

Thermal History and Epicratonic Basin-Forming Mechanisms: Williston Basin

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Epicratonic basin origin and evolution remains a significant geodynamic problem. Several, begin in the early Paleozoic, including the Williston Basin. They exhibit geographically persistent, symmetrical subsidence that preserves thin successions. Some have proposed a single persistent subsidence mechanism. However, other features, including protracted and episodically accelerated subsidence, combined with links to larger tectonic elements suggest multiple, perhaps, distinctive mechanisms. Data against which plausible tectonic models can be evaluated relied previously on geohistory without other thermal and mechanical constraints. Thermal history constraints are also important because for diagenesis and petroleum generation processes.

Apatite fission track (AFT) thermochronology constrains shallow crustal behavior. The method provides a thermal history record below ~110°C. Using AFT thermochronology we derive Precambrian basement thermal history underlying both Williston Basin and the adjacent Canadian Shield. The combination of these thermal history models with organic maturity data significantly modifies geodynamic history and its link to petroleum systems.

Most important is the inferred link between the middle Devonian onset of accelerated Kaskaskia sequence deposition and a late Paleozoic thermal anomaly, which reaches the top of the crystalline crust ~75 m.y. after the onset of accelerated subsidence. This interval is consistent with a lithospheric thermal anomaly originating from a rapid and dynamic thinning of the continental lithosphere. A similar, but smaller, Cretaceous and Tertiary thermal anomaly is observed during subsidence of the Laramide Interior seaway, which evolved contemporaneous with the Cordilleran orogeny. Thermal anomalies similar in age and magnitude to those observed in the epicratonic basin are also observed on the flanking Canadian Shield, where no Phanerozoic sedimentary record is preserved. This leads us to hypothesize a potential link between accelerated epicratonic basin subsidence and "farfield" plate margin interactions. We infer, for Williston Basin at least, a primary Cambro-Ordovician subsidence with characteristics suggestive of a thermal contraction mechanism, possibly accompanying the cooling of thick sills. Subsequently, the continental lithosphere is dynamically thinned, probably as a result of far-field Antler and Laramide orogenic interactions such that the region underlain by the early Paleozoic intrusions responds differently than the Precambrian Shield, although both regions see the anomalous heating events. This suggests that the lithological composition and position of the early Paleozoic intrusive bodies exerts a protracted effect on the mechanical behaviour of the continental lithosphere that distinguishes the Epicratonic basin region from the surrounding Precambrian craton. The search for and elaboration of these mechanisms has potentially important economic consequences for both petroleum system history and diagenesis (hydrothermal dolomitization and MVT deposits).