recovery energy environment economy
2011 CSPG CSEG CWLS Convention

Overview of the Tertiary Cooling-uplift History of Northernmost Yukon Adjacent to the Beaufort Basin, Based on Apatite Fission Track Studies

Larry S. Lane *
Geological Survey of Canada, Calgary
Larry.Lane@NRCan-RNCan.gc.ca
and
Dale R. Issler
Geological Survey of Canada, Calgary

Summary

The Tertiary Yukon Fold Complex is the onshore continuation of the arcuate Beaufort Foldbelt of the western Beaufort Basin (Lane and Dietrich, 1995). Offshore structures such as Adlartok in the Beaufort Foldbelt contain proven hydrocarbon reserves. The age progression of the Beaufort Foldbelt is constrained by biostratigraphy from wells penetrating the seismic sequences (e.g., Lane, 2004) and by seismically imaged unconformities (e.g., Dietrich et al., 1989). Onshore, deformed Paleocene outcrops together with examples of onshore-offshore structural continuity require that the adjacent onshore deformation has similar timing. However, the north Yukon Fold Complex extends southward as far as the Ogilvie Mountains where age constraints are more loosely defined (e.g., Dixon, 1992; Lane, 1998). This overview discusses the ages of uplift and cooling of the North Yukon Fold Complex based on published and unpublished apatite fission track (AFT) ages from across the region. Published AFT cooling ages document an early Eocene event coincident with the regionally dominant deformation offshore (O'Sullivan and Lane, 1997). Uplift magnitudes for the Yukon coastal plain determined from the apatite data are consistent with 5-7 km uplift estimates previously interpreted from well-based thermal maturity analyses (Majorowicz and Dietrich, 1989).

In most cases the onshore AFT analyses produced long track lengths indicative of rapid cooling through the partial annealing zone. In samples from the British and northern Richardson mountains and Keele Range, cooling ages typically vary between ~60Ma and ~40Ma (Figure 1, Table 1). Apatites from the Late Devonian Dave Lord syenite yielded the oldest cooling ages at 84Ma. Whether this age reflects a structural low or composition-related differences in fission track retentivity is the subject of ongoing work. Farther south, Proterozoic strata yielded a 67.6Ma cooling age from an inlier in the southern Nahoni Range; and a 34.8Ma cooling age from the northernmost Mackenzie Mountains. In the latter case, shortened track lengths indicate that slow or incremental cooling through the partial annealing zone has occurred; and that further modelling may be required to clarify the cooling history. Finally, two Cretaceous samples from northernmost Eagle Plain produced cooling ages similar to, or older than, the depositional ages of the units. These incompletely annealed samples will also undergo further modelling to assess the local cooling history.

Altogether, these data largely underpin our understanding of the pattern of Paleocene to early Eocene deformation ages across northern Yukon (Lane, 1998). Additional data from northeastern Brooks Range and Kandik Basin have provided similar results (e.g., O'Sullivan et al., 1995). In adjacent Alaska, as well as offshore Beaufort Sea, Miocene deformation pulses are locally significant. Also, indications of Neotectonic displacements are locally documented (e.g., Duk-Rodkin and Hughes, 1994; Mazzotti and Hyndman, 2002). The AFT dataset presented here does not reveal evidence of these younger deformation episodes. This is partly because most samples were rapidly cooled through the partial annealing zone; as indicated by the long track lengths. Also, the Neotectonic setting suggests primarily strike-slip kinematics on major structures. Although secondary uplifts would be expected locally, the magnitudes may be too modest to be readily apparent. Additional modeling of the partially annealed samples and further targeted analyses are in progress to elucidate the ages and magnitudes of these Tertiary cooling events.

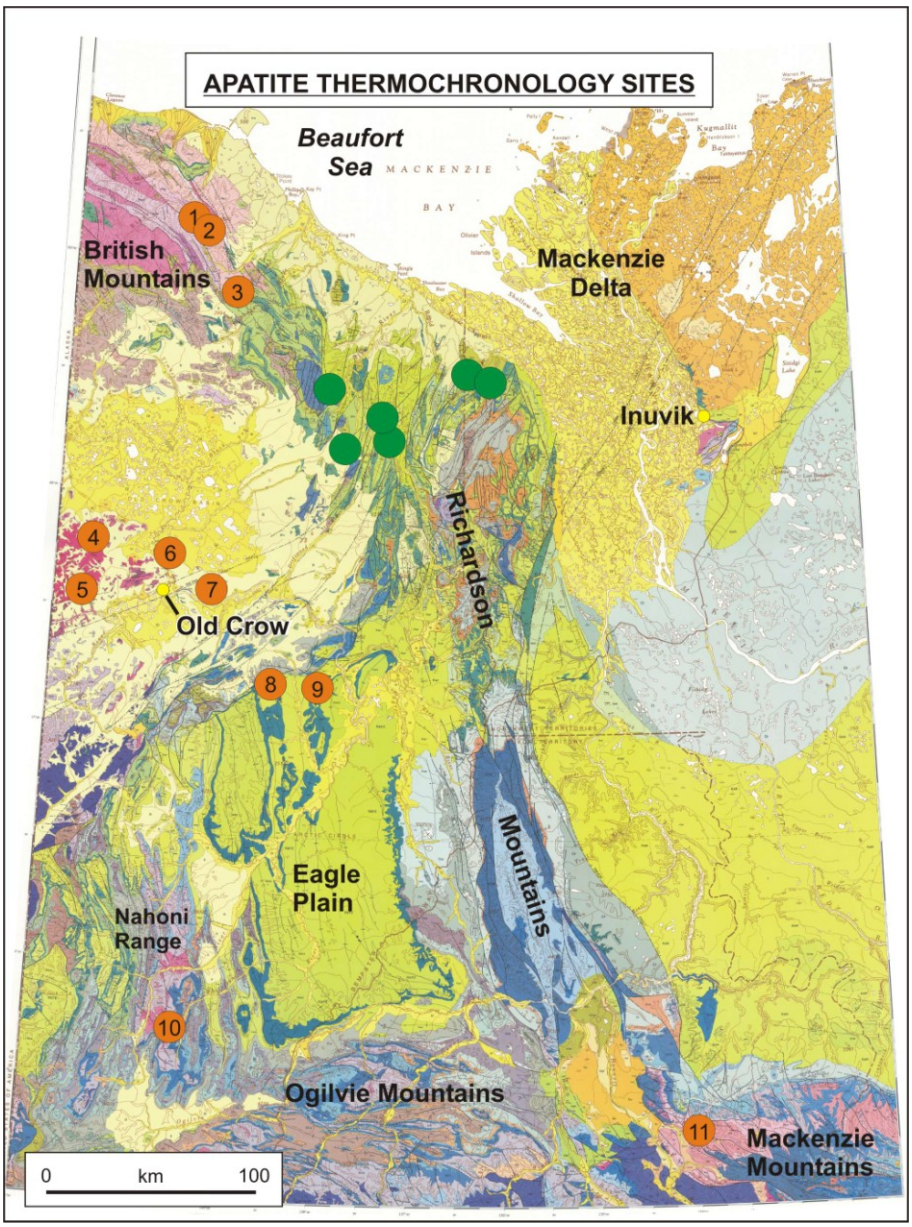

Figure 1. Apatite fission track data: numbered orange sites are keyed to Table 1; green sites refer to O'Sullivan and Lane (1997). Base map from Norris (1984).

Table 1: AFT Sample Data Summary

Site	Name	Dep. Age	Mean Age	1σ Error	Track length	1σ Error
1	Neruokpuk A	Prot. C	58 Ma	9 Ma	14.62 μm	0.65
2	Neruokpuk B	Prot. C	51 Ma	9 Ma	13.76 μm	0.59
3	Sedgwick	U. Dev	41 Ma	2 Ma	13.26 μm	1.68
4	NE Old Crow	U. Dev	51.2 Ma	3.8 Ma	13.66 μm	0.83
5	SE Old Crow	U. Dev	56 Ma	7 Ma	13.96 μm	1.05
6	Schaeffer	U. Dev	56 MA	3 Ma	13.95 μm	1.41
7	Dave Lord	U. Dev	84 Ma	4 Ma	13.80 μm	1.77
8	Sharp Mtn.	L. Cret	133 Ma	26 Ma	12.95 μm	2.36
9	Burnthill Ck.	U. Cret	103 Ma	7 Ma	12.47 μm	2.66
10	Fishing Branch	Prot. ?A	67.6 Ma	9.2 Ma	14.11 μm	1.32
11	Wind River	Prot. C	34.8 Ma	3.8 Ma	12.49 μm	2.11

References

Dixon, J., 1992, Stratigraphy of the Mesozoic strata, Eagle Plain area, northern Yukon: Geological Survey of Canada Bulletin 408, 58p.

Dietrich, J.R., Dixon, J., McNeil, D.H., McIntyre, D.J., Snowdon, L.R., and Cameron, A.R., 1989, The geology, biostratigraphy and organic geochemistry of the Natsek E-56 and Edlok N-56 wells, western Beaufort Sea, Arctic Canada: Current Research, Part G, Geological Survey of Canada Paper 89-1G, 133-157.

Duk-Rodkin, A. and Hughes, O.L., 1994, Tertiary-Quaternary drainage of the pre-glacial Mackenzie Basin: Quaternary International, **22/23**, 221-241.

Lane, L.S., 1998, Latest Cretaceous-Tertiary Tectonic Evolution of Northern Yukon and Adjacent Arctic Alaska: American Association of Petroleum Geologists Bulletin, **82**, 1353-1371.

Lane, L.S., 2004, Temporal-Spatial Evolution of Tertiary Deformation, Beaufort Sea-Mackenzie Delta Region: Geological Survey of Canada Open File 4666, 1 oversize poster.

Lane, L.S. and Dietrich, J.R., 1995, Tertiary structural evolution of the Beaufort Sea-Mackenzie Delta region, Arctic Canada: Bulletin of Canadian Petroleum Geology, **43**, 293-314.

Majorowicz, J.A. and Dietrich, J.R., 1989, Comparison of the geothermal and organic maturation gradients of the central and southwestern Beaufort-Mackenzie Basin: Current Research Part G, Geological Survey of Canada Paper 89-1G, 63-67.

Mazzotti, S. and Hyndman, R.D., 2002,Yakutat collision and strain transfer across the northern Canadian Cordillera: Geology, **30**, 495-498.

Norris, D.K., 1984, Geology of the northern Yukon and northwestern District of Mackenzie: Geological Survey of Canada Map 1581A, 1:500,000 scale.

O'Sullivan, P.B. and Lane, L.S., 1997, Early Tertiary thermotectonic history of the northern Yukon and adjacent Northwest Territories, Arctic Canada: Canadian Journal of Earth Sciences, **34**, 1366-1378.

O'Sullivan, P.B., Hanks, C.L., Wallace, W.K., and Green, P.F., 1995, Multiple episodes of Cenozoic denudation in the northeastern Brooks Range: fission track data from the Okpilak Batholith, Alaska: Canadian Journal of Earth Sciences, **32**, 1106-1113.