Thermal history of the external Humber Zone, western Newfoundland, as constrained by apatite fission track modelling: implications for hydrocarbon exploration and evolution of the Maritimes basin

Glen S. Stockmal[1], Dale R. Issler[1] and Art Slingsby[2]
[1]*Geological Survey of Canada, 3303-33rd Street N.W., Calgary, Alberta T2L 2A7, Canada*
[2]*Diamond M Resources Limited, 1802-9 Street S.W., Calgary, Alberta T2T 3C3, Canada*

Western Newfoundland has become a recent focus of renewed petroleum exploration in the wake of reinterpretations of its structural and tectonic setting. To better constrain the timing of structural trap development relative to hydrocarbon generation and migration, we have examined apatite fission data from two key areas: (1) Port au Port Peninsula, and (2) the Bonne Bay-Table Point area. Among maturation indicators, the apatite fission track technique is unique because it provides constraints on the time-temperature history, as opposed to constraining maximum temperatures only.

Fission tracks are zones of linear crystal damage produced almost exclusively through spontaneous fission decay of ^{238}U. Track density is a measure of fission track "age", whereas the length distribution of tracks provides thermal history information because fission track length reduction (annealing) is a temperature-dependent process. The annealing zone for apatite is 60 to 120°C; therefore, the technique is very useful for petroleum exploration. Using an inverse model to fully assess the range of possible time-temperature solutions permitted by the data, we construct a set of acceptable time-temperature paths which statistically fit the observed fission track age and track length distribution of a given sample.

Our solutions for western Newfoundland are additionally constrained by independent geological information: (1) available Conodont Alteration Index (CAI) values; (2) known regional erosional denudation of the Carboniferous Maritimes basin following North Atlantic rifting; and (3) for the Port au Port Peninsula area: pre-Visean erosional exhumation followed by Visean and later burial in the Maritimes basin. Our results indicate that all our apatite fission track samples were heated into the partial annealing window in post-Visean time; in nine of eleven samples, this heating event represented the thermal peak. Significantly, this timing also post-dates Ordovician through Devonian thin- and thick-skinned deformation. The results for seven of eleven samples are fully consistent with the CAI values; the remaining samples can be modelled with temperatures only 10°C warmer than indicated by the CAI values. Extrapolation of these temperatures to depth suggests temperatures of 100 to 160°C in the autochthonous platform, which lies comfortably within the oil window, consistent with the results of traditional maturation studies in the area.