Dual evaluation of the U-isotopes modelling for brazilian groundwaters

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Theoretical background and studied area

Changes in $^{234}U/^{238}U$ activity ratio (AR) and the U content of groundwaters have been utilized for characterizing ages and mixing processes, being related to the geochemical (redox) conditions in the aquifer, extent of the rock-water interface, and amount of U in solution/rock matrix (Andrews et al. 1982; Osmond et al. 1974). U-isotopes data for (non)thermal groundwaters from Poços de Caldas city situated at the Poços de Caldas alkaline massif, Brazil, allowed to evaluate the applicability of the U-isotopes modelling in the area.

Application for dating purposes

The phonolites and related volcanic rocks close to the studied area are evenly fractured, with relatively high hydraulic conductivities. Holmes et al. (1991) used an uniform conductivity of 10^{-8}m/s to calculate flow velocities of 6-218 mm/day (average 50 mm/day), that imply on short residence times of up to 214 years for deep (1800 m) thermal waters at Poços de Caldas city. U-modelled ages only may reach an equivalent value when 1 μm fracture openings (20,000 cm^2 fracture surface area per unit volume of interstitial water) are used in the calculations, which are inconsistent with the hydraulic conductivities and the field observed fresh fracture openings greater than 1mm (2-3 mm per m of rock). Such geometrical factor provides non-compatible ages in relation to those calculated from hydrogeological tests, suggesting that the U-isotopes model could include other parameters like the degree of interconnection of joints and fracture/shear zones.

Application for mixing evaluation

The waters of one spring exhibited values of pH, Eh, CO_2 partial pressure, ionic strength and dissolved Na^+, $HCO_3^- + CO_3^{2-}$, SO_4^{2-}, F^-, and U contents compatible with those of the thermal (27-45°C) waters, however, its temperature (23°C) was closer to those of the colder waters (20-22°C), clearly indicating to be a well-mixed water. The AR and reciprocal of the dissolved U content data defined a ternary plot that allowed to calculate the relative volumes of three source waters for the mixed water, i.e. 23%, 68% and 9%, respectively, for waters having smaller, higher, and intermediate values of temperature. Thus, the U-isotopes modelling proved to be useful to evaluate mixing proportions of waters having different temperature.

References

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Dust impact on marine biota and atmospheric CO_2 in glacial periods

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The observations that iron availability limits phytoplankton growth in the ocean and that the supply of iron-rich dust was increased during glacial periods provide an indirect mechanism by which dust and glacial-interglacial cycles of atmospheric pCO_2 are linked: marine biota could lower atmospheric pCO_2 in a dusty and iron-rich glacial climate (MARTIN, 1990). We assess the impact of high dust deposition rates on marine biota and atmospheric CO_2 using a state-of-the-art ocean biogeochemistry model (PISCES, AUMONT et al., in press) which includes an explicit representation of two groups of phytoplankton and co-limitation by iron, silicate and phosphate. We compare these simulations with a global compilation of paleo-export production proxies from more than 100 deep-sea cores.

High dust deposition rates from the Last Glacial Maximum (LGM) produce an increase in the relative abundance of diatoms in today's iron-limited regions, causing a 6% increase in global export production and an atmospheric CO_2 drawdown of 15 ppm. When the combined effects of glacial-interglacial changes in dust, temperature, ice cover and circulation are included, the model reproduces general regional changes in export production during the LGM observed in paleoceanographic proxies. In the Southern Ocean, the model reproduces the observed glacial increase in export production north of 50°S and decrease south of 50°S. The model also captures the observed dipole in North Pacific export production, with glacial increases in the western and decreases in the eastern North Pacific, compared to today.

We derive a residual CO_2 signal corresponding to the fraction of CO_2 at Vostok which can be associated to high dust deposition rates. This residual signal suggests that the impact of dust on atmospheric CO_2 during glacial periods is <30 ppm, consistent with our model results. Moreover, the timing of changes in dust concentrations relative to CO_2 changes in ice core records shows a decrease of atmospheric CO_2 by 60 ppm even before dust begins to increase. This delayed increase in atmospheric dust concentration would then impact on iron-limited marine ecosystems, resulting in an additional CO_2 decrease (~15 ppm) to the level of the glacial minimum. The initial CO_2 drawdown of 60 ppm must be accounted for by other mechanisms other than iron fertilisation.

References

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