# Reconstructing Pleistocene pluvial phase environments, Western Desert, Egypt, from the geochemistry of authigenic water-lain deposits

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Authigenic spring and lacustrine carbonates and ironstone spring mounds of Kharga and Dakhleh Oases record pluvial-phase discharge of waters derived from groundwater resident in local Libyan Plateau cap limestones as well as lower-pH Nubian aquifer groundwater. $\delta^{18}O$ and $\delta^{13}C$ variation within discrete tufa localities along the Libyan Escarpment can provide qualitative paleoclimatic constraints, if non-climatic sources of variation can be controlled for. Analyses of mm-scale variation within individual tufa samples suggest that adjacent primary allochems do not typically differ by > 0.3‰. Tufas sampled from strata sloping away from fossil-spring orifices provide an estimation of isotopic variation controlled by distance from spring source. The often strong positive isotopic covariance in Kharga tufas sampled from different strata and facies may be in part a diagenetic series. Alternatively, changes in the relative contribution of rainfall from different sources (Atlantic vs. Indian Ocean), coupled with shifts in recharge area productivity or aquifer residence time could explain the covariance, if the fraction of relatively heavy Indian Ocean rainfall increased during phases of longer groundwater residence times or decreased biological productivity. Enhanced evaporation during dry times could also cause the observed covariance, but stable isotope and minor element analyses of associated lacustrine sediments do not indicate strong evaporative effects on lake water, but do suggest mixing of isotopically and chemically distinct waters. Furthermore, minor-element analysis of dated tufas can be used to approximate the relative groundwater residence time of spring waters during different stages of pluvial events, and thus may help date periods of enhanced local recharge.

The stable isotope geochemistry, mineralogy and sedimentology of Dakhleh lacustrine sediments suggest that this paleolake was fed by discharge both from the Nubian aquifer and from local limestone aquifers. Authigenic minerals (hydronium jarosite, goethite, minor hematite, and ?ferrihydrite) in Dakhleh spring deposits indicate Nubian aquifer discharge during the initial stages of paleolake formation was more acid than current spring discharge. Understanding the transition between localized Nubian groundwater ponding and larger-scale lake level rise initiated by enhanced local precipitation will allow for clarification of the paleohydrologic response of this region to climate change.