Natural Fracturing of the Canol Formation Oil Shale: An Unconventional Spin on the Norman Wells Oilfield

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Abstract

Oil was discovered at Norman Wells in the Devonian Kee Scarp reef in 1920. The current phase of development began in 1985 and over 90 years the field has produced over 220 million barrels of oil. Whereas the oilfield appears to be a straightforward conventional system, available data are not necessarily consistent. We start with the proposition that a conceptual model should incorporate all available data, and find that a slightly unconventional idea helps to explain why there is oil at Norman Wells. New advancements in understanding unconventional resources have changed our view of shale and hydrocarbon systems. Rock properties of certain shales allow for retention of oil and gas within source rocks. We propose a new conceptual model for the Norman Wells oil field:

1) Deposition of Devonian Hare Indian, Ramparts, and Canol formations on the flank of a paleohigh (Keele Tectonic Zone).

2) Maximum burial and thermal maturity were reached prior to exhumation that began in the Triassic. Oil was generated at that time and a portion was trapped within pores of the Canol Formation. The majority of hydrocarbons generated from the Bluefish Member were expelled and eventually lost to the system.

3) Pre-Albian uplift and erosion left the Devonian succession of Hume-Hare Indian-Ramparts-Canol-Imperial formations exposed at the surface on the flanks of the Keele Tectonic Zone. Any conventionally trapped hydrocarbons were flushed or biodegraded.

4) During Cretaceous and Tertiary deposition the Keele Tectonic Zone was a paleohigh onto which wedge-shaped stratal geometries onlapped. The result was much less burial than regions to the west, followed by post-Eocene uplift and erosion.

5) Strain from collision of the Yakutat terrane beginning at 5 Ma was translated across the Cordillera and drove displacement on the Norman Range Thrust Fault. During uplift, fault-related fractures released hydrocarbons trapped within Canol Formation and provided conduits for migration.

6) Migrating hydrocarbons were trapped within the Kee Scarp reef, and some migrated through fractures to the surface where they were discovered as oil seeps.