Paleoclimatic regimes over Saharan Africa alternated between dry and wet periods throughout the Pleistocene Epoch, and it is during the wet periods that the Saharan fossil aquifers were recharged. The present study investigates the role of groundwater-related processes in shaping the Saharan landforms (e.g., theater-headed valleys [THV]; depressions, escarpments, playas, and tufa deposits) over areas occupied by the largest of these aquifer systems, the Nubian Sandstone Aquifer System (NSAS). The present study reviews the suggested hypotheses for the origin of these landforms in the Sahara, and in similar settings elsewhere, and presents evidence in support of the following: in Pleistocene wet periods groundwater under high hydrostatic pressures accessed deep-seated structures, discharged at the free faces, THV developed, scarps retreated, fluvial (in wet periods) and aeolian processes (in dry periods) together with seepage weathering eroded and transported loose debris, and depressions were formed. Evidence includes: (1) extensive distribution of THV indicative of sapping processes were mapped (using a GIS-based logistic regression model) along faulted scarps extending for over 1450 km in the NSAS; (2) widespread distribution of tufa deposits plastered on scarp
faces of the natural depressions within the NSAS with isotopic compositions consistent with deposition from NSAS fossil groundwater ($\delta^{18}O$: $-12.8$ to $-8.0\%$); (3) absence of well-developed drainage systems over the Libyan Plateau; (4) onset of endorheic streams from the identified THV along the NSAS escarpments (within the Qattara, Kharga, Farafra, and Dakhla depressions) and at the boundary between massive limestone formations and underlying erodible shale and argillaceous sandstone formations consistent with a groundwater discharge origin for the endorheic streams; (5) reported carbonate-rich playa deposits within scarp-foot depressions at the terminations of the endorheic streams; (6) artesian upward leakage of depleted NSAS groundwater ($\delta D$: $-81$ to $-72\%$; and $\delta^{18}O$: $-12.8$ to $-8.0\%$) into shallower Oligocene, Miocene, and Pliocene aquifers ($\delta D$: $-0.7$ to $7.2\%$; $\delta^{18}O$: $-1.13$ to $1.20\%$) as evidenced by the mixed isotopic composition ($\delta D$ range: $-62.6$ to $-2.6\%$; $\delta^{18}O$ range: $-7.0$ to $-1.09\%$) of groundwater. Previous attempts to reconstruct the paleoclimatic conditions in the Sahara using basinal deposit (i.e. lacustrine, tufa and travertine) records is complicated by the groundwater origin of many of these deposits and by the lag between the time of groundwater recharge (timing of wet periods) and the time of groundwater discharge and deposition of basinal deposits. To constrain the timing of the wet periods in the Sahara, eleven samples were collected from two stratigraphic successions that were deposited from surface stream flow in a small watershed (Wadi Feiran) in Sinai and were dated using Optically Stimulated Luminescence (OSL). Quartz extracts from these sediments yielded OSL ages between ca. 27 and 11 ka and place these wetter conditions during the last glacial period. The present study contributes to our understanding of the nature and timing of the wet climatic periods in Saharan Africa and Arabia and emphasizes the possible role of groundwater sapping in the evolution of the Saharan and Arabian landscape, similar settings worldwide, and of the Martian landscape as well.