Apatite fission track constraints on the late Cretaceous heating of the Atlantic margin: Possible effects of anomalously high palaeo-mean surface temperatures

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Modelling of new apatite fission track (AFT) data from the Digby D1 drillhole in the South Mountain Batholith (close to the Triassic unconformity), indicates that near surface rocks were heated to temperatures in excess of 60°C during late Cretaceous times (ca. 100-80 Ma). These results must be evaluated in the context of previous studies. AFT studies had determined that the Atlantic margin, including the Maritimes Basin, was buried under at least 4-5 km of strata in late

Palaeozoic times, and that basin inversion removed much of this cover by Triassic/Jurassic times. Vitrinite reflectance of Cretaceous lignite within exposed sinkholes at Gays River, and AFT data on mainland Nova Scotia suggested Cretaceous heating of a few tens of degrees above present surface temperatures. Maturation parameters in the Jurassic sequence of the Bay of Fundy also imply substantial heating in late Mesozoic times. AFT studies on the Scotian Basin by the authors confirmed an episode of late Cretaceous heating in most wells, meaning that the Cretaceous sediments were at one time hotter than their present temperature in the wells. New AFT data, and better constrained time-temperature modelling on samples from outcrops (pre-Carboniferous basement, Permian strata, Mesozoic dikes, Triassic unconformity sediments) and drillholes onshore and wells offshore Nova Scotia indicate that the late Cretaceous heating event is widespread and significant. Heating of subsurface rocks to oil-window temperatures in the Late Cretaceous has obvious implications for hydrocarbon charge models.

There are several possible explanations for the heating event: 1) an increased palaeo-geothermal gradient, perhaps related to regional magmatic activity; 2) circulation of warm fluids at depth, in response to some structural/tectonic driving force; 3) considerable burial by sediments and subsequent exhumation; 4) sub-surface heating in response to a thermal blanket, the result of a long-term increase in the palaeo-mean annual surface temperature, or a combination of several of these causes.

The AFT data for samples from 60 to 1437 m in the Digby D1 drillhole suggest a normal late Cretaceous palaeo-geothermal gradient of 25°C/km; hence, hypothesis one is unlikely. Alkalic magmatism in New England and the Montreal area occurred around 90 Ma and localized mafic magmatism on the margin (New England Seamounts) could have had local effects. Late Mesozoic faulting was important in the Atlantic margin, and warm fluid circulation through them is a likely possibility, but is an unlikely cause of heating in the Digby well. There is geological evidence for late Cretaceous high sea levels and considerable sediment accumulation, but not to the extent of the >2 km that would be required to explain the regional AFT data as a result of simple burial heating. The fourth option may provide an explanation for heating with only limited burial, since a major world-wide climate change took place in the Turonian-Coniacian (92-86 Ma) which brought anomalously high mean annual surface temperatures to the Canadian Arctic Archipelago and consequently to the lower latitudes. Simple numerical calculations demonstrate that a long-term (1-10 my) increase in mean annual surface temperature (by, for example 15-20°) would cause a similar magnitude of heating at depths extending to several kilometres within the crust. The appraisal of the above hypotheses and time-temperature parameters for the Atlantic margin are the subject of the first author's Ph.D. thesis.