Paleogeographic reconstruction of the Falher “F” and the implication to its chert-influenced durability fairway, Wapiti Field, Alberta

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Introduction

The lower Albian Falher Member of the Spirit River Formation has been recognized as one of the most prolific gas reservoirs in the Deep Basin of the Western Canada Sedimentary Basin (WCSB) (Masters, 1979; 1984). During its early decades of exploration, interest was focused on the regressive shallow marine conglomeratic succession. These intervals are composed of very well sorted, clast-supported unimodal to bimodal conglomerate beds capping shoreface to deltaic sandstone successions. The conglomerate unit naturally was an attractive target as they exhibit high permeability (10 md up to darcys) coupled with moderate to high porosity (up to 20%), compared to the underlying tight sandstone, which exhibits relatively low permeability and low porosity (0.01-0.5 md and 4-7%, respectively) (Cant, 1983a; b). However, the advancement of horizontal drilling and multi-stage fracs has encouraged the exploration of these thicker, laterally more extensive finer-grained sandstone units (Moslow et al., 2017; Zonneveld et al., 2017). Attempts for reservoir characterization in the last decade have particularly been emphasized on tight sandstone plays of the lower sub-member of the Falher, which are the Falher “F” and Wilrich-equivalent Falher “G” sub-member (e.g. Moslow and Ala, 2012; Bann and Ross, 2014; Fawcett, 2014; Newitt and Pedersen, 2016).

Nevertheless, current drilling programs using horizontal wells often face several issues such as the low rates of penetration (ROP) and frequent bit replacement due to the durability heterogeneity within the sandstone intervals. One of the likely causes in terms of mineralogy is the high percentage of durable components, i.e. chert grains and clasts, within the succession (Zonneveld et al., 2017). Thus, this study is established to integrate sedimentology, stratigraphy, and petrography approaches to predict the distribution of chert and understand such occurrence in a paleogeographic context within the Falher “F”.


Methods
Twenty-one cores penetrating the Falher “F” in a study area extending from T65-67, R8-11WM were described. Geophysical well logs from more than 300 wells penetrating the Falher “F” were also analyzed to establish the paleogeographic reconstruction. As many as 63 thin sections from varying stratigraphic levels, depositional environments, and regions in the study area were also collected and analyzed. Several different mineralogical plots were then produced to establish a corresponding trend.

Preliminary Results
The Falher “F” was deposited as a strandplain succession and along-strike wave-dominated delta equivalents. The deposition took place in a series of four parasequences, informally assigned F1 through F4. These parasequences consist of sand-bearing strata, with the exception of F3 which is enriched with thick pebble-rich conglomerate beds that laterally grade into sandstone.

The isopach map of the conglomerate beds displays exceptional thickening in the eastern portion of the study area. This is associated with the presence of major distributary channels that directly supply pebbles and gravels into the basin. Their spatial distribution also correlates with a structural feature of underlying Devonian Gold Creek reef. Nodwell & Hart (2006) interpreted this topographic feature to be the principal control for preferential pebbles and gravels trapping following that ENE-WSW trend. The presence of chert, whether as clasts or matrix, was observed throughout the entire depositional environment across all stratigraphic levels, from fluvial channel to lower shoreface, albeit in varying proportions. Sandstone units are typically ranging from chert arenite to quartz-rich litharenite, while conglomerate units are either unimodal (chert-rich) to bimodal (chert- and rock fragments-rich).

Trends could be discerned where proximal to distributary channels and where wave reworking was the dominant sedimentary process. Besides the ratio of chert/quartz, which serves as our particular interest, some other features that could be delineated include changes in the proportion of less stable components such as feldspar and lithic fragments as well as the textural framework. Our study shows that primary factors that affect variations in chert distribution and the corresponding petrographic features include proximity to fluvial sources, mechanical abrasion, and possibly chemical weathering to some extent. Other influence that has been suggested by previous workers include tectonic-influenced fluvial depositional style (Plint & Walker, 1987).
Figure 1. Examples of Falher “F” sandstone petrographic samples taken from various depositional environments including strandplain succession and fluvial channel. A) Sample representing foreshore setting. Notable increase in textural and compositional framework as evidenced by the high ratio of quartz/chert and moderately-rounded, well-sorted quartz grains, albeit with some presence of mud matrix and rock fragments. The presence of chert is limited to clasts. B) Sample taken from upper shoreface. Moderately sorted, subrounded to subangular grains, and decreased ratio of quartz/chert compared to the foreshore sandstone. Chert is seen as both clasts and matrix. C) Sample taken from middle shoreface. Apparent carbonate cement, texturally and compositionally immature. Chert occludes pore spaces.
D) Sample taken from lower shoreface. Features are similar with middle shoreface sandstone, with quartz grains that are slightly more angular and lessening degree of good sorting. E) Sample taken from tidal channel. In spite of their stratigraphically similar setting with foreshore (intertidal zone), they exhibit opposing features. This sample is rather poorly sorted with elevated percentage of chert that acts as both clasts and matrix. F) Sample taken from fluvial channel. There is remarkable increase in quartz/chert ratio, with chert occurs primarily as matrix. (Abbreviation: qz = quartz, ct = chert, rf = rock fragment, he = hematite-stained clast, d = non-ferroan dolomite cement, fd = ferroan dolomite cement, cl = chlorite, bm = biotite mica, mm = muscovite mica, pq = polycrystalline quartz, py = pyrite, f = feldspar, p = pore.)
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References


