From Basement Rocks to Mineral Systems: Demonstrating the Value of In-Situ Zircon (U-Th)/He Thermochronology

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Many economically significant mineral systems, such as porphyry copper, tin granites, alkaline intrusions, and pegmatites, are closely associated with intrusive magmas. Constraining the timing and thermal evolution of these intrusions is critical for understanding ore-forming processes and enhancing exploration models. This study highlights the application of in-situ laser ablation zircon (U-Th)/He (ZHe) thermochronology, a rapid HF-free analytical technique, for resolving the thermal histories of such systems with high spatial resolution.

As part of an undergraduate research initiative through the AGeS-DiG program, we tested the capabilities of in-situ ZHe analysis on zircon grains collected from the Llano Uplift in Central Texas, USA, where Mesoproterozoic granites are unconformably overlain by Paleozoic sedimentary rocks. While the primary objective focused on explaining the timing of exhumation related to the Great Unconformity, the analytical approach demonstrated significant potential for broader applications in economic geology studies and mineral exploration.

Our results reveal a phase of rapid basement exhumation at ~850 Ma, associated with Rodinia rifting, and three subsequent Phanerozoic burial-exhumation cycles. These findings, supported by numerical modeling in HeFTy, demonstrate the effectiveness of in-situ ZHe thermochronology in reconstructing complex thermal histories relevant to intrusion-related mineralization. This investigation highlights the value of deploying advanced thermochronology techniques, which offer faster, high quality data acquisition and refined thermal constraints to better understand intrusion-related mineral systems worldwide.