GeoConvention 2014 FOCUS
adapt
refine
sustain

Facies Analysis of the Lower Cretaceous Wilrich Member (Lower Falher) of the Spirit River Formation.

Kerrie L. Bann, Ichnofacies Analysis Inc. and Daniel J. K. Ross, Tourmaline Oil Corp.

Historically, the Falher Member of the Spirit River Formation has been explored and as one of the primary natural gas reservoirs in the Deep Basin of West-Central Alberta (e.g., Falher F in Wapiti; Nodwell and Hart, 2006). Linear upper shoreface and foreshore conglomeratic trends (paleostrandlines) were the primary target due to enhanced permeability relative to other Spirit River Formation horizons (typically low permeability quartzose sandstone units; Cant & Ethier, 1984). In recent years, the Wilrich and lower Falher sands have seen increased exploration and development focus in the Deep Basin with the advancement of horizontal drilling and completion technologies. Over 300 wells have targeted the Wilrich/lower Falher spanning from Musreau-Kakwa in the north to Lovett and Brazeau River regions in the south. Test results as high as 70 mmscf/d have been reported.

To date, most of the detailed sedimentological and ichnological work of the Spirit River Formation has focused on the Elmworth-Wapiti region of the Deep Basin (Armitage et al, 2004; Schmidt & Pemberton, 2004; Zonneveld & Moslow, 2004; MacEachern & Hobbs, 2004; Nodwell & Hart, 2006). However the type and distribution of Wilrich and lower Falher reservoir facies over a wider geographic area are not clearly understood. By utilizing high resolution ichnological and sedimentological analyses, this study sets out to determine regional facies variations, and calibrate this data to reservoir quality and ultimately to deliverability. The analysis is being carried out on numerous cores across the Deep Basin.

Several facies have been recognized from the study including offshore/shoreface strandplain deposits and different types of deltaic deposits that reflect varying degrees of river, wave and storm influence. Middle to upper shoreface/foreshore deposits of the Wilrich Member are typically characterized by planar laminated, trough cross stratified and current ripple-laminated fine-grained sandstones. In most cases bioturbation is generally rare to absent (bioturbation intensity, BI, between 0-1). In some regions, foreshore deposits vary along strike from sandstone dominated successions to pebble conglomerates.

Deltaic deposits have strikingly different ichnological and sedimentological features from offshore/shoreface strandplain deposits. Deposits range from mixed influenced prodelta, distal delta front and proximal delta front, to mouthbar/terminal distributary channel deposits occurring at the top of the deltaic parasequences. The best reservoir quality sands are associated with proximal delta front and mouthbar/terminal distributary channel (e.g., Resthaven).

Mixed influence proximal delta front deposits consist of laminated medium-grained sandstones. Laminations change from silty to carbonaceous upwards. Wavey-parallel laminations and oscillation ripples reflect wave influence whilst soft-sediment-deformation reflects rapid dumping of sediment during heightened fluvial dishcharge. Locally occurring claystone drapes reflect deposition via buoyant mud plumes. The deposits are predominantly unbioturbated but they are crypto-bioturbated reflecting the activities of micro-scale infauna that disrupt the laminations.

Mouthbar/terminal distributary channel deposits occur at the top of the deltaic parasequences and consist of a fining-upwards body of fine- to medium-grained sandstone with parallel and low-angle laminations, trough cross-bedding and current, combined and climbing current ripple-cross-lamination. Mudstone and siltstone laminations ranging from between mm scale and several cm are uncommon but occur locally. Carbonaceous detritus and mudstone rip-up clasts occur locally. Bioturbation occurs locally, mainly associated with the mudstone interbeds. All forms are deposit-feeding structures, diminutive in nature and include *Planolites* and *Teichichnus*. The assemblage represents a highly stressed expression of the *Cruziana* Ichnofacies.

Ichnological and sedimentological expressions of the Wilrich/lower Falher are critical components to hydrocarbon exploration and development. HZ wells have targeted both deltaic and upper shoreface/foreshore sands with varying success, in part due to complex heterogeneous facies. For example, foreshore conglomerates don't necessarily have optimum reservoir quality due to varying permeability profiles which change significantly across a few miles laterally. Conglomeratic zones also provide challenges for core to log porosity calibration where log data underestimates porosity; hence understanding facies distribution is critical for determining net reservoir, GIIP and landing targets for horizontal wells. The study also highlights the significance of deltaic sedimentation processes involved with Wilrich/lower Falher deposition, impacting reservoir quality variations along depositional strike and interpreted planform geometries of the reservoir sands.

References

Armitage, I.A., Pemberton, S.G. and Moslow, T.F. 2004. Facies succession, stratigraphic occurrence, and paleogeographic context of conglomeratic shorelines within the Falher "C", Spirit River Formation, Deep Basin, west-central Alberta. Bulletin of Canadian Petroleum Geology, v. 52, p. 39-56.

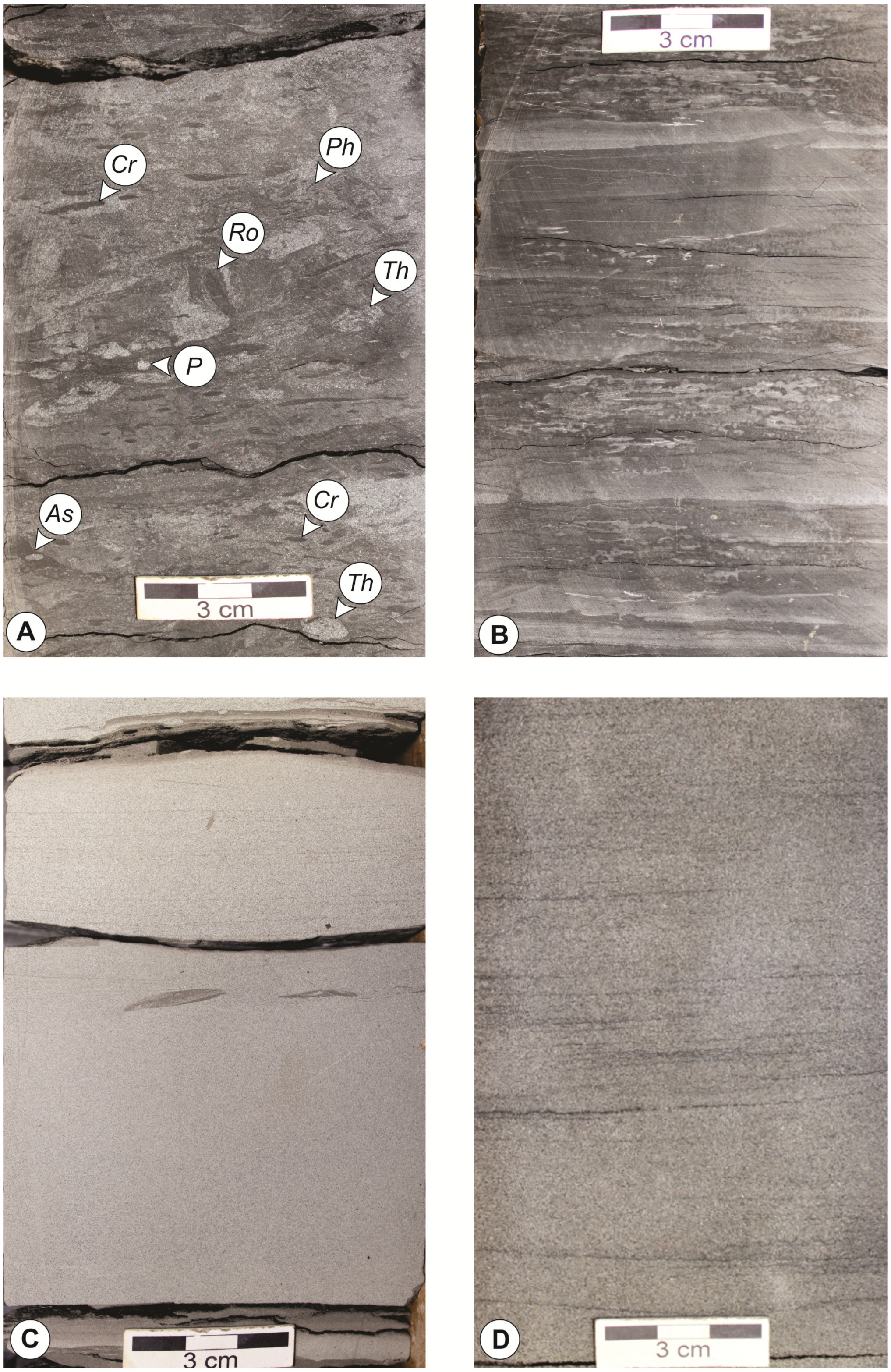
Cant, D.J. and Ethier, V.G. 1984. Lithology-dependent diagenetic control of reservoir properties of conglomerates, Falher Member, Elmworth Field, Alberta. American Association of Petroleum Geologists Bulletin, v. 68, p. 1044-1054.

MacEachern, J.A. and Hobbs, T.W. 2004. The ichnological expression of marine and marginal marine conglomerates and conglomeratic intervals, Cretaceous Western Interior Seaway, Alberta and northeastern British Columbia. Bulletin of Canadian Petroleum Geology, v. 52, p. 77-104.

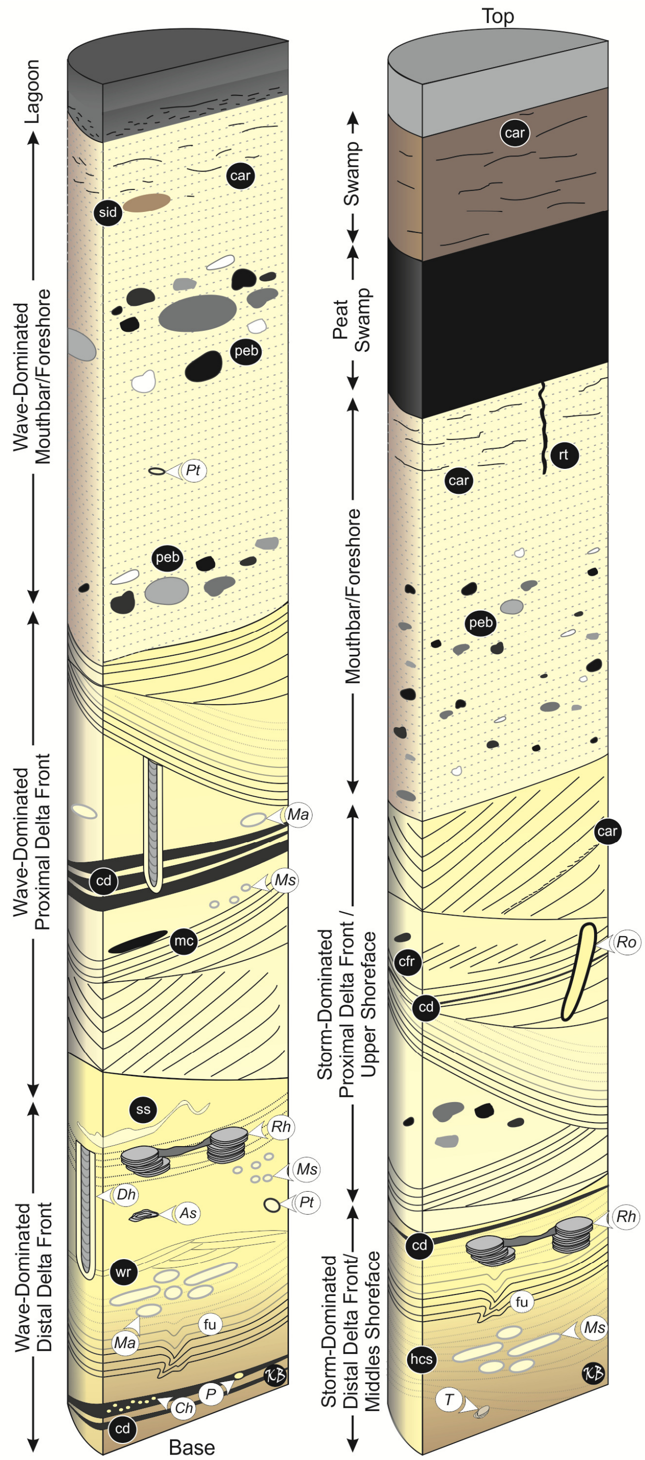
Nodwell, B.J. and Hart, B.S. 2006. Deeply-rooted paleobathymetric control on the deposition of the Falher F conglomerate trend, , Wapiti Field, Deep Basin, Alberta. Bulletin of Canadian Petroleum Geology, v. 54, p. 1-21.

Schmidt, G.A. and Pemberton, S.G. 2004. Stratigraphy and paleogeography of a conglomeratic shoreline: the Notikewan Member of the Spirit River Formation of west-central Alberta. Bulletin of Canadian Petroleum Geology, v. 52, p. 57-76.

Zonneveld, J.P. and Moslow, T.F. 2004. Explroation potential of the Falher G shoreface conglomerate trend: evidence from outcrop. Bulletin of Canadian Petroleum Geology, v. 52, p. 23-38.



(A): Pervasively bioturbated offshore deposit with diverse *Cruziana* Ichnofacies. *Thalassinoides (Th), Cosmorhaphe (Cr), Asterosoma, Rosselia (Ro), Planolites (P), Phycosiphon (Ph).* (B): Heterolithic mixed-influence prodeltaic deposit. (C): Fine-grained sandy distal delta front deposits with claystone rip-up clasts and drapes. (D): Fine- to medium-grained proximal delta front deposit with carbonaceous laminae.



This core consists of two sandy parasequences overlain by a coal and carbonaceous mudstone. The lower parasequence consists of a wave-dominated distal delta front to mouthbar succession that basically resembles a shoreface profile with minor deltaic signals such as claystone drapes (cd) with *Chondrites (Ch)* and *Planolites (P),* and soft-sediment-deformation (ss). The distal detla front contains wave-generated structures such as wave ripples (wr). The trace fossil suite is sparse and consists of *Macaronichnus isp (Ma), Asterosoma (As), Palaeophycus tubularis (Pt), Macaronichnus segregatis (Ms), Diplocraterion habichi (Dh)* fugichnia (fu-escape traces) and complex irregular *Rhizocorallium (Rh).* This assemblage represents a highly stressed expression of the *Cruziana* Ichnofacies which is typical of distal deltaic deposits. The proximal delta front consists of trough-cross-stratification with locally occurring clay drapes, small and large *Macaronichnus (Ma, Ms)* and *Diplocraterion habichi (Dh).* This occurrence of deposit-feeding structures in high energy sandstones is characteristic of deltaic deposits. The mouthbar deposits look like pebbly (peb) foreshore deposits. The parasequence is overlain by a thin carbonaceous mudstone that represents a lagoon deposit. The overlying parasequence contains a similar arrangement of facies but there is less evidence of deltaic deposition and more evidence of storm deposition such as hummocky-cross-stratification (hcs). Clay drapes (cd), locally abundant carbonaceous detritus (car) and combined flow ripples (cfr) are deltaic signals. Again the trace fossil assemblage is largely composed of deposit-feeding structures such as *Teichichnus (T), Macaronichnus* isp *(Ma),* complex irregular *Rhizocorallium (Rh)* and truncated *Rosselia* stalks *(Ro).* The assemblage represents a stressed expression of the *Cruziana* Ichnofacies. This occurrence of *Cruziana* style behaviour in such sandy substrates is characteristic of deltaic deposits. Rootlets (rt) occur at the top of the sandy profile which is overlain by a coal and subsequently a carbonaceous mudstone which both represent terrestrial swamp deposits.