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Tectonic and provenance history of the Neotethyan margin in NE Africa recorded by detrital zircon (U-Th)/He thermochronometry from a borehole in the Western Desert, Egypt

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The subsurface of the Western Desert of Egypt contains multiple stacked sedimentary basin deposits separated by major unconformities reflecting the long-lived tectonic evolution of the Neotethyan continental margin in eastern North Africa. In this study, zircon (U/Th)/He (ZHe) data were collected from cuttings from a ~15000 ft borehole that penetrated Tertiary and Cretaceous strata and a major erosional unconformity at 13000 ft that juxtaposes Cretaceous and Cambro-Ordovician strata. A total of 56 samples spanning the borehole from 750-15400 ft yielded >200 single-grain ZHe ages in order to elucidate the thermal evolution of the borehole and constrain the thermal history of detrital provenance. ZHe ages above the unconformity are significantly older than the depositional age, suggesting detrital ZHe ages that were not reset subsequent to deposition. ZHe ages from Cambro-Ordovician strata below the unconformity are substantially younger than the minimum depositional age suggesting major cooling and resetting of zircon (>200C) during the Hercynian orogeny. In detail, ZHe ages form Cretaceous strata above the unconformity show the following trends. (1) ZHe ages from 6000-9000 ft (Aptian-Early Cenomanian) are characterized by a ZHe age peak at ~450 Ma and a minor Albian peak, (2) samples from 9000-12000 ft (Late Hauterivian-Barremian) show two major detrital ZHe age peaks at ~450 and 350 Ma, while (3) samples from 12000-13000 ft (Early Hauterivian) exhibit three dominant ZHe age components at ~450 Ma, 350 Ma, and 170-200 Ma. Additional cuttings from an offset containing complete stratigraphy yielded ZHe ages that mainly represent a strong Hercynian input as well as Late Triassic and Early Jurassic components of Tethyan related input. These ZHe age peaks display provenance characteristics typical for cooling signatures of rocks from the eroding Arabian-Nubian Shield, a North-African Hercynian source, and eroded material from exhumed fault blocks along the Triassic-Jurassic Neotethyan rifted margin. While immediately above the unconformity Hercynian ZHe ages dominate, the occurrence of Triassic or Early Jurassic suggest the presence of eroding rapidly cooled and exhumed Tethyan normal fault blocks. At decreasing depth, first Jurassic-Triassic, and then Hercynian source input disappears and the arrival of detritus from the Arabian-Nubian Shield begins to dominate the North African passive continental margin in the Western Desert in the middle to late Cretaceous. This unique data set illustrates the power of ZHe thermochronometry as a thermochronometer in boreholes with temperatures in excess of other low-temperature dating techniques and as a detrital provenance tool, not constraining crystallization ages, but rather shedding light on the cooling and exhumation history of the source terrane and the tectonic/geological environment of the basin deposits.