

Developing Predictive Facies Models for the McMurray Formation: How to Recognize and Employ a Suitable Modern Analogue

Shahin E. Dashtgard¹, Stephen M. Hubbard², and Murray K. Gingras³

¹Applied Research in Ichnology and Sedimentology Group (ARISE), Department of Earth Sciences, Simon Fraser University, 8888 University Drive, Burnaby, B.C. V5A 1S6

²Centre for Applied Basin Studies (CABS), Department of Geoscience, University of Calgary, Calgary, AB T2N 1N4

³Ichnology Research Group (IRG), Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, AB T6G 2E3

Modern analogues are commonly used to assist construction of depositional models for ancient sedimentary systems. Features at different scales of observation – such as the basin morphology, shape and size of the depositional system, character of the depositional elements of the system (e.g. point bar, offshore bar), and sedimentary facies characteristics – can be employed in developing such models. In modern studies, the use of airphotos and satellite data, resin peels, box cores, and vibracores provides very high-resolution sedimentological, ichnological and morphological data in the horizontal plane (Fig. 1). However, these datasets tend to be restricted vertically. At the range of scales / sedimentological data available from subsurface studies, and considering the vertical limitations of modern datasets, the utility of modern analogues can be considered highest at the bed scale and lowest at the basin scale. To truly develop a robust model for the McMurray Fm that accounts for complexities in the ancient depositional system, multiple modern analogues, at various scales of observation (e.g., bed scale, depositional environment scale, basin scale), are needed.

For several reasons, identifying appropriate depositional analogues for McMurray Formation strata is particularly challenging. At the facies scale, analogy to the McMurray can be drawn from mixed tidal-fluvial systems that locally display bedforms and burrows that bear similarity to those that characterize the rock record. Examples of this include inclined heterolithic stratification, fluid-mud deposits, and the presence of brackish-water bioturbation. Because bed-scale features result from sedimentary processes that are observed in a variety of marginal-marine depositional settings, analogy at this scale is not always appropriate for understanding larger scale aspects of the formation. At the scale of the depositional system, analogues such as channel bars and abandoned channel reaches provide ideas pertaining to the distribution and extent of reservoir and non-reservoir layers. Fluvial point-bar analogues, for example, can be useful spatially even if facies-scale characteristics are not honored: e.g., fluvial point bars can provide important architectural information despite the fact that they may lack facies-scale similarities such as tidal indicators and bioturbation. To truly constrain the depositional architecture of the Middle McMurray the depositional architecture of a spectrum of tidal-fluvial depositional environments, from the fluvial extreme to the fully marine realm, are required.

At the broadest scale of observation, the basin morphology and low accommodation at the time of McMurray deposition ensured that fluctuations in base level caused significant and widespread shifts in the depositional environment. Variation in the depositional system with time was highly complex, consisting of a myriad of stacked

marginal-marine settings, including: estuarine, deltaic, tidally-influenced meandering fluvial channel belts, and lacustrine settings to name a few. Analogies for the nature of the depositional system focus dominantly on the regional distribution of depositional elements: it is only at this scale that the morphology of the analogous depositional system is especially relevant. Conversely, good analogy at the basin scale is the most difficult to reconcile. Thus, researchers should be compelled to develop abstract depositional hybrids based on a range of modern studies. Although it is difficult to provide appropriate analogies for basin character, a few key considerations should be recognized, including basin subsidence rates, typical bathymetric profiles, and sediment source areas and distribution. In short, the McMurray Formation is the product of a dynamic and evolving sedimentary system that, even from the minimalistic point of view, benefits from the application of multiple modern analogues.

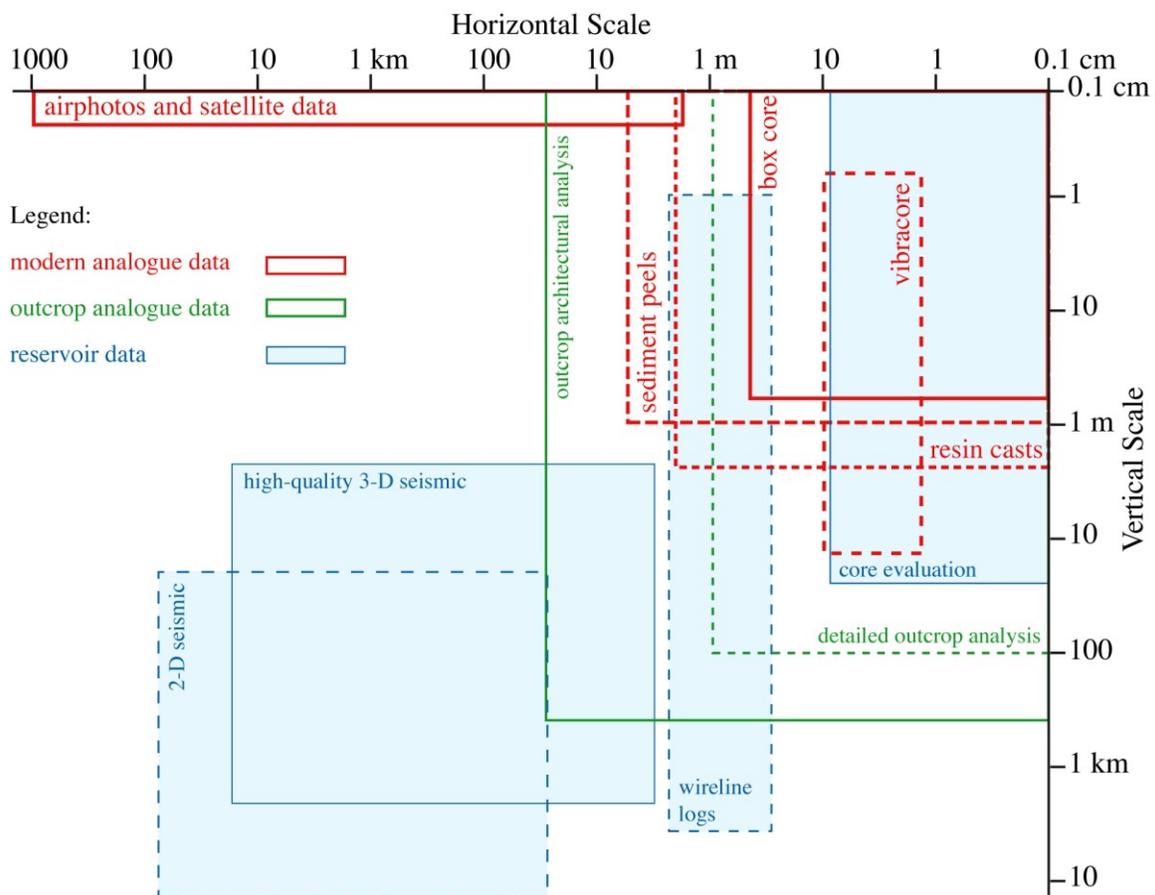


Figure 1 – A schematic representation of the horizontal and vertical scales of modern, outcrop, and subsurface reservoir datasets. Modern datasets provide high-resolution sedimentological, ichnological, and morphological data at a broad range of lateral scales, but tend to be vertically restricted. Outcrop, and more so, subsurface datasets cover a greater vertical range, but are commonly much lower resolution than modern datasets. As well, subsurface and outcrop data provide much lower resolution data in the horizontal plane.