Bilen[1], R.M. Akmaz[1], and B.G. Lottermoser[2]

[1]Zonguldak Bülent Ecevit University, Turkey
[2]RWTH Aachen University, Germany

INTRODUCTION

Graphite is a typical natural form of carbon (C) element. Its unique properties make it a suitable candidate for a broad range of applications such as in the production of innovative energy storage and conversion systems, including modern lithium-ion batteries (LIB). The latter has resulted in the mineral being one of the most in-demand materials for energy technologies by 2050[1]. As a result, graphite is defined as a critical raw material by major economies such as the European Union, United States of America, Japan, and Australia due to its potential geopolitical supply risks and the importance of the renewable energy transition[2]. Currently, China is the largest producer of graphite and accounts for ~80 % of the world's graphite supply (2021 production), followed by Mozambique and Brazil[3]. Due to the increasing demand for graphite, especially for high-tech applications such as LIB, a possible shortage of graphite is to be expected. The resulting mismatch between supply and demand is likely to be a global challenge in the future. Therefore, new graphite mine developments and innovative mining and processing methods of natural graphite are crucial. Turkey could become a key player in the supply of graphite as it hosts the world's largest graphite reserves at 90 Mt, accounting for 35 % of global reserves[3]. Despite the known enormous graphite resources in Turkey, its current production is low. In 2021 Turkey contributed only 0.27% to global graphite production[3]. In this study, a preliminary assessment is made of natural graphite resources in Turkey, their potential to be mined and mineral processing options.

METHODOLOGY

Every graphite mine site requires detailed assessment of its resources, ore characteristics, and its own mining and mineral processing design (Figure 1). The individual processing steps depend on the graphite type, ore properties and the required concentrate qualities, such as carbon content.

Figure 1. Aspects of graphite resource assessment and value chain.

[1] Hund, K., La Porta, D., Fabregas, T. D., Laing, T., & Drexhage, J. (2020). Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition. World Bank.

[2] IEA. (2021). The Role of Critical Minerals in Clean Energy Transitions.

[3] USGS. (2022). Mineral Commodity Summaries: Graphite. https://hcss.nl/wp-content/uploads/2022/03/Graphite-HCSS-2022.pdf

Several graphite deposits have been identified in Turkey (Figure 2). The Kütahya-Oysu graphite mine is the only producer of natural graphite in Turkey, which is located in the southern part of the Kütahya district. In addition to the Oysu deposit, other deposits are also known[4]. Even though many Turkish graphite occurrences are known, our understanding of Turkish graphite resources is limited. In future, any development of Turkish graphite deposits will require resource evaluations based on a sound knowledge of ore properties, and the selection of ore-specific mining and processing methods. Graphite ores possess graphite phases of different particle sizes and size distributions, and with variable impurities. Consequently, graphite ores have been categorised into vein, flake and microcrystalline graphite types. The characteristics and properties of the graphite ores are economically important factors, because they relate to market applications and product price[5]. Thus, fundamental ore parameters need to be assessed rigorously with any graphite resource evaluation. To date, graphite ore properties are assessed using well-established characterisation methods, such as optical microscopy (OM), X-ray diffraction (XRD), and scanning electron microscopy (SEM). However, these techniques do not allow for an understanding of the three-dimensional (3D) distribution of graphite among gangue phases. Industrial computed tomography (CT) is a newly established, non-destructive X-ray computerised method for studying multicomponent materials and construction in a 3D regime. It is currently the only method that allows the observation and analysis of internal and external microstructures of objects without sample preparation, and without strong limitations on the size and shape of the objects studied. Recent research demonstrates that innovative non-destructive CT can be used for investigating flake graphite ores in a 3D regime [6]. Thus, CT scanning of graphite ore may be a promising method to better understand the properties of graphite ores.

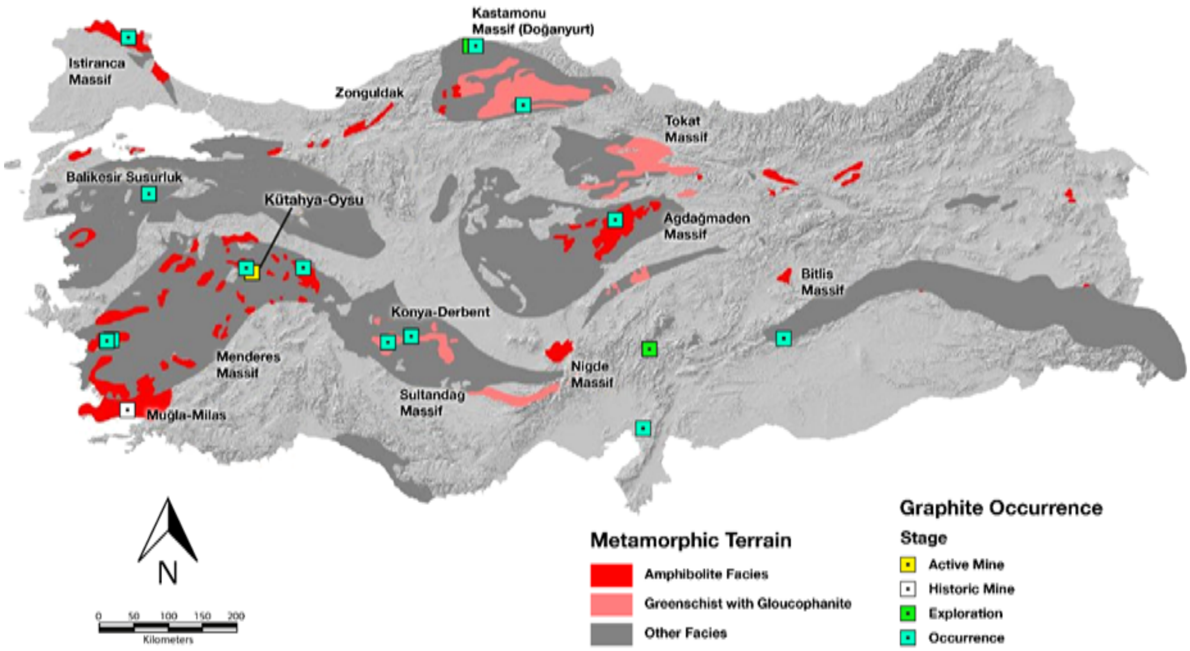

Figure 2. Distribution of graphite deposits in Turkey and their relation to the geological setting (modified after[4]).

[4] Sari, R., Ilhan, A., & Yildirim, Y. (2021). Hidden graphite resources in Turkey: A new supply candidate for Europe? *European Geologist Journal*, 49.
[5] Chelgani, S., Rudolph, M., Kratzsch, R., Sandmann, D., & Gutzmer, J. (2016). A Review of Graphite Beneficiation Techniques. *Mineral Processing and Extractive Metallurgy Review*, 37(1), 58–68. https://doi.org/10.1080/08827508.2015.1115992
[6] Krebbers, L., Gainov, R., Lottermoser, B. G., Lohmeier, S., & Hennig, A. (2021). Applications of Industrial Computed Tomography in the Mining Sector. Mining Report.

Flake and amorphous graphite is generally mined worldwide using conventional open pit and underground mining methods; whereas gangue graphite is currently mined exclusively underground[7]. Innovative (digital technology, remote control, etc.) mining and strata control methods are needed, particularly for safe and efficient underground production of high-quality deep graphite deposits. To produce high-quality graphite concentrates and to manufacture graphite products, processing flow charts are adapted to the respective properties of the mined graphite ores.

CONCLUSION

Natural graphite resources in Turkey can be an important supply candidate for future demand of this critical raw material. Any development of Turkish graphite deposits requires resource evaluations based on a sound knowledge of ore properties and the selection of ore-specific mining and processing methods within an interdisciplinary approach. The usage of innovative laboratory methods combined with innovative mining and processing techniques will allow a sustainable and efficient production of graphite in Turkey and other parts of the world where graphite deposits with economic potential exist.

Ahmet Özarslan

Prof.Dr.
Zonguldak Bülent Ecevit University

Ahmet Özarslan received his master and Ph.D. degrees in Mining Engineering from Zonguldak Karaelmas University, Turkey in 1995 and 2002, respectively. He is currently working as a professor of Zonguldak Bülent Ecevit University, and is the Head of the Mining Engineering Department. His research interests include rock mechanics, strata control, mining systems, underground storage and renewable energy applications in the mining sector. He worked at the RWTH Aachen University, Germany between 1999 and 2000, as a visiting scientist funded by DAAD (German Academic Exchange Service). He is a member of the ISRM (International Society for Rock Mechanics), Turkish Tunnelling Society and Chamber of Mining Engineers.

[7] Szurlies, M., Schippers, A., Kuhn, T., & Duba, J. (2021). Rohstoffrisikobewertung—Graphit.