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What Archean zircon reveals: from cryptic ages to anatectic melt entrapment

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Reconstructing the evolution of the Archean crust is challenging due to the limited preservation of Earth's early geological record. When surviving fragments have experienced ultrahigh-temperature (UHT) metamorphism, primary mineralogical and geochemical signatures are commonly overprinted, further limiting their interpretation. Zircon often remains a resilient archive in such rocks, yet the fidelity of the information it retains can sometimes be compromised.

An orthopyroxene–clinopyroxene–amphibole granulite from a juvenile-like Archean relict of the Paranapanema Block in the Brasília Orogen (Brazil), exemplifies how zircon can retain a complex and cryptic history. U-Pb data from zircon cores smear along the Concordia curve, which could suggest prolonged crystallization or metamorphism. However, homogeneous Hf isotopes across cores with distinct apparent U-Pb dates indicate Pb loss. Integration of the isotopic systems constrains a minimum crystallization age of ca. 2.55 Ga for the protolith [1]. This exposes a limitation for provenance studies: sources affected by similar disturbance may remain undetected or misinterpreted [2]. The zircon grains further record two metamorphic events at ca. 2.4 Ga and 2.1 Ga, revealing a multistage evolution not reflected in the granulite mineral assemblage, overprinted during Neoproterozoic UHT metamorphism. These ages differ from surrounding units and carry implications for paleogeographic reconstructions. Additionally, melt inclusions in zircon cores represent anatectic melt generated during Neoproterozoic metamorphism, indicating a complex history of entrapment, underscoring the potential vulnerability of inclusion-based interpretations in zircon [3].

These findings demonstrate that ancient zircon from metamorphic rocks can preserve a complex and counterintuitive record. Deciphering this record requires integrated microstructural and multi-isotopic approaches to distinguish primary signatures from later modification.

References

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