Assessing significance of unconformities through thermal history modelling: a case study from the Mackenzie River Plain, Canada

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Meaningful information on the temperatures experienced by strata during burial is essential in sedimentary basin analysis and petroleum system modelling. Whereas traditional methods of assessing burial history, including shale compaction profiles and organic thermal maturity parameters, can estimate paleotemperature and eroded thickness, these methods cannot directly evaluate the timing of thermal events in the basin. Unconformities further complicate the interpretation of these data, as the thermal effect of multiple packages of eroded material is difficult to quantify. In the Mackenzie River Plain of Canada's Northwest Territories, Devonian strata have undergone two major burial and unroofing events since deposition, resulting in regional Devonian - Cretaceous and post-Paleocene unconformities. Understanding the duration and magnitude of these thermal events is essential for determining the timing of hydrocarbon maturation from regional Devonian source rocks.

Apatite (U-Th)/He (AHe) and apatite fission track (AFT) thermochronology data for the Devonian Imperial Formation were collected from six surface samples across the plain. AHe dates from 53 analyses vary from 225 ± 14 Ma to 3 ± 0.2 Ma, whereas AFT single grain dates from four samples are between 485 ± 118 Ma and 9 ± 6.5 Ma. We calculate the AFT kinetic parameter r_{mr0} from apatite chemistry analyses and use these data to explain dispersion in both our AFT and AHe datasets. Thermal history modelling of multi-kinetic AFT and AHe samples reveals that the Devonian strata reached maximum burial temperatures (120–190°C) prior to Paleozoic to Mesozoic unroofing. Strata were reheated to lower temperatures (100°C) in the Cretaceous to Paleogene, and have a protracted Cenozoic cooling history. We compare our modelled temperatures from outcrop with borehole organic thermal maturity profiles from the plain to estimate the thickness of the sub-Cretaceous and post-Paleocene eroded sections across the region. Ultimately, these data reflect the ways in which dispersion amongst thermochronometers from detrital populations can be quantified to assess protracted, multi-phase burial and unroofing histories in sedimentary basins.