Reconstructing ancient landscapes: Molecular insights to spatial patterns in ecosystems and water

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Water shapes vegetation and natural landscapes at different spatial and temporal scales – defining habitats, selective pressures and the evolution of fauna. Hydroclimate may have catalyzed morphologic and behavioural adaptations in early humans through changing spatial patterns in ecosystem structure. These can be evaluated using molecular and isotopic ‘landscape biomarkers’ lending insights to ancient habitats and providing means to test links between evolution and environment. We apply these to landscapes at spatial scales of human habitation (~1 km^2) from paleosol and lake deposits at Olduvai Gorge (*ca*. 1.845 million years ago).

Biomarker signatures reveal heterogeneity in sources and composition of sedimentary organic matter. Near to a freshwater spring (tufa) deposit, algae (heptadecane [nC_{17}]) and sedge (*n*-alkylresorcinol [*n*AR]) biomarkers are associated with positive ratios between the lignin monomers syringic acid/vanillic acid (S/V) and *p*-coumaric acid/vanillic acid (C/V). In contrast, sediments associated with early human remains contain nominal nC_{17}, *n*AR and C/V, instead showing high plant-wax (hentriacontane [nC_{31}]) abundances. Plant-wax biomarkers $\delta^{13}C$ values range nearly 14‰ across the 1 km paleosol transect, between sediments associated with early human remains (-33.0‰) and grass phytoliths (-19.3‰).

Our data indicate pronounced heterogeneity in this early human habitat, consistent with geochemical and faunal data.[1] Near the spring deposit, biomarkers suggest a shallow wetland environment with emergent vegetation. Nearby, depleted $\delta^{13}C_{31}$ values and nominal C/V indicate a shrubby or wooded environment. This area is proximal to sites with $\delta^{13}C_{31}$ and C/V ratios that indicate grassland. This study focuses on a time slice with dominant grassland (C_4) signals captured in lake sediments. In this dry time, woody and wetland vegetation drew early humans[2] to their resources.

[1] Dominguez-Rodrigo *et al*. (2010) *Quat. Res*. **74**, 315–332.
[2] Blumenschine *et al*. (2002) *Science* **299**, 1217–1220.

Lithium – Light metallic traveller through crusts of the Earth and beyond

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Lithium isotopes have become an increasingly used tool for unraveling metasomatic processes in the mantle, extent and duration of fluid transfer in subduction settings or alteration of oceanic crust, for example. Only recently have Li isotopes been employed to study the magmatic evolution, metamorphism, alteration and weathering of continental crust. This is rather surprising considering the large economic potential of Li deposited in the crust and its utility in modern technologies. Available data suggest a dominant control of protolith heterogeneities and modal mineralogy for bulk terrestrial crust, superimposed on long-term secular evolution of Li in the continental crust as a response to weathering and recycling through subduction zones.

For the Moon, the limited dataset for highland crust shows a dramatic difference between mafic lower crust and calcic plagioclase-dominated rocks of the upper anorthositic layer, with the latter showing extreme net Li depletions coupled with high δ^7Li that extends far beyond the range of mare basalts. Whether plagioclase segregation from lunar magma ocean exerts a major control on crust–mantle Li isotope fractionation remains to be investigated.

That as yet unsampled evolved (crustal?) reservoirs may exist on Mars can be deduced from the nakhlite lava sequence as well as from two distinctive lithologies found in Zagami and having different Li (and also Ca) systematics. Yet, this finding is still consistent with linear Li-δ^7Li relationship recorded for the enriched shergotittes, thought to contain larger proportion of evolved crustal material among shergottites. These data point toward a low-Li high-δ^7Li reservoir that may have once existed early in Martian history. On the contrary, bulk Martian crust appears basalt-andesitic in composition, leaving granitic rocks subordinate although, on Earth, granitic rocks develop distinctive Li fingerprints as a consequence of complete geological cycles. This applies perhaps to 4 Vesta too despite local exposures of highly evolved terrains.

It may well be that juvenile crust in general develops a uniform Li isotope signature as observed in Iceland, for example, with invariant δ^7Li over a large range of chemical compositions. Only with ample time would Li become enriched and fractionated in the crust relative to the mantle on a planetary scale.