Paleoclimatic context of the origins of modern humans in South Africa: Based on speleothems isotopic records

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Little is known of paleoclimates and paleoenvironments from terrestrial sources over the last 400,000 years in the southern latitudes of Africa. This region is critical to many research agendas, including correlating northern and southern Hemispheric climatic shifts, as well as understanding the environmental context for the origins of modern humans. Our study, focusing on the south coast of South Africa near Mossel Bay, is using a multi-proxy approach to this problem.

Caves have been cut by high sea levels into fault breccias of the Skurweberg Formation of the Table Mountain Group (quartzitic sandstone of Odovician age), which is overlain by fossil shelly dunes and calcretes of Late Quaternary age. Dunes that formed on the now-submerged continental shelf during regressed seas once sealed these caves, and then were eroded by high sea levels, revealing speleothems of various forms and ages. Some of these caves were occupied by early modern humans and studies of the speleothems potentially provide important insights into the climate at these times.

High resolution dating shows that speleothems formation was active during several phases. Among them was a major growth periods between 90 and 50 kyr, characterized by speleothems deposition in isotopic equilibrium with rapid $\delta^{18}O$ fluctuation within a range of $-5.5‰$ to $-2.5‰$. $^{87}Sr/^{86}Sr$ vs. 1/Sr falls on a mixing line with Sr isotopic ratio end members of 0.70920 and 0.70940 with $\sim$1000 and <500 ppm Sr, respectively. These variations match changes in $\delta^{18}O$ values with $^{87}Sr/^{86}Sr$ ratios being closer to the marine value when $\delta^{18}O$ values are maximal. Several factors could have been responsible for these correlations including frequent climate oscillations observed in northern latitudes, sea level fluctuations and changes in the dominance of the Aghulus and Benguela currents.

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Crustal evolution in North America recorded in heat production

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The superior province. We use measurements of heat flow and U, Th, and K concentrations to determine the amount of heat generated in various belts of the Superior Province of the Canadian Shield, the largest Archean craton on Earth. From these data, we estimated the average crustal heat production and compositional differences between upper and lower crustal assemblages. The bulk average heat production of the Superior Province crust is 0.64 μWm^{-3}, with very little differences between belts of slightly different ages, illustrating the remarkable uniformity of crust-building mechanisms during the final assembly of the Superior Province.

Crustal evolution in North America. In the wider context of the North American continent, the bulk crustal heat production decreases from 1.0 μWm^{-3} in the oldest Slave Province to a minimum of 0.55 μWm^{-3} in the Paleo-Proterozoic Trans-Hudson Orogen. It increases in younger provinces, culminating with a high value of 1.05 μWm^{-3} in the Phanerozoic Appalachian Province. During the Proterozoic, juvenile crust has much lower heat production than sediments derived from Archean cratons. In all provinces, U and Th enrichment is systematically associated with sedimentary accumulations.

We have observed very similar trends in the heat flow and heat production data available in other cratons (South-Africa, Australia).

Crustal differentiation. We define a crustal differentiation index as the ratio between the average values of heat production at the surface and in the bulk crust. The differentiation index is correlated with the bulk average heat production, which suggests that crustal differentiation processes are largely driven by internal radiogenic heat.

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