Subsurface Constraints on Paradox Basin Thermal History from Borehole (U-Th)/He Thermochronology within the Cane Creek Petroleum Play, Southeastern Utah

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Abstract

Thermochronological data have provided critical insight into the complex geologic history of the Paradox Basin by revealing multiple phases of basin subsidence, exhumation, and denudation tied to regional tectono-sedimentary and climatic events. Most public domain data are derived from outcrop samples which, while useful for landscape evolution study, may yield only limited insight into subsurface thermal conditions through time. Subsurface constraints are necessary to accurately characterize the geologic processes that have occurred in the basin, especially when defining the thermal history of emergent petroleum plays like the hydrocarbon-rich Cane Creek clastic interbed of the Pennsylvanian Paradox Formation. To account for this, we conducted down-hole detrital apatite and zircon (U-Th)/He thermochronology analysis of Jurassic-age and older strata in three wells (Threemile 43-18-H; Cane Creek 18-1; and State 16-2) located within the southern, central, and northern sectors, respectively, of the Cane Creek unconventional petroleum play. Success in the central and southern play regions has not yet been matched in the northern part of the play and the geological controls on the unconventional resource potential are not well understood. Our research intends to (1) assess whether the subsurface thermal history of the northern Paradox Basin differs significantly from other regions and (2) determine how individual thermal histories impacted oil and gas systems within prospective zones. (U-Th)/He thermochronology data were derived from 19 samples of well cuttings and 8 yielded data with analytical uncertainties acceptable enough to model numerically. Apatite (U-Th)/He age-[eU] trends indicate a three-stage thermal history for the Cane Creek play area. First, stratigraphic overburden development in the study area caused slow and steady heating in the subsurface through the Cretaceous with a rate increase ca. 100 Ma and peak ca. 70 Ma. This initial heating/burial phase was followed by thermo- tectonic quiescence from 60 to 6 Ma. The third stage is marked by rapid regional exhumation and cooling beginning ca. 6 Ma to modern day because of overburden removal—results indicate ~25°–30°C of cooling with removal of ~1–1.2 km of overburden—and this signal is observed in other published studies in the region. Partially reset zircon He ages indicate that maximum paleo-temperatures within parts of the Cane Creek play reached ≤180°C during a relatively brief period ca. 70 Ma, which indicates potential impacts to petroleum system development. To account for some site-specific challenges presented to the (U-Th)/He thermochronology method from inherent rock mineralogy, subsurface thermal conditions, and analytical-grade apatite and zircon yield variability, research has expanded into fission-track thermochronology to provide a wider range of paleo-temperature modeling and more precise interpretations.

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