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Timing and Possible Mechanisms of Tilting of the Barrow Arch, Arctic Alaska, Revealed by Low-temperature Thermochronology

William H. Craddock[1], Dave Houseknecht[1], and Paul B. O'Sullivan[2]

[1]U.S. Geological Survey
[2]GeoSep Services

ABSTRACT

Along the western Barrow arch of Arctic Alaska, seismic reflection and thermal maturity and compaction data from wells reveal an onshore area of ~104 km2 where more than 1 km of post- Cenomanian section has been removed, approximately in the Cenozoic. Along the strike of the arch to the east, about half of the oil that was originally reservoired at Prudhoe Bay spilled during Paleogene, down-to-the-east tilting. Particularly in light of three recent oil discoveries, there is a practical need to better understand vertical motions along the strike of this geologic element. We present apatite fission track (AFT) and (U-Th)/He (AHe) data from full-diameter cores from wells along the strike of the Barrow arch. From the NW coast to Point Barrow, AFT data from six wells indicate exhumational cooling was ongoing by ~55 Ma, and persisted into the Neogene. The magnitude of cooling decreased subtly to the east by ~10Â°C over ~200 km. AHe data resolve the later part of this cooling and corroborate the rates of ~0.5-1.0Â°C/Myr. 260 km east of Point Barrow, AFT data from the Kalubik Creek 1 well show that maximum paleo-temperatures are similar to modern temperatures. Although the exhumation mechanism remains unclear to us, we highlight several attributes of the western Barrow Arch that may be relevant. First, Mississippian-Triassic strata pinch out by onlap against a long-lived paleo-high in the west, which encompasses the exhumed area and is known as the Arctic Platform. Second, seismic reflection profiles along the Beaufort shelf show that a zone of north-dipping normal faults is truncated to the west by the northern flank of the Arctic platform. The first two observations suggest a rheologic and/or compositional contrast between the Arctic Platform and surrounding crust. Third, the timing of exhumation along the western Barrow Arch is similar to the Paleogene rejuvenation of contraction in the Brooks Range to the south. Although exhumed Cretaceous strata are broadly warped, they are not otherwise internally deformed. At least some of the exhumation along the Barrow Arch may have been caused by crustal flexure related to northward emplacement of northeastern Brooks Range. Finally, bottom-hole temperatures and depth-vitrinite reflectance gradients indicate that the Arctic platform is flanked at present and/or during times of maximum paleo-temperature by areas of elevated heat flow, suggesting an additional mechanism that could have modified crustal buoyancy.