Burrow Fabrics in the Ordovician Yeoman Formation, and Their Effect Upon Subsequent Diagenesis

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ABSTRACT
Textural and micro-chemical changes produced by burrowing and boring organisms can greatly affect porosity and permeability. Diagenetic overprints can enhance these small-scale heterogeneities, and thus influence reservoir quality. Detailed 3-D modeling of the burrow framework is essential for developing accurate reservoir models and for making reliable estimations of hydrocarbon reserves. This type of reservoir heterogeneity has been examined in the Devonian Wabamun Formation (Alberta, Canada), Cretaceous Shuaiba Formation (Qatar) and the Jurassic Arab-D Formation (Saudi Arabia). This study focuses on the differences in burrow and associated diagenetic fabrics found in the Yeoman Formation of Southern Saskatchewan, at the Midale Pool (TWP 6-7, R11 W2).

Since the discovery of Berkley et al. Midale 4-2-7-11W2 in 1995, over 65,000 m^3 of oil have been produced from the Midale Pool alone (Haidl et al., 2000). The abundance of closely-positioned cored wells makes this an excellent area to examine reservoir scale heterogeneities caused by both primary and secondary fabrics. Diagenesis has a varied influence on production. In some areas, valuable porosity was occluded by dolomitization, silicification or anhydrite cementation. Elsewhere, dolomitization of burrow fills and aureoles around burrows enhanced porosity and permeability. Some burrows were enlarged by dissolution, and were not occluded by anhydrite. Reserve calculations can be greatly reduced or increased where burrows and associated diagenetic features act as flow conduits.

The Ordovician Yeoman Formation (or Burrowed ‘C’ Interval of the Red River Formation) of Southern Saskatchewan is the subsurface equivalent of the well-known Tyndall Stone. It was deposited in a shallow epeiric seas, and is believed to be part of a larger carbonate package which covered the entire North American craton at time of deposition (Macauley, 1964; Zenger and Lemone, 1995). Although the Red River sedimentation was relatively uniform throughout the Williston Basin, a relationship between sedimentation patterns and basement structures exists (Kreis and Kent, 2000). As burrow fabrics vary with the sedimentation patterns, the burrow-related diagenetic fabrics also vary with sedimentation. Kent (pers. comm. 2000) found that the burrow patterns varied from the crest to the flanks of basement structures. Although it has been recognized that burrows greatly affect the diagenetic history, there is a paucity of literature describing the ichnology (*ichnofacies?*) of the Yeoman Formation. These subtidal carbonates have distinctive burrow-mottles, which are commonly interpreted as *Thalassinoides* (Kendall, 1976, 1977;Canter, 1998; Kissling, 1999). Some have proposed that these may in fact be diagenetic aureoles around smaller causative burrows (Carroll, 1979; Gingras et al., *in review*). *Planolites*, *Paleophycus*, *Skolithos* and *Chondrites* are pervasive throughout the Yeoman Formation. Not all burrows have mottles, nor do all mottles form around a specific type of burrow. Due to diagenetic overprinting the different burrow types cannot always be distinguished. Evidence for the recognition and classification of burrow types will be discussed.

The variability in dolomitization is highly variable even within a single oil pool, and several phases are recognized. Correlative zones may be limestone, dolomitic limestone or dolomite. Many large-scale dolomitization models have been proposed for the Yeoman (Red River) Formation, but no agreement has been made concerning what processes are responsible for the dolomitization of the Yeoman Formation. Seepage-reflux dolomitization, as described by Longman et al. (1987) has been most widely applied. Such a model however has not been universally accepted (Kendall et al., 1984). More recent studies have begun to look more closely at small-scale diagenetic models (Zenger, 1996; Gingras et al., *in review*). It has been suggested that the dolomitization may be intricately linked to the burrow networks and the magnesium source was the sea-water. Dolomitization associated with the burrow networks is inferred to be syndepositional or early diagenetic.

Berkley et al. Midale 11/07-03-07-11W2 and Berkley et al. Midale 41/02-10-7-11W2 are located in the same township. Corresponding facies can easily be recognized. These wells have different diagenetic overprints, yet they are both producing. Production from 11/07-03-07-11W2 has been 12,924.7 m3 in 134 hours and from 41/02-10-7-11W2 13,132.5 m3 in 2198 hours. The most striking difference is that former has some dolomitized zones, whereas the latter is still calcareous. Some burrows are more readily recognized in dolomitized zones, and others in the calcareous zones.

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