Forensic Chemostratigraphy: A Tool to Determine Lateral Wellbore Placement*

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Abstract

This study tests the efficacy of using chemostratigraphy to remain in zone during horizontal drilling, utilizing an example from the Alberta Bakken Petroleum System (ABPS) of southwestern Alberta. Whole rock geochemical data has been acquired from three vertical wells and one associated lateral that penetrate the Banff, Exshaw, Big Valley and Stettler formations. As is the case with many resource plays, these formations are best exploited using multilateral drilling techniques. However, the lack of offset drilling causes difficulty in stratigraphically targeting key zones, which in this case is the dolomitic interval of the Big Valley Formation. This study demonstrates how whole rock inorganic geochemical data can be used to characterize and correlate the Mississippian-Devonian sequences of southern Alberta encountered in three vertical pilot holes, and how the geochemical data can then be used as a "forensic" tool to determine if key stratigraphic units have been penetrated along the length of a 1 km lateral well bore.

Introduction

For several decades, chemostratigraphy has been used to establish reservoir-scale and basin-wide stratigraphic zonation schemes in purely siliciclastic or carbonate plays (Pearce et al., 2005; Ratcliffe et al., 2010; Wright et al., 2010a; Hildred et al., 2010). In recent years, chemostratigraphy has been applied to shale resource plays in order to subdivide the relatively homogenous sequences (Schmidt et al., 2010). In this study, chemostratigraphy has been applied to a mixed clastic-shale sequence to better characterize the reservoirs, and to identify key intervals that can then be targeted to maximize production.

Method

Whole rock geochemical data was obtained from 57 core samples from a vertical well (Well A) using ICP-OES/MS techniques, acquiring data for 50 major and trace elements. Using this core dataset, it was possible to devise a series of elemental profiles and ratios that allowed the study interval to be divided into a series of ten (10) chemostratigraphic packages and four (4) units. This framework was used as a "chemostratigraphic type section" against which two additional vertical pilot holes, Wells B and C, were correlated to create a robust chemostratigraphic framework. These three wells comprise a north-to-south transect that captures a proximal to distal depositional trend in these sequences. This chemostratigraphic framework was subsequently used to determine which parts of the study interval the 1 km lateral had encountered, post-drill.

The target zone in the vertical type section is in the Big Valley Formation, and it comprises an approximately 5 m dolomite interval underlain by anhydrite (Stettler Formation) and overlain by a limestone cap below the Exshaw Shale (Figure 1). Geochemically, the limestone cap is characterized by high CaO values coupled with very low MgO/CaO values, which differentiates it from the underlying anhydrite and dolomite sequences of the Big Valley and Stettler formations. The dolomitic target interval in the Big Valley is clearly identified by high MgO/CaO, Th/Al2O3, and MnO values, all of which decrease in the underlying anhydrite. Sulphur, although not available for Well A, has shown to be another decisive element that easily differentiates the targeted Big Valley zone from the underlying anhydrite in the Stettler, in Wells B (Figure 1) and C.

The lateral portion of Well A was drilled along a highly sinuous well path through an anticlinal structure that may contain small-scale faulting. A total of 109 cuttings samples were analyzed using ICP/MS-OES techniques at 10 meter intervals along the entirety of the 1000 m lateral. Using the chemostratigraphic type section devised from the vertical portion of Well A, it was possible to identify all of the stratigraphic units penetrated by this lateral, which included portions of the Banff, Exshaw, Big Valley and Stettler formations (Figure 2). Due to the sinuous nature of the wellbore and the probable faulting, many units were encountered several times along the well path; however, it was possible to clearly identify when the targeted dolomitic zone was encountered.

Conclusions

The application of chemostratigraphy outlined in this study can be extended to many other scenarios where lateral well placement is critical. The methodologies shown in this article can be applied to any resource and hybrid play. Chemostratigraphy can also be used when faced with a variety of other geological questions such as provenance, climatic conditions, etc.

Beyond the stratigraphic use of geochemical data it is also possible to derive the relative brittleness of the target zones in order to better identify zones for completion and the resultant placement of hydraulic fracture stages, thereby making exploitation of resource plays more cost effective.

Acknowledgements

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References Cited

Hildred, G.V., K.T. Ratcliffe, A.M. Wright, B.A. Zaitlin, and D.S. Wray, 2010, Chemostratigraphic applications to low-accommodation fluvial incised-valley settings; an example from the Lower Mannville Formation of Alberta, Canada: Journal of Sedimentary Research, v. 80/11, p. 1032-1045.

Pearce, T.J., D.S. Wray, K.T. Ratcliffe, D.K. Wright, and A. Moscarello, 2005, Chemostratigraphy of the Upper Carboniferous Schooner Formation, southern North Sea, *in* J.D. Collinson, D.J. Evans, D.W. Holliday, and N.S. Jones, eds., Carboniferous hydrocarbon geology: the southern North Sea and surrounding onshore areas: Yorkshire Geological Society, Occasional Publications series, v. 7, p. 147-64.

Ratcliffe, K.T., A.M. Wright, P. Montgomery, A. Palfrey, A. Vonk, J. Vermeulen, and M. Barrett, 2010, Application of chemostratigraphy to the Mungaroo Formation, the Gorgon Field, offshore Northwest Australia: APPEA Journal, 50th Anniversary Issue, p. 371-385.

Schmidt, K., M. Poole, and G. Hildred, 2010, A Triumvirate of Targeting - A Three-Pronged Approach to Keeping a Horizontal Well in the Desired Eagle Ford Reservoir Interval: AAPG International Annual Convention & Exhibition, September 12-15.

Wright, A.M., K.T. Ratcliffe, B.A. Zaitlin, and D.S. Wray, 2010, The application of chemostratigraphic techniques to distinguish compound incised valleys in low-accommodation incised-valley systems in a foreland-basin setting: an example from the Lower Cretaceous Mannville Group and Basal Colorado Sandstone (Colorado Group), Western Canadian Sedimentary Basin, *in* K.T. Ratcliffe and B.A. Zaitlin, eds., Application of Modern Stratigraphic Techniques: Theory and Case Histories, SEPM Special Publication No. 94, p. 93-107.

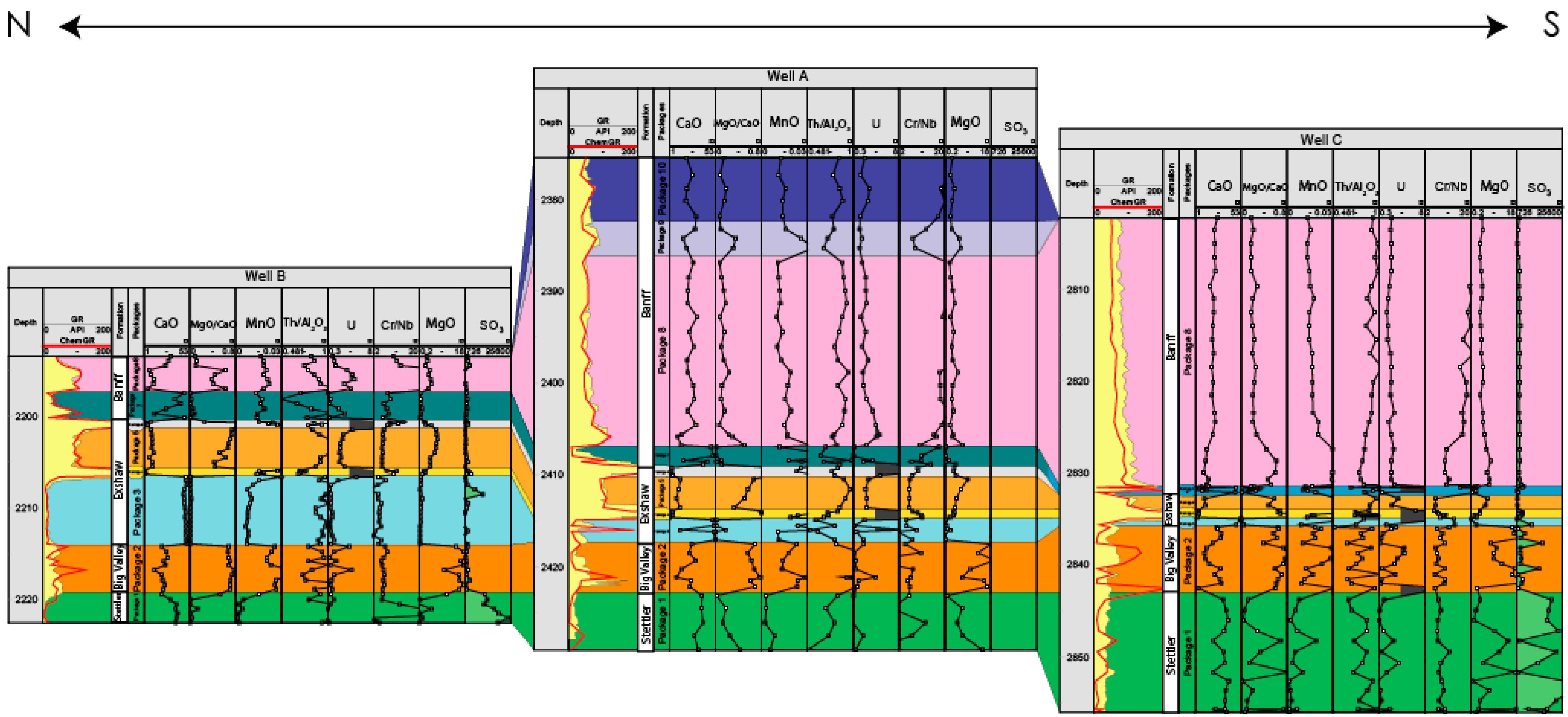

Figure 1. Chemostratigraphic characterization and correlation of three vertical wells of the Alberta Bakken Petroleum System (ABPS) of southwestern Alberta.

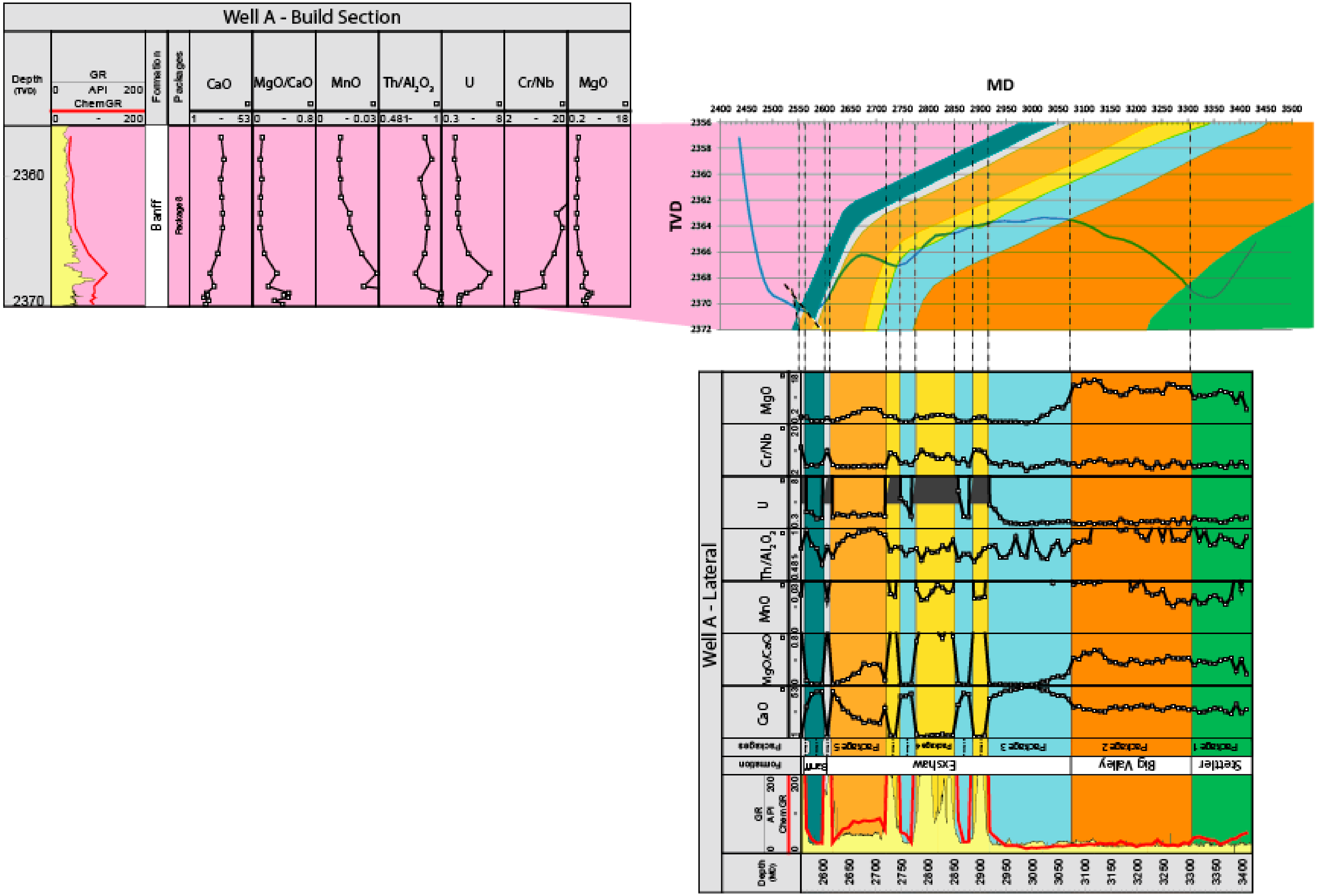

Figure 2. Placement of the lateral section of Well A.