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The bone that got away: consequences of dissolution on fossil bone geochemistry and implications for paleoenvironmental reconstructions

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Vertebrate fossil bones provide an archive of past terrestrial ecosystems and climate. Direct interpretations of behavior, diet, niche partitioning, and ecological interactions rely on the analysis of preserved fossils and often utilize the major (e.g., Ca) and trace (e.g., Sr) elements preserved within the fossil bones as proxies. However, the taphonomic history of fossils culminates with exposure to present day physical, chemical, and biological processes at Earth's surface, which work against bone preservation. To date, studies evaluating the consequences of modern day taphonomic alteration on bone are limited. Through controlled dissolution experiments under pH conditions representative of current precipitation (pH 4, 5, 6) and using organic (acetic) and inorganic (hydrochloric) acid, fossil bone demonstrated significant mass loss over the course of 21 days. Mass loss was primarily driven first by removal of amorphous phases from bone, followed by dissolution of calcite into solution. The greatest mass loss occurred under organic acid treatments at pH 4 and included loss of calcite as well as primary apatite. Solution chemistry across all treatments supports dissolution of Ca-bearing phases (calcite and apatite), resulting in significant Ca increases in solution. The major and trace element chemistry of pre-dissolution and post-dissolution fossils revealed significant changes to remaining fossil chemistry including increases in Sr, Ca, and P. Remaining fossil mineralogy across all treatments was characterized by a proportional increase in apatite compared to initial mineralogy. Thermodynamic modeling of solution chemistry suggests continued undersaturation with respect to the primary mineral phases despite progressive dissolution and likely reflects competing dynamic equilibrium conditions that may further drive dissolution. These results demonstrate potential consequences of the final stage of taphonomy (e.g., exposure at Earth's surface) in altering major and trace element fossil bone geochemistry, which has significant implications for the use of elements obtained from fossils as reliable archives of past ecosystems and climate.