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Chemical and isotopic evolution of dissolved inorganic carbon in groundwater of the Okavango Delta, Botswana

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We investigated the origin and the chemical and isotopic evolution of dissolved inorganic carbon (DIC) in groundwater in the Okavango Delta in semi-arid Botswana. The Okavango Delta is one of the few examples of large river systems where carbon is cycled entirely in the terrestrial system and we hypothesized a river origin for carbon in groundwater. We measured DIC concentrations and the stable carbon isotopes of DIC ($\delta^{13}C_{DIC}$), hydrogen (δD) and oxygen ($\delta^{18}O$) in groundwater. We used our results along with published chemical and isotopic results for groundwater and surface water to assess the origin and evolution of DIC in groundwater in the Okavango Delta.

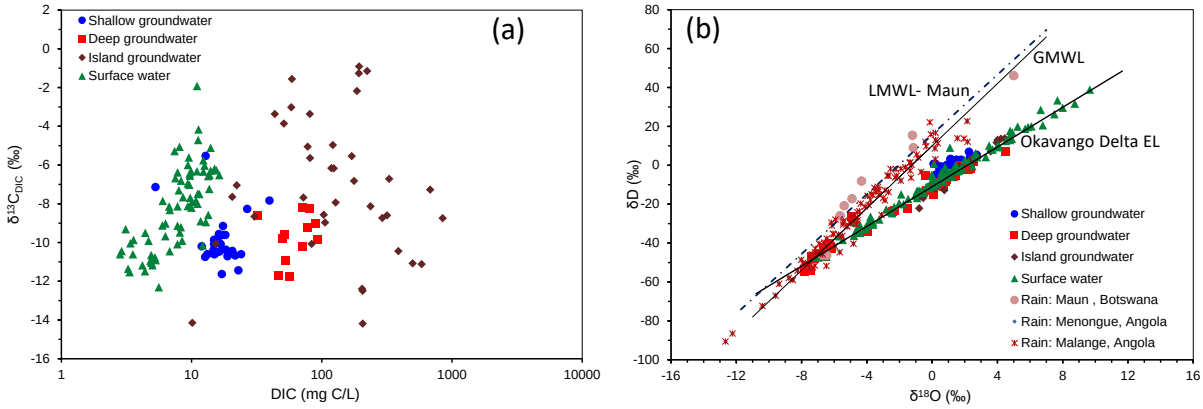

Figure 1: (a) Dissolved inorganic carbon (DIC) concentrations vs. Stable carbon isotopic composition of DIC ($\delta^{13}C_{DIC}$) and (b) stable oxygen isotope composition ($\delta^{18}O$) vs. stable hydrogen isotope composition (δH). LMWL-Maun = Local Meteoric Water Line for Maun, GMWL = Global Meteoric Water Line and Okavango Delta EL = Okavango Delta Evaporation Line.

The DIC concentrations increase progressively from surface water to shallow groundwater (<5 m) to deep groundwater (≥50 m) and the DIC concentrations are two to ten times higher in groundwater than in the Okavango River. The $\delta^{13}C_{DIC}$ of the shallow and deep groundwater were lighter than for surface water, suggesting that the carbon if from River water recharge was modified by input of DIC with lighter carbon isotope. The δD and $\delta^{18}O$ for surface waters are enriched by evaporation, and when compared to groundwater, the isotopes distinguish groundwater that is recharged by the evaporated river water and directly by rain. Despite the differential recharge sources (rain vs. river) with marked isotopic differences, the chemical evolution of the groundwater within the Okavango Delta and surrounding is

indistinguishable and is not chemically related to modern day river water and shallow groundwater. We suggest open system carbonate evolution for river water and island groundwater and closed system carbonate evolution for deep groundwater. The lack of genetic connection between the chemical evolution between modern day Okavango River water and deep groundwater suggest that the deep groundwater is not be recharged by present day Okavango River. We conclude that DIC concentrations in groundwater of the Okavango Delta originates from subsurface production of DIC, and is mostly old DIC stored in the groundwater system for long periods of time (>4,000 Ka).