Structural-diagenetic evolution of fractures in folds: A TGS example from the Alberta Foothills, Canada

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The late Jurassic-early Cretaceous Nikanassin formation is generally characterized as a tight gas sandstone formation with submilidarcy values of permeability and porosities typically less than 6% [1]. However, the Nikanassin produces gas at commercial rates where it contains a network of open fractures. But exploration and development outcomes are mixed, underlining the necessity for a better understanding and characterization of the more fractured and potentially more productive regions [2].

A unique combined outcrop and core study of fractures associated with three reservoir-scale anticlines reveals the presence of two main fracture sets in all three mesostructures: fracture set one is perpendicular to the fold axis, whereas fracture set two is parallel. Both sets have an associated conjugate oblique fracture set. Scanline data indicate a higher fracture intensity in the steeply-dipping limbs of the folds than in the shallower-dipping limbs. Cathodoluminescence images of cemented fractures reveal several generations of quartz and ankerite cement that are synkinematic and postkinematic relative to fracture opening. Based on homogenization temperatures of two-phase aqueous inclusions in crack-seal cement, synkinematic fracture opening and cement precipitation occurred at or near maximum burial in core samples (190-210°), and during exhumation in outcrop samples (120-160°).

Structural models constructed using MOVE [3] predict a higher strain accumulation in the steep limb of the Sternie Creek Anticline than in the fold hinge and shallow limb. Models also predict an early opening of fracture set 1, which is in accordance with the general observation that set 2 cross-cuts set 1 in outcrop. Opening of most fractures probably occurred during regional folding at the end of the Laramide orogeny.

[1] Solano *et al*. (2011) *SPE Res. Eval. & Eng.* **14,** 357-376 [2] Hayes (2009) *Search and Discovery* article #10182 [3] MOVE *Midland Valley* Structural Restoration Software

Anammox in an ammonium-impacted groundwater aquifer

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The novel anaerobic ammonium oxidation pathway (anammox) is today recognized as an important sink for reactive N, removing biologically available N in the form of ammonium and nitrite to the gaseous N_2, providing a competition to the dissimilatory nitrite reduction by denitrifiers. Anammox activity and the responsible bacteria are currently demonstrated in a wide range of ecosystems, however; the knowledge about anammox in freshwater systems, like ammonium-impacted groundwater aquifers, is still scarce. With the necessary electron donors and acceptors present in the groundwater system, the activity and abundance of anammox bacteria could be of significant importance since biologically available N, resulting from anthropogenic sources, is a major threat to groundwater quality.

We hypothesize that the anammox process occurs in a contaminated groundwater system, when NO_2^- and NH_4^+ are present under low oxygen conditions. Isotope-based methods were used to quantify anammox activity through the isotope pairing technique: two-meter sediment cores were collected from a groundwater system adjacent to the abandoned landfill site Risby, Denmark; chosen intervals were sectioned and incubated anaerobically as sediment slurries. The production of $^{29}N_2$ and $^{30}N_2$ was monitored over time after addition of labelled N and unlabelled N as: $^{15}NO_3^-$ + $^{14}NH_4^+$ for detecting anammox, denitrification (nitrite reduction to N_2) and DNRA (dissimilatory reduction of ammonium) and with $^{15}NH_4^+$ + $^{14}NO_3^-$ for detecting anammox production. Our results show that both anammox and DNRA are active, with denitrification as the dominating pathway.

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