Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.38054

Assessing post-depositional uranium uptake in dinosaur eggshell U–Pb dating

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While stable isotope analyses of fossil eggshells are valuable paleoclimatic proxy records [1], it is challenging to anchor them to a robust chronological framework in deep time. Recent work has developed accurate U-Th model ages of Pleistocene avian eggshells, capitalizing on the rapid secondary uptake and retention of uranium (U) and exclusion of secondary thorium (Th) [2]. This has inspired new studies test older eggshells with U-Pb dating. Recent studies using laser ablation inductively coupled plasma mass spectrometry (ICP-MS) produced uranium-lead (U-Pb) ages of dinosaur eggshells by pooling results from multiple eggshell fragments [3, 4]. To account for variable post-depositional U uptake from soil pore waters among individual eggshell fragments, we evaluate the potential of U-Pb dating of eggshells by studying 39 dinosaur eggshell fragments from four independently dated Cretaceous formations: the Anacleto Formation from South America, and the Cloverly, Two Medicine, and Wayan Formations of North America.

Concentrations of ^{238}U and ^{208}Pb across eggshell cross sections were measured using triple quadrupole laser ablation ICP-MS. U and Pb distributions generally follow eggshell microstructure. Average [U] in eggshell centers is ~0.1 ppm, while [^{208}Pb] is more variable and spatially heterogeneous even within a single fragment. Eggshells of the same taxon and the same locality exhibit distinct [U] and [^{208}Pb] profiles, indicating differential post-depositional uptake among fragments from a single site. In-situ U-Pb dating on 23 eggshell fragments yielded mostly unreliable ages due to abundant common Pb. However, three eggshells from the Two Medicine Formation (ca. 82.4–74.4 Ma), one of unknown taxon and two recrystallized ornithopod eggshells, exhibited low $^{208}Pb/U \leq 0.1$. Their U-Pb ages are systematically younger than, but overlap within uncertainty with bracketing tephra ages, suggesting that dinosaur eggshells might provide minimum age constraints on host deposits. Multi-collector ICP-MS analyses and U uptake modeling will further test the precision and accuracy of eggshell as a U–Pb geochronometer.

[1] Niespolo et al. (2020), *Quaternary Science Reviews* 230, 106142; [2] Sharp et al. (2019), *Quaternary Science Reviews* 219, 263-276; [3] Chen et al. (2025), *Frontiers in Earth Science* 13, 1638838; [4] Tucker et al. (2025), *Communications Earth & Environment* 6, 872