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Unraveling complex tectonothermal histories of polymetamorphic terranes through the application of multiple geochronometers

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Deciphering the geological history of a complex terrane that has undergone multi-stage magmatic and metamorphic events requires an approach integrating various geochronological techniques. By combining U-Pb dating using zircon, monazite, and titanite, with garnet Lu-Hf and Sm-Nd, and titanite and apatite Sm-Nd dating, we can constrain the timing of magmatism, metamorphism, and thermal disturbances. Zircon and monazite U-Pb dating of the protolith provides a robust framework for identifying pulses of magmatic activity, revealing the crust-forming history of the terrane. Garnet Lu-Hf and Sm-Nd geochronology from the same samples records the timing of peak metamorphism and subsequent cooling. Comparing the two garnet ages allows for understanding the duration of metamorphism and crustal modification processes. Titanite U-Pb, titanite Sm-Nd, and apatite Sm-Nd ages record isotopic resetting during thermal events, providing information for responses of isotope systems to metamorphic events.

The NW Wyoming Province (U.S.) preserves evidence of the complex processes involved in the assembly of the North American craton. Here, we investigate a suite of metaigneous rocks from this area using multiple geochronometers. Zircon U-Pb ages from these rocks indicate distinct magmatic events at ~2.7, 2.4, and 1.8 Ga. Garnet Lu-Hf isochrons yield ages of ~2.4, 2.1, and 1.8 Ga, recording peak metamorphic episodes. Garnet Sm-Nd isochrons from the same samples yield ages of ~2.1 and 1.8 Ga, recording cooling stages following peak metamorphism. Most Sm-Nd ages are younger (<30 myr) than their Lu-Hf ages due to the difference in closure temperatures, reflecting the duration of metamorphism. Both titanite and apatite Sm-Nd isochrons yield ages of ~1.8 Ga, indicating that the Sm-Nd system was reset during pervasive metamorphism. We interpret the 2.7-Ga age as representing the initial timing of crustal formation, while the 2.4-Ga age represents both the timing of magmatism and metamorphism. The 2.1-Ga age is interpreted to represent a regional metamorphic event, and the 1.8-Ga age signifies a major crust-forming event accompanied by high-grade metamorphism that re-equilibrated the Sm-Nd system. Our results reveal a complex history of magmatism and metamorphism spanning over hundreds of millions of years, offering new insights into the geological evolution of the NW Wyoming Province.