Neon identifies two billion year old fluid component in Kaapvaal Craton

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We analysed shallow (to ~1 km) and deep fracture waters (to > 3 km) from the Witwatersrand Basin, South Africa for their noble gas isotopic composition. Their neon signature clearly differentiates a group of typical crustal fluids from another one with a significantly enriched nucleogenic neon signal with the highest $^{21}Ne/^{22}Ne$ ratios (0.160 ± 0.003) ever reported in groundwater [1]. Fluid inclusions in adjacent rocks yield even higher $^{21}Ne/^{22}Ne$ ratios between 0.219 and 0.515, consistent with an extrapolated $^{21}Ne/^{22}Ne$ value of 3.3 ± 0.2 at $^{20}Ne/^{22}Ne = 0$. We show that this enriched nucleogenic neon end-member represents a fluid component that was produced in the fluorine-depleted Archaean formations and trapped in fluid inclusions > 2 Ga ago [1]. The observation of enriched nucleogenic neon signatures in deep fracture water implies the release of this billion-year-old neon component from the fluid inclusions and its accumulation in exceptionally isolated fracture water systems. The observed association of this Archaean neon signature with H_2-hydrocarbon-rich geogases of proposed abiogenic origin [2] dissolved in the same deep groundwater suggests that the fracture systems have also allowed for the accumulation of various products of water-rock reactions throughout geologic times. One of these fracture systems contained a chemolithotrophic, single species ecosystem surviving on radiolytically produced H_2 and sulfate completely independent of the surface photosphere [3, 4].

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An Atlantic Ocean $^{231}Pa/^{230}Th$ survey

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The Atlantic Ocean circulation is an important contributor to Earth's meridional heat flux and much effort has been devoted to reconstructing its past variability. In particular, downcore records of the ratio of ^{231}Pa and ^{230}Th from marine sediments are increasingly used to infer past changes in the strength and structure of the Atlantic meridional overturning circulation (AMOC) [1, 2]. Modelling studies support the use of this tracer [3, 4], but they also indicate that an extensive database is required to apply the method to its full potential [5, 6]. A given strength and geometry of AMOC generates a unique distribution pattern of $^{231}Pa/^{230}Th$ in the water column and sediments. Documenting past changes in this pattern requires systematic sampling on bathymetric profiles at different latitudes to fully capture the vertical and horizontal gradients in sediment $^{231}Pa/^{230}Th$ generated by the AMOC. At any single location, the same $^{231}Pa/^{230}Th$ ratio can be generated by various combinations of AMOC strength and geometry and cannot be uniquely interpreted. Likewise, the pattern generated by an overturning circulation, particularly the vertical gradient, is quite distinct from that generated by changes in opal flux. Here we present a compilation of Atlantic Ocean $^{231}Pa/^{230}Th$ from the literature and new measurements for the Holocene and the Last Glacial Maximum (LGM). Comparing the data to the outputs of a 2D scavenging model [6] indicates that the Holocene $^{231}Pa/^{230}Th$ pattern is consistent with the strength and geometry of the modern AMOC, while the LGM $^{231}Pa/^{230}Th$ distribution pattern points to a different mode of AMOC with a stronger but shallower North Atlantic overturning cell, consistent with paleonutrient proxies [7].

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