Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.36571

Calcium isotope ratios as tracers of bone mineral balance: inter-batch reproducibility in an expanded cohort of the Caltech Bone Health Study

ESTHER LAHOUD[1], FRANCO MARCANTONIO[2], THEO TACAIL[1], REBECCA RYAN[1], PRISCILLA BOO[1], RAMESH KESAVALU[3], SHAHIN BAGHERI[3] AND FRANÇOIS L.H. TISSOT[1]

[1]California Institute of Technology
[2]Texas A&M University
[3]Lakeside Community Healthcare

Osteopenia and osteoporosis are characterized by progressive loss of bone mineral density (BMD) and represent a major public health concern in aging populations. Dual-energy X-ray absorptiometry (DXA) remains the clinical standard for diagnosis. However, it provides a static measure of bone mass and does not directly quantify ongoing bone mineral balance. Calcium isotope ratios ($\delta^{44}Ca$) in urine and blood have emerged as promising and non-invasive tracers of bone mineral dynamics [1, 2]. Because bone formation preferentially incorporates lighter calcium isotopes into the mineral phase, shifts in bone remodeling are reflected in measurable variations of $\delta^{44}Ca$ in body fluids.

To better understand the Ca isotope proxy and its potential to track Ca balance in the human body, we have been conducting an open Bone Health Study at Caltech. Following our initial report of feasibility and analytical robustness of high-precision calcium isotope measurements in human urine [3], we here investigate an expanded dataset focusing on healthy and osteoporotic individuals over 50 years of age.

In the first set of measurements (n = 100), conducted as part of the ongoing study, a statistically significant relationship was identified between bone health status and urinary $\delta^{44}Ca$ values: individuals diagnosed with osteoporosis exhibited lower $\delta^{44}Ca$ compared to non-osteoporotic participants [4]. These results are consistent with enhanced net bone mineral loss in osteoporotic patients. To further evaluate the strength and reproducibility of this signal, we are analyzing an additional 100 urine samples bringing the total dataset to 200 participants. The additional 100 samples were collected within the same clinic. All samples from both analytical batches were processed using identical automated chromatographic purification protocols and analyzed by MC-ICP-MS under the same instrumental conditions. At the conference, we will present the full dataset including all isotopic and concentration data in relation to participants health status to assess clinical relevance.

[1] Eisenhauer *et al.*, (2019) *Bone Rep.* **10**, 100200, Jun. 2019

[2] Skulan & DePaolo, (1999) PNAS **96**, 13709–13713,

[3] Tissot *et al.*, (2024) *Metallomics* **16**, mfae050

[4] Marcantonio *et al.*, (2025) *Goldschmidt2025 abstracts*, European Association of Geochemistry