Towards an analytical proof of origin for natural graphite

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Natural graphite is a critical high-tech raw material of great importance. Unfortunately, Europe's high-tech companies are currently reliant on foreign graphite. Looking at the supply, China (67 %) took the top spot for the graphite world production in 2021, followed by Brazil (7 %) and Mozambique (5 %). Other supplier countries, such as North Korea, Russia and Ukraine are also not emerging as the most stable countries and the supply cannot always be ensured. With its high electrical and thermal conductivity, excellent thermal stability and lubricity, graphite is suitable for a wide range of industrial applications. Graphite is indispensable in lithium-ion batteries, which are used in everything from phones to electric vehicles. The demand for those products is likely to emerge within the next 30 years. Thus, the demand for graphite is estimated to rise by nearly 400 % within the next 30 years. The aim of this research project is to develop methodical approaches for an analytical proof of origin procedure for graphite. Different deposits distributed worldwide are included in the project. The analytical proof of origin for graphite aims to differentiate between various origins of the material, in particular from African countries, but also from Korea, China, Brazil and others. Graphite offers several options for an analytical proof of origin. A meaningful combination of the methods allows to decipher geological and mineralogical processes and define the source of a material as unique. The parameters must be robust to alteration or other changes of the raw material itself. Also, the applied parameters must be easy to reproduce and the analytical methods must be widely available. In case of changes during later geological history (e.g., diagenesis, metamorphism), some geochemical characteristics must be preserved to an extent that the original chemical signature is still recognizable. Therefore, the following parameters are considered as useful and important: 1) Geochemical parameters such as minor and trace element compositions and isotopic ratios of carbon and possibly sulphur allow conclusions about depositional processes. 2) Crystallographic parameters (e.g., d-values in XRD and Raman spectral parameters) allow conclusions about the prevailing metamorphic P-T conditions and 3) Grain morphology as assessed by microscopical work (e.g., SEM and light microscopy) is controlled by crystal growth but also weathering and abrasion, being important indicators of the sample origin. 4) The mineral paragenesis is another important parameter to decipher the geologic history of the sample, assessed through detailed in-situ microscopic studies or XRD analysis. Analytical proof of origin (APO) methods in general are regarded as the least corruptible methods, as they directly relate to the chemical composition of the raw material. Other methods such as conventional documents, tracers, QR codes and barcodes can be outmaneuvered in one way or another. The approach of the analytical proof of origin at the same time poses challenges in terms of costs, flexibility and cooperation between companies and the willingness to implement. The most plausible application of APO is seen in the case of conflict minerals and precious metals. In the future it might also be applied to critical minerals that are essential for the future development of our industry and society, although the supply is heavily dependent on certain supplier countries.