Fission-track re-evaluation of thermal inversion of the Scotian Margin: the need to consider the presence of diagenetic apatite and drilling-mud contamination

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Previous apatite fission track (FT) studies of the Scotian Basin (and onland Nova Scotia) have suggested a thermal event in the Late Cretaceous or Tertiary and subsequent thermal inversion, so that the rocks deep in some wells were hotter in the past than at present. Suggested explanations have included significant post-Eocene erosion (base level changes or fault tectonics), higher mean annual surface paleo-temperatures, local circulation of hot fluids, effects of salt, and analytical artefacts.

Fifteen apatite samples from cuttings and core from 8 wells: Abenaki J-56, Venture B-43, Panuke H-08, Thebaud I-93, Wenonah J-75, Alma F-67 (Shelf) and Crimson F-81 and Balvenie B-79 (Slope), were analyzed by the FT method, using optical track counting and measuring of confined track length and etch-pit size (D-par), combined with LA-ICPMS and EPMA of apatite grains. The latest methodology provides an order of magnitude more length measurements than the previous one, and a wealth of apatite geochemical composition data that allow for discrimination of populations with different provenances. The age, length, and geochemical data were modelled using HeFTy© and a few the AFTINV software. The methodology allows for individual time-temperature modelling of discrete groupings (populations) of apatite, an important improvement over past studies.

Although the results of earlier studies have been validated, the new methodology discovered two complications not considered before: (1) Apatite grains sampled in Scotian Basin wells were always assumed to be detrital. However the innovative modelling utilized shows that some apatite populations cannot be detrital. Some can be best modelled as authigenic apatite, having grown in situ during diagenesis; a mixture of detrital and (unsuspected) diagenetic apatite modelled together could mimic temperature inversion. (2) Some apatite samples from cuttings include populations that have evaded any heating in the basin, indicating that they are accidental contaminants of the drilling fluids, making their data worthless.

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