

Hydrocarbon Reservoirs in Deeper-Water Carbonates: Paleobiological Breakdown of Permeability Barriers in Mississippian Dolomudstones, Midale Beds, Weyburn Oilfield

Arjun D. Keswani and George Pemberton

Earth & Atmospheric Sciences, University of Alberta, Edmonton, AB, Canada.

Most petroleum geologists consider mudrocks to represent relatively tight strata that traps hydrocarbons, or a source rock rich in organic matter. Reservoir potential in muddy strata has rarely been considered in construction of geologic models for exploration and development. Yet, bioturbated dolomudstones of the Upper Midale Beds represent giant hydrocarbon reservoirs, where oil reserves are estimated at 1.4 billion barrels in the Weyburn Oilfield. Since reservoir strata are characterized by an abundance of bioturbate textures, this suggests widespread organism-sediment interactions have played a significant role in development of porosity-permeability characteristics in otherwise tight strata. Hence, an understanding of paleobiological breakdown of permeability barriers in mudstones is useful for deciphering potential targets, where reservoir development may otherwise be overlooked.

The Upper Midale Beds provide an example of reservoir development in bioturbated dolomudstones, characteristic of deeper-water carbonates. Relatively stable, fully-marine, offshore paleoenvironments have been inferred on the basis of trace fossils representing the distal-Cruziana ichnofacies, including common occurrence of Zoophycos, Planolites and Chondrites, some Helminthopsis, Asterosoma, Teichichnus and Palaeophycus, and rare Siphonichnus. This ichnofossil suite suggests bioturbation consisted of predominantly deposit-feeding activities. Petrographic studies on bioturbated dolomudstones show nearly-complete pelletization of the mud. Widespread re-organization of mud into fecal pellets introduced porosity-permeability characteristics in otherwise relatively tight muddy strata. For example, introduction of both intraburrow- and interburrow-fabric intergranular voids, and connectivity of pore spaces in alignment of fecal pellets along spreiten and wall structures has resulted in enhanced local permeability. Such biogenically-emplaced permeable conduits facilitated setup of a cross burrow-fabric fluid flow regime, which dolomitized pelleted muddy substrates. Furthermore, subsequent percolation of leaching fluids resulted in dissolution of skeletal fragments, and enhanced reservoir quality. Thus, inherent relationships in bioturbation-diagenesis forms the genetic cornerstones of this deeper-water model for carbonate reservoir development.