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# Macro- to Microscale C- and O-isotope Investigation of Magnesite deposits in Ultramafic Rocks of Southern Peninsular India: Implications for Natural $CO_2$ Sequestration

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Carbonated ultramafic rocks are excellent proxies for investigating fluid-rock interaction processes, fluid source, and physicochemical conditions because they serve as markers of past geological fluid circulation. Magnesite, a predominant carbonate mineral, is formed through CO2 influx into ultramafic rocks as veins/stockworks. This study aims to investigate the origin of the mineralizing fluids and the conditions controlling magnesite formation through a comprehensive macro to micro scale investigation of magnesite deposits from Archean to Neoproterozoic ultramafic rocks in southern Peninsular India. Most of these deposits are confined to depths of approximately 25m below surface, primarily within the soil horizon. Isotopic data from southern peninsular India reveal consistent carbon and oxygen sources in magnesite formation, with atmospheric CO2 and meteoric water playing a key role. In Karnataka, (δ18O 30.6‰; δ13C -2.6‰), and Salem, (δ13C -3.6‰; δ18O of 25.5‰) suggest atmospheric CO2. Attappadi (δ13C: -5 to -0.6‰; δ18O: 26‰–28‰) and Thennilai (δ13C: -3.5 to 0.94‰, δ18O: 26.4‰ to 30.22‰) samples further support meteoric water source and low temperature mineralization. Magnesite veins show relatively stable δ18O values but notable variations in δ13C. These differences are more pronounced between thick and thin veins, with thicker veins generally having lower δ13C values and thinner veins showing relatively higher values. A similar trend is observed in the δ13C composition of the fluids involved in magnesite formation, where thicker veins correspond to lower values and thinner veins to slightly higher ones. These variations are influenced by isotopic equilibrium reactions within the CO2–bicarbonate–carbonate system, which lead to enrichment of 13C in the carbonates. These isotopic signatures reveal a consistent carbon and oxygen sources, highlighting the significant influence of atmospheric CO2 and meteoric water in magnesite formation, and underscoring the role of surface processes, such as meteoric water circulation and soil-derived organic carbon in ultramafic environments. Understanding the formation processes of magnesite in ultramafic settings provides insights into natural $CO_2$ sequestration mechanisms, offering a potential long-term sink for atmospheric $CO_2$ and playing a crucial role in mitigating climate change.