ICHNOLOGICAL VARIATIONS IN BRACKISH-WATER CENTRAL-BASIN COMPLEXES OF WAVE-DOMINATED ESTUARINE INCISED-VALLEY FILLS, LOWER CRETACEOUS VIKING FORMATION, CENTRAL ALBERTA

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This study integrates ichnological, sedimentological and stratigraphic analyses of the Lower Cretaceous (Albian) Viking Formation in west-central Alberta, facilitating the recognition of sand- and mud-prone heterolithic central basin deposits in wave-dominated, estuarine incised valley fills. Core descriptions from 110 wells in four fields (26 wells from Crystal, 4 from Cyn-Pem, 50 from Willesden Green, and 30 from Sundance-Edson) comprise the data set.

Central basin settings diverge from open marine settings based on conditions of reduced and fluctuating salinity. Indications of brackish-water conditions can be subtle, often leading to the misidentification of central basin deposits as open marine "Regional Viking" parasequences. Ichnology is ideally suited to assist in the identification of such brackish-water deposits. Ichnological suites, bioturbation intensities, and physical sedimentary structures are used to differentiate five recurring brackish-water, central basin facies associations. Although central-basin deposits are not significant hydrocarbon producers, associated sand-prone facies of incised valley-fills are lucrative. Central basins comprise the most volumetrically extensive deposits of the valley fills and, as a result, exploration and early development wells are most likely to intersect these heterolithic successions.

Facies Association CB1 is mud-dominated, and contains trace fossil suites indicative of the most marine conditions of all the central basin deposits. Facies of CB1 are interpreted to record deposition in marine-influenced bays of incompletely barred estuaries. Intervals encompass BI 3-5, with abundant Planolites, Teichichnus, Palaeophycus, Chondrites, "Terebellina" (sensu lato), and Thalassinoides, and subordinate Ophiomorpha, Helminthopsis, Phycosiphon, Asterosoma, Skolithos, Lockeia, Cylindrichnus, Rhizocorallium, Arenicolites and fugichnia. CB1 bay deposits are particularly common to the Sundance-Edson valley system.

Facies Association CB2 is also mud-dominated, but generally lacks those ichnogenera considered to be restricted to fully marine settings (e.g., Palaeophycus, Asterosoma, Rhizocorallium, and Helminthopsis). Intervals display variable and generally reduced bioturbation intensities (BI 1-4). Suites comprise Planolites, “Terebellina” (sensu lato), Teichichnus, and secondary Cylindrichnus, Ophiomorpha, Rosselia, Palaeophycus, Diplocraterion, Arenicolites, Skolithos and fugichnia. Very rare occurrences of Chondrites and Lockeia are locally present. Facies of CB2 reflect accumulation in low-energy, strongly brackish bays of well-barred estuarie, and is common to Willesden Green and some Crystal successions.

Facies Association CB3 comprises sand-prone heterolithic successions, deposited along shallow bay margins of well-barred estuaries (where it grades upwards from CB2), and/or adjacent to bay-head deltas. The facies displays BI 0-3, with a low-diversity suite of Planolites, Teichichnus, “Terebellina” (sensu lato), Ophiomorpha, diminutive Palaeophycus, and fugichnia. Rarely, Rosselia, Cylindrichnus, Thalassinoides, Diplocraterion, Arenicolites, and Skolithos, and very uncommon occurrences of Chondrites, Rhizocorallium, and Phycosiphon are present. Facies of CB3 are common to the Willesden Green valley and landward portions of the Crystal valley.

Facies Association CB4 corresponds to sand-dominated heterolithic intervals. The facies display BI 1-4, with robust ichnogenera and high diversity suites (e.g., Planolites, Teichichnus, fugichnia, Palaeophycus, Ophiomorpha, Thalassinoides, Rosselia, Arenicolites, Cylindrichnus, Diplocraterion, Skolithos, Lockeia, Chondrites, Phycosiphon, Siphonichnus, Taenidium, Asterosoma, and “Terebellina” (sensu lato)). Facies Association CB4 is interpreted to represent bay-margin positions of incompletely barred estuaries (e.g., the Sundance-Edson valley, where it grades upwards out of Facies CB1), as well as late-stage bay infill associated with the early stages of transgression (e.g., all Viking incised valleys studied).

Facies Association CB5 encompasses sandstones deposited along the seaward edges of central basins, adjacent to the estuary mouth (e.g., associated with flood-tidal deltas and storm-washover fans). This facies displays BI 0-3, with a strongly marine-influenced trace fossil suite. Ichnogenera comprise Planolites, Ophiomorpha, Palaeophycus, Skolithos, and fugichnia, with secondary Teichichnus, Diplocraterion, Arenicolites, Rosselia, “Terebellina” (sensu lato), Thalassinoides, Chondrites, Phycosiphon, Asterosoma, Bergaueria, and Conichnus. Facies of CB5 are common to Willesden Green and Crystal valley successions.

Ongoing research seeks to identify characteristic geophysical well-log signatures for central-basin deposits, in order to enhance recognition of estuarine incised-valley fills. Bay-fill signatures in wave-dominated estuaries are commonly misidentified as open-marine parasequences, as bays are generally characterized by sanding-upward successions. Central basins constitute the most areally extensive subenvironments of wave-dominated estuaries, and their deposits are the most likely to be encountered during drilling. Consequently, reliable identification of central basins could facilitate future discoveries of incised valleys. Estuarine incised valley fills are under-represented in the Viking Formation, given the abundance of forced regressive, lowstand, and transgressively incised shoreline trends that have been identified. Integrating ichnology with sedimentology and stratigraphy will assist in the recognition of incised valley fills in the rock record.

INTRODUCTION

Channel sandstones of incised valley fills (IVF) are a prime hydrocarbon exploration target in Alberta, since the discovery of these deposits in the Crystal Field in 1978 (cf. Reinson et al., 1985; 1988). The productive Crystal estuarine deposits occur in the Albian-aged (Lower Cretaceous) Viking Formation (Fig. 1). Subsequent IVF successions were recognized from the Willesden Green (Boren 1989; Boren and Walker, 1991), as well as the Sundance-Edson and Cyn-Pem fields (Pattison, 1991; Pattison and Walker, 1994; 1998) (Fig. 2). These systems correspond to the wave-dominated estuary model of Zaitlin et al. (1994) (Fig. 3). The wave-dominated or barred estuary model displays a well-developed tripartite zonation of facies, characterized by a sand-prone estuary mouth complex, a mud-prone central basin succession, and a sand- to gravel-prone bay-head delta-distributary complex fed by the river system. Nevertheless, significant variability can be anticipated, even within the end-member wave-dominated estuary type. Depending upon the interplay of tidal flux and wave