Rapidly assessing changes in bone mineral balance using natural stable calcium isotopes

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We demonstrate that variations in the Ca isotope ratios in urine rapidly and quantitatively reflect changes in bone mineral balance. This variation occurs because bone formation depletes soft tissue of light Ca isotopes, while bone resorption releases that isotopically light Ca back into soft tissue.

In a study of 12 individuals confined to bed rest, a condition known to induce bone resorption, we show that Ca isotope ratios shift in a direction consistent with net bone loss after just 7 days, long before detectable changes in bone density occur. Consistent with this interpretation, the Ca isotope variations track changes observed in N-teleopeptide, a bone resorption biomarker, while bone-specific alkaline phosphatase, a bone formation biomarker, is unchanged. Ca isotopes can in principle be used to quantify net changes in bone mass. Ca isotopes indicate an average loss of 0.62 ± 0.16 % in bone mass over the course of this 30-day study. The Ca isotope technique should accelerate the pace of discovery of new treatments for bone disease and provide novel insights into the dynamics of bone metabolism.
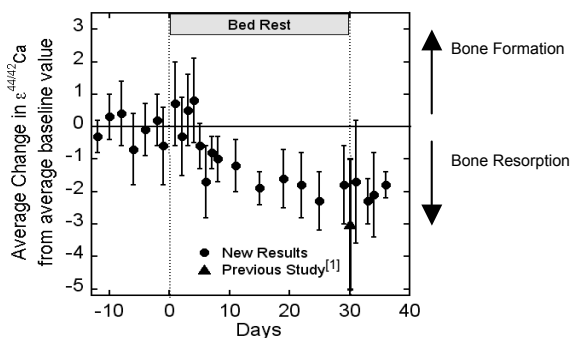

Figure 1: Change in Ca isotope ratios of urine as a result of bed rest.

[1] Skulan et al. (2007) Clinical Chem. **53**, 1155–1158.

Improving the accuracy of the ^{40}Ar/^{39}Ar geochronometer

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The accuracy of the ^{40}Ar/^{39}Ar system relies on a number of parameters, most notably decay constants for the branched decay of ^{40}K to ^{40}Ar and ^{40}Ca, and the ^{40}Ar/^{40}K ratios (or ages) of mineral standards used as neutron flux monitors.

Although these parameters can be assessed to an extent through intercalibration efforts (e.g. [1]), a serious effort to better constrain these parameters based on metrologically traceable measurements, modern technologies, and rigorous uncertainty analyses is overdue [2, 3, 4].

Here we present steps towards a 'first principles' calibration of the ^{40}Ar/^{39}Ar system by measurement of ^{40}Ar and ^{40}K concentrations. These measurements will be used both to determine the ^{40}Ar/^{40}K ratios of mineral standards (thus allowing for calculations of their K-Ar ages) and also the ^{40}Ar branch of the ^{40}K decay constant via ingrowth experiments in material enriched in ^{40}K.

^{40}Ar concentration measurements are based on sensitivity corrections via a calibrated pipette system working under the principles of the ideal gas law. This system relies on components with calibrations traceable to international standards and will be both renewable, with a lifetime of ca. 1 month for gas in the reservoir, and portable, to permit interlaboratory calibrations.

^{40}K concentration measurements are based on TIMS measurements and NIST standard reference materials for elemental (SRM999b) and isotopic (SRM985) potassium.

This series of measurements aims to directly calibrate the ^{40}Ar/^{39}Ar system using measurements traceable to international standards, similar to recent steps taken by the U-Pb community [6].

[1] Kuiper et al. (2008) Science **320**, 500–504. [2] Min et al. (2000) GCA **64**, 73–98. [3] Begemann et al. (2001) GCA **65**, 111–121. [4] McDougall & Wellman (2010) Chem.Geol. **280**, 19–25. [6] Condon et al. (2010) GCA **74**, 7127–7143.