

Carbon Isotope Geochemistry of Flake Graphite in the Neoproterozoic Mozambique Belt, Tanzania: Implications for Graphite Mineralization

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Graphite in the Makanjiro and Namapwia prospects is hosted within metasedimentary rocks of the Neoproterozoic Mozambique Mobile Belt, Tanzania. The belt is comprised of high-grade metamorphic rock units and late intrusions formed during the 650-500 Ma Pan-African Orogeny.

The occurrence of graphite is broadly classified into two genetic categories: syngenetic and epigenetic. Syngenetic graphite originates from the metamorphism of organic matter deposited in sediments, whereas epigenetic graphite forms through the precipitation of carbon from carbon-rich fluids. Syngenetic graphite forms through the in-situ transformation of organic matter in sediments during metamorphism. This transformation from disordered organic matter to crystallized graphite involves compositional and structural changes with increasing temperature.

In this study, elemental C–H–N analyses were conducted on graphite samples from the Makanjiro and Namapwia prospects. Samples from the Namapwia prospect show carbon contents ranging from 44.06 % to 84.25 %, with low hydrogen (0.13 %- 0.27 %) and nitrogen (4.33 % - 4.87 %) concentrations. In the Makanjiro prospect, carbon content ranges from 54.8 % to 72.7 %, hydrogen content ranges from 0.11 % to 0.21 %, and nitrogen content ranges from 2.52 % to 2.75 %.

Graphite separates from both prospects were also analyzed for carbon isotopes. The $\delta^{13}\text{C}$ values of graphite from the Makanjiro prospect range from -19.5 ‰ to -25.5 ‰ (average -23.8 ‰), while samples from the Namapwia prospect range from -22.4 ‰ to -25.7 ‰ (average -24.0 ‰).

The $\delta^{13}\text{C}$ compositions form a continuum between -19.5 ‰ and -25.7 ‰, consistent with carbon derived from organic matter. The relatively high carbon contents and low hydrogen and nitrogen values further support graphite formation through metamorphic transformation of organic matter. However, localized remobilization associated with decarbonation reactions to form calc-silicate assemblages may have caused isotopic exchange during metamorphism, which has been evaluated using the Rayleigh fractionation model.