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Alberta Energy Regulator

Regional Correlation of the Beaverhill Lake Group in the Subsurface of Alberta, Townships 29 to 113 and Ranges 1W4 to 13W6

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Alberta Energy Regulator
Alberta Geological Survey

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Abstract

Regional correlation of the Beaverhill Lake Group in the subsurface of Alberta is presented in the form of strike- and dip-oriented stratigraphic cross-sections. Lithostratigraphic units described in this report are the Watt Mountain Formation of the Elk Point Group (the top of which forms the base of the Beaverhill Lake Group), the Fort Vermilion Formation, the Slave Point and Swan Hills formations, and the Waterways Formation. Member-level stratigraphy within the Waterways Formation is discussed, but these units are not correlated within the study area. Picking criteria are outlined in an examination of representative wells from distinct geographic areas that encompass various depositional realms during Beaverhill Lake Group time. Important carbonate depositional realms covered by the study area include (1) the Swan Hills Formation carbonate complexes of west-central and southwestern Alberta, (2) the Slave Point Formation carbonate complex of the Peace River region in northwestern Alberta, (3) the Slave Point Formation carbonate complex of the Hay River Platform in northwestern Alberta, and (4) the carbonate complex within the Waterways Formation—the Eastern Platform—in southeastern and east-central Alberta. Additionally, the evaporites of the Fort Vermilion Formation and the argillaceous carbonates and calcareous shales of the Waterways Formation basinwards of the main carbonate complexes are correlated and discussed. Measured depths of formation tops from cross-section wells are included in an associated data release, DIG 2014-0024.

1 Introduction and Background

The Middle to Upper Devonian Beaverhill Lake Group of Alberta comprises a regionally extensive subsurface succession of carbonates, argillaceous carbonates, calcareous shales, evaporites, and lesser, areally restricted sandstones. Strata of the Beaverhill Lake Group outcrop along rivers near Fort McMurray (Athabasca, Clearwater, and Christina rivers), underlying the Lower Cretaceous McMurray Formation of the Mannville Group (Prior et al., 2013). During Beaverhill Lake Group time, the Alberta Basin was characterized by bioherm and biostrome development in the form of extensive platforms, banks, and isolated reef successions.

The economic importance of the Beaverhill Lake Group is demonstrated by significant hydrocarbon exploitation, particularly within carbonate complexes on the western side of the Alberta Basin. Initial hydrocarbon discoveries were made as early as 1957 within reefal strata of the Swan Hills Formation (Oldale and Munday, 1994). Beyond the production of hydrocarbons, strata of the Beaverhill Lake Group are, or may become, critical sources for industrial water, as well as reservoirs for wastewater disposal and carbon sequestration. As engineering advances continue to expand the boundaries of what is considered a producible reservoir, the Beaverhill Lake succession will continue to be economically important. A solid understanding of the stratigraphy, lithological heterogeneity, and stratal architecture of these units across the basin is important for informed and responsible decisions regarding subsurface resource development and waste disposal.

The purpose of this report is to present regional correlation of the Beaverhill Lake Group, and the formations therein, in the form of strike- and dip-oriented stratigraphic cross-sections. The cross-sections cover a large part of Alberta, from Township 29, Range 1, west of the Fourth Meridian in the southeast, to Township 113 and the Alberta–British Columbia border in the northwest (Figure 1). Picking criteria from five representative wells from paleogeographically significant areas accompany the cross-sections (Figure 1). Regional correlation of the Beaverhill Lake Group contributes to the broader Alberta Geological Survey goal of modelling the three-dimensional distribution of Devonian strata across the province of Alberta.

2 Stratigraphy

The Beaverhill Lake Group in Alberta comprises, in ascending stratigraphic order, the Fort Vermilion, Slave Point, Swan Hills, and Waterways formations (Figure 2). The Slave Point and Swan Hills formations are partly equivalent shallow-water and open-marine carbonates. The nomenclatural distinction is due to these formations being discovered at different times in various geographic regions—namely the discovery of hydrocarbon-bearing reef strata in the Swan Hills area and the Hay River and Peace River regions (Figure 3).

In general, the Waterways Formation describes argillaceous carbonates associated with the Eastern Platform (Wendte and Uyeno, 2005) in the eastern part of the basin. Here, the Waterways Formation displays a number of alternating shaley and carbonate-rich units, recognizable on wireline logs, that have been subdivided into the Firebag, Calumet, Christina, Moberly, and Mildred members (Crickmay, 1957). Keith (1990) proposed raising these members to formation status; however, in this report, I follow Crickmay's original classification defining the Waterways Formation and its constituent members. The members of the Waterways Formation become gradually more difficult to define westwards from the Eastern Platform in the area of the Waterways sub-basin, where the Waterways Formation becomes increasingly argillaceous (Figure 3). Because of this, members of the Waterways Formation were not correlated within the study area but are shown on the representative wells where they are well defined.

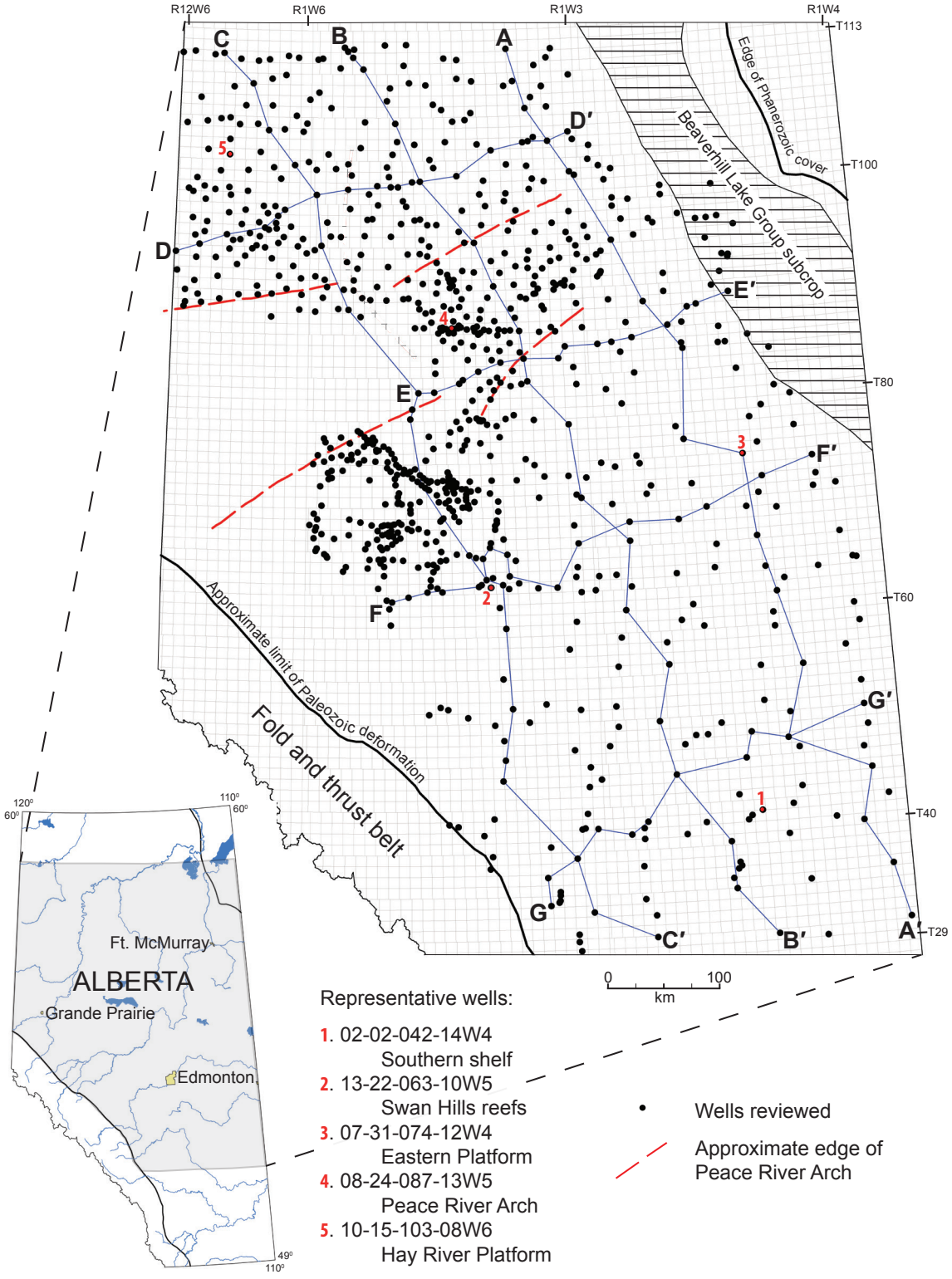


Figure 1. Location of the study area within Alberta. The location of wells reviewed, lines of cross-section A–A′ through G–G′, and representative wells 1 through 5 are shown (approximate edge of Peace River Arch from O'Connell, 1994).

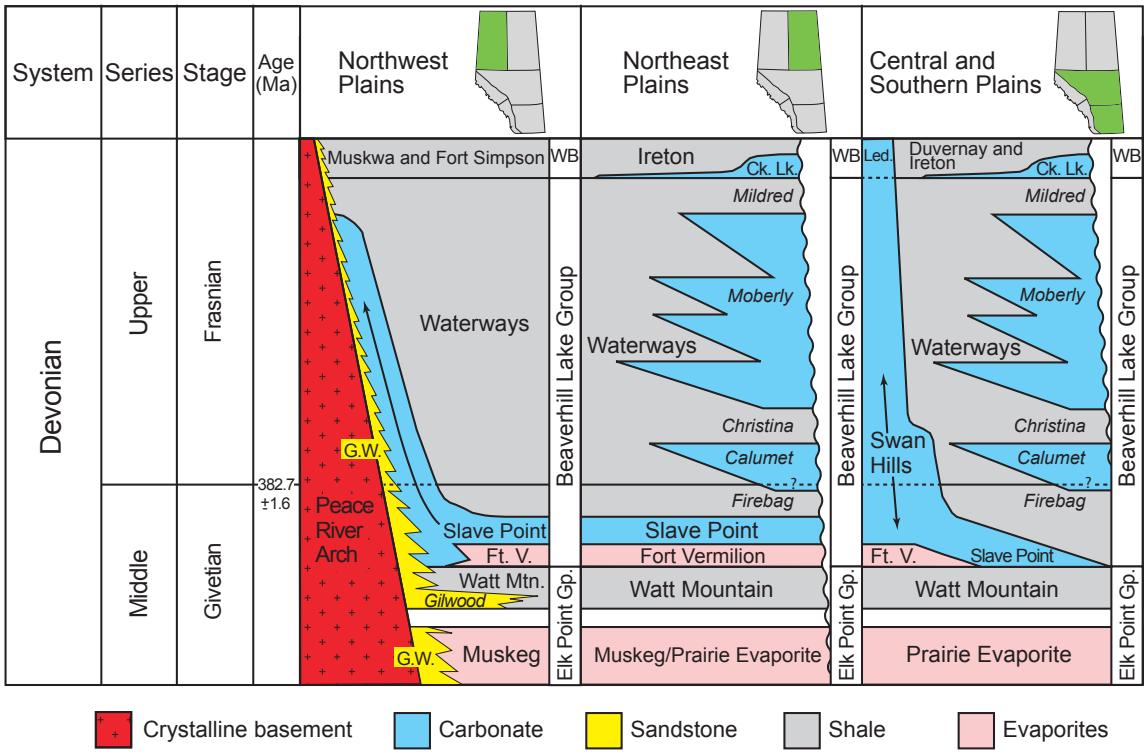


Figure 2. Schematic lithostratigraphic column showing the distribution of upper Givetian to lower Frasnian strata in the Alberta Basin. Member nomenclature in italics. Abbreviations: WB, Woodbend Group; G.W., Granite Wash (lithosome); Ft. V., Fort Vermilion; Ck. Lk., Cooking Lake; Led., Leduc; Mtn., Mountain; Ma, millions of years. The age for the Givetian-Frasnian boundary is from the International Chronostratigraphic Chart (www.stratigraphy.org).

The distribution of strata in the area is complicated by the presence of the Peace River Arch (PRA) (Figure 3). Within the Alberta Basin, the PRA is a complex basement structure that has influenced depositional patterns from at least the lower Paleozoic (O'Connell et al., 1990). During Devonian deposition, the PRA was continuously onlapped as sediments accumulated in the basin. It remained emergent throughout the time of deposition of the Beaverhill Lake Group strata and was a continuous source of siliciclastic sediment that was shed in an apron around the margin of the structure (Figure 3). The siliciclastics are therefore diachronous, forming complex interfingering deposits within the entire Beaverhill Lake succession (Figure 2).

The Beaverhill Lake Group is Middle to Late Devonian—Givetian to Frasnian—in age in the Alberta Basin (Figure 2). In northeastern Alberta, the Givetian-Frasnian boundary falls somewhere within the upper Firebag Member or lower Calumet Member of the Waterways Formation (Braun et al., 1988; McLean and Klapper, 1998). Within the western shallow-water carbonates of the Slave Point and Swan Hills formations, the Givetian-Frasnian boundary is more difficult to discern due to a lack of diagnostic biostratigraphic fauna (Braun et al., 1988; Wendte and Uyeno, 2005).

In the study area, the Beaverhill Lake Group has been affected by erosional events associated with the sub-Cretaceous unconformity. In the northeast, progressively older Beaverhill Lake strata are exposed eastwards along a subcrop belt (Figure 1). Along the subcrop belt, Beaverhill Lake Group strata are affected by deformation and karstification due to subsurface evaporite dissolution and collapse (Schneider, 2011; Schneider et al., 2012). The strata are eventually truncated in the far northeast of the study area.

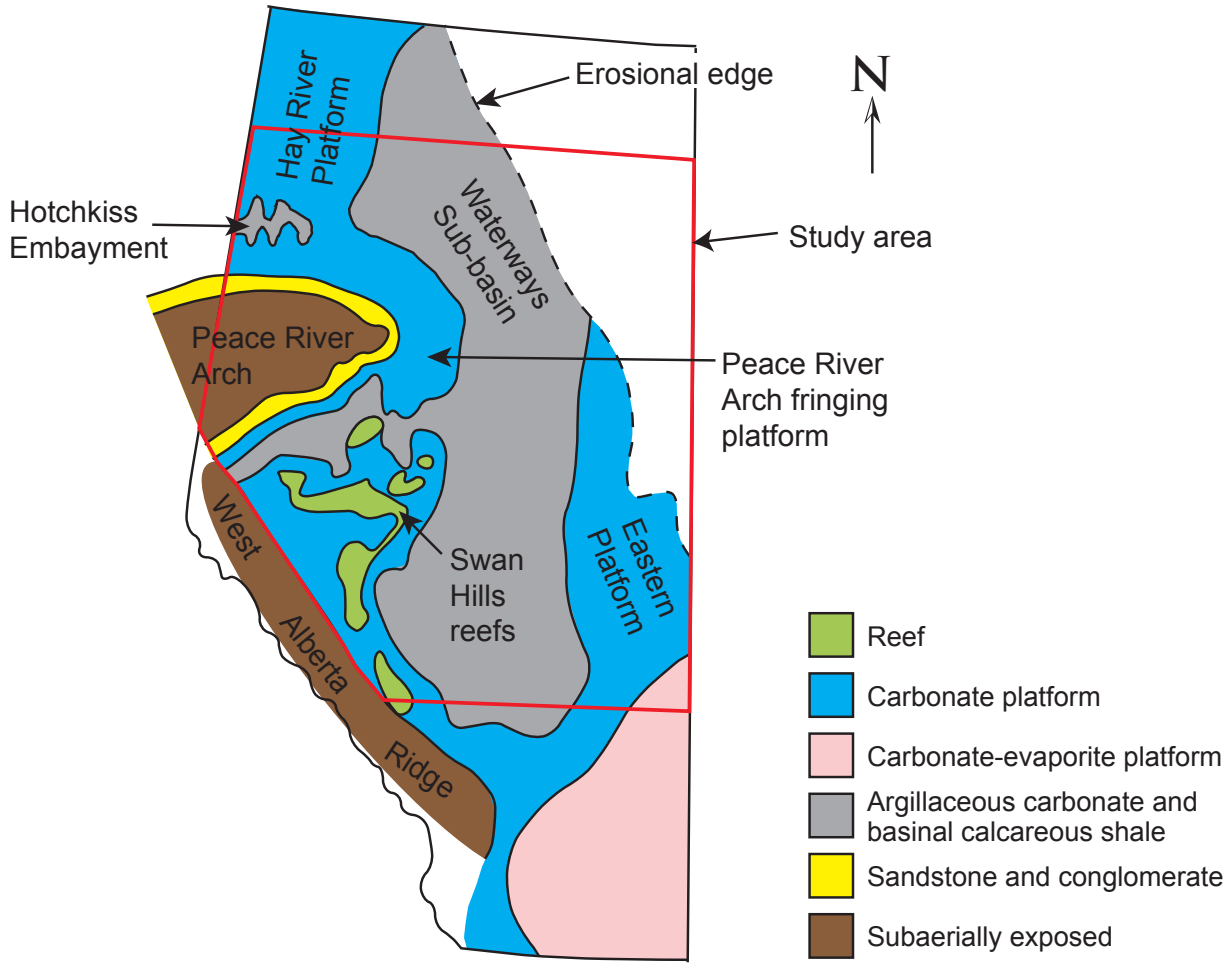


Figure 3. Paleogeography of the Alberta Basin during the lower Frasnian (modified from Campbell, 1992).

2.1 Watt Mountain Formation, Elk Point Group

The Watt Mountain Formation was mapped for two reasons: (1) it forms the base of the Beaverhill Lake Group, and (2) it is an excellent laterally continuous stratigraphic datum across the majority of the study area.

The Watt Mountain Formation disconformably overlies the evaporites of the Prairie Evaporite and Muskeg formations of the Elk Point Group (Braun et al., 1988). It can be mapped throughout most of the areal extent of the Beaverhill Lake Group in the study area with the exception of the PRA area, where the Watt Mountain Formation onlaps the arch and is overstepped archwards by the overlying Slave Point Formation carbonates. The Watt Mountain Formation includes varicoloured shales with subordinate limestone, dolostone, and anhydrite that interfinger with and overlie the Gilwood Member sandstones (Rottenfusser and Oliver, 1977). Whereas the shales of the Watt Mountain Formation thin in a basinwards direction away from the arch, the Gilwood Member thickens towards the arch (from which it is sourced), and comprises sandstones of fluvial to marginal-marine environments (ibid.).

2.2 Fort Vermilion Formation, Beaverhill Lake Group

The Fort Vermilion Formation conformably overlies the shales of the Watt Mountain Formation. It is present in much of the study area eastwards from the Beaverhill Lake Group erosional edge. Strata of the Fort Vermilion Formation comprise laminated dolomite and anhydrite as well as more massive and nodular anhydrites. Interbedded limestones are also present (Jansa and Fischbuch, 1974; Wendte and Uyeno, 2005). Along the northern flank of the PRA, restricted-marine carbonates and evaporites of the Fort Vermilion Formation interfinger with the shallow-water carbonates of the Slave Point Formation (Figure 2). It is possible that in this area, Slave Point Formation carbonates grew contemporaneously with the Fort Vermilion Formation due to access to marine waters through the Hotchkiss Embayment. In the northwest of the study area, Fort Vermilion Formation strata interfinger with Slave Point Formation carbonates associated with the Hay River Platform and eventually pinch out. In central Alberta, the anhydrites of the Fort Vermilion Formation eventually pinch out and, south of Township 64, are replaced by dolomitic mudstones and clastics deposited in a supratidal to continental setting (Oldale and Munday, 1994).

2.3 Slave Point Formation, Beaverhill Lake Group

The Slave Point Formation conformably overlies the Fort Vermilion Formation. Where the restricted-marine carbonates and evaporites of the Fort Vermilion Formation pinch out, the shallow-water carbonates of the Slave Point Formation directly overlie the Watt Mountain Formation. Where the Watt Mountain Formation pinches out near the PRA, the Slave Point Formation overlies the Granite Wash lithosome. This basal contact of the Slave Point Formation can be disconformable or conformable—the latter being the case where Slave Point carbonates that fringe the arch are coeval with evaporites of the Fort Vermilion Formation (e.g., Slave Point Formation strata of the Cranberry Field; Campbell, 1992). The Slave Point Formation can be mapped throughout most of the study area westwards from the Beaverhill Lake erosional edge in the east.

Near the PRA, carbonates of the Slave Point Formation accumulated on a platform fringing the arch. Stromatoporoid mounds and platform-edge reefs are common (Meijer Drees et al., 1994). Closer to the PRA, the Slave Point carbonates interfinger with nearshore siliciclastics that were shed from the exposed PRA highlands (Figure 3). The carbonates of the Slave Point Formation are variably dolomitized in locations around the PRA but have generally remained limestone. Sheasby (1971, Figure 5) provided a map of major areas of dolomitization in the Slave Point Formation around the PRA.

In the Waterways sub-basin and underlying the Eastern Platform, the Slave Point Formation thins significantly compared to the area around the PRA and the Hay River Platform (Figure 3). The northwestern expression of the Hay River Platform in British Columbia is known as the Presqu'ile Barrier Reef, which formed a long-lived northeast-trending barrier to the open ocean from Elk Point Group time into Beaverhill Lake Group time. In between the northern part of the PRA fringing platform and the Hay River Platform, a west-trending, open-marine embayment known as the Hotchkiss Embayment existed (Campbell, 1992; Bernstein and Stoakes, 1996; Figure 3). Slave Point carbonates fringing this embayment form the gas-producing Cranberry (Bernstein and Stoakes, 1996) and Hamburg fields (Oldale and Munday, 1994).

2.4 Swan Hills Formation, Beaverhill Lake Group

The Swan Hills Formation is an areally extensive carbonate platform, bank, and bioherm complex in the Swan Hills area of west-central Alberta (Figure 3). The Swan Hills Formation conformably overlies the Fort Vermilion and Watt Mountain formations. The latter case is observed in areas close to the West

Alberta Ridge (Figure 3), where anhydrites of the Fort Vermilion thin significantly and appear to pinch out depositionally, shifting to a more nearshore siliciclastic facies that is difficult to differentiate from the siliciclastics of the underlying Watt Mountain Formation. Towards the West Alberta Ridge, the Watt Mountain Formation becomes progressively sandier, particularly where the Gilwood Member is best developed in fluvial-deltaic complexes (Jansa and Fischbuch, 1974). Here the Swan Hills Formation overlies a coarser grained, more nearshore siliciclastic facies.

Hydrocarbon production from the Swan Hills Formation is significant and has resulted in extensive well and core coverage. Such exploration has enhanced the understanding of reef growth cycles and associated depositional models. A number of the regional cross-sections in this report include portions of the Swan Hills Formation. Relevant field names are included on the cross-sections to give the reader a sense of the depositional complexity associated with hydrocarbon production.

The Swan Hills Formation can be characterized by a number of different cycles of reef growth, some of which are equivalent to the Slave Point Formation carbonates fringing the PRA and in the Hay River Platform (Oldale and Munday, 1994, Figure 11.24). The Slave Point Formation in these areas contains Middle Devonian faunas (Norris, 1963). Fischbuch (1968) recognized nine divisions within the Swan Hills Formation. His divisions I to V contain Middle Devonian faunas (Fischbuch, 1968), and therefore at least part of the Swan Hills Formation is equivalent to the Slave Point Formation. In general, growth of the Swan Hills Formation carbonate complex began as a widespread carbonate platform, which became a more areally restricted (backstepped) series of reef-rimmed banks and isolated reefs, the latter forming outboard of the banks and overlying the platform (Fischbuch, 1968; Wendte, 1992; Oldale and Munday, 1994; Wendte and Uyeno, 2005).

Carbonates of the Swan Hills Formation are encased in, and overlain by, basinal argillaceous carbonates and shales of the Waterways Formation. Some exceptions occur where shallow-water carbonate accumulation continued into the overlying Leduc Formation of the Woodbend Group (Figure 2). Due to the backstepping nature of the carbonate complex and the variation in continuation of growth in banks and isolated bioherms, the nature of the contact between the Swan Hills and Waterways formations is varied. Fischbuch (1968) considered the contact to be unconformable, marking a pronounced shift from shallow-water to basinal conditions (Fischbuch, 1968). In areas of the platform where carbonate growth ceased due to backstepping, the contact with the overlying Waterways Formation can be considered a drowning unconformity (Schlager and Camber, 1986; Godet, 2013). Wendte and Uyeno (2005) describe a submarine hardground with *Trypanites* borings at the top of the final stage of Swan Hills reef growth, which suggests a depositional hiatus prior to burial by Waterways Formation strata.

2.5 Waterways Formation, Beaverhill Lake Group

Calcareous shales and argillaceous carbonates of the Waterways Formation abruptly overlie the Slave Point Formation. The nature of the contact with the Slave Point Formation is debatable, with some authors proposing a disconformable relationship (Crickmay, 1957; Loranger, 1965) and others a conformable one (Belyea, 1952; Norris, 1963). Although it appears that the Waterways Formation downlaps the Slave Point Formation within the Waterways sub-basin and along the eastern edge of the Hay River Platform, it is evident that parts of the Slave Point platform fringing the PRA continued to accumulate and were coeval with at least part of the Waterways Formation (Keith, 1990). This is also true of the relationship between the shallow-water carbonates of the Swan Hills Formation and the Waterways strata in the Swan Hills area (Wendte and Uyeno, 2005; Figure 3). The nature of the contact is therefore complex and varies depending on geographic location.

The Waterways Formation is progressively more carbonate rich in the east and southeast of the study area, where a series of progradational carbonate platforms comprise the Eastern Platform. (Figure 3). Strata of the Eastern Platform originally extended an unknown, but possibly significant, distance to the east of the present day subcrop belt. West of the Eastern Platform, progradational units of the Waterways Formation exhibiting clinoform stratal geometries progressively fill the Waterways sub-basin from the east towards the west. Clinoform models (e.g., Rich, 1951) have been invoked to describe the geometry of the Waterways strata by a number of authors (Griffin, 1965; Sheasby, 1971; Williams, 1977; Keith, 1990; Oldale and Munday, 1994). The top of the clinoforms can be mapped throughout the study area and are marked by either an abrupt or gradational upwards transition to more carbonate-lean lithologies. These clinoforms downlap the thin Slave Point carbonates in the Waterways sub-basin and eventually onlap and bury the Slave Point Formation fringing the PRA and the majority of the Swan Hills Formation in the Swan Hills area. (There are some exceptions, where carbonates of the Leduc Formation grew directly on top of the Swan Hills Formation, such as in the Snipe Lake reef in the northwestern part of the Swan Hills area [Wendte and Uyeno, 2005].) In a similar fashion to the underlying Beaverhill Lake Group formations, Waterways strata interfinger with a nearshore siliciclastic facies abutting the PRA (Meijer Drees et al., 1994; Figure 2).

The Waterways Formation has been subdivided into five members (Figure 2; members were not mapped for this report), which were originally defined based on those areas where they are best developed—that is, in the eastern portion of the study area. In ascending stratigraphic order they are the Firebag, Calumet, Christina, Moberly, and Mildred members (Figure 2). These members can be traced for some distance westwards away from the Eastern Platform into the Waterways sub-basin, where they eventually transition to increasingly argillaceous carbonates and eventually calcareous shales.

3 Methods

The study area covers a large portion of Alberta, spanning the width of the province (with the exception of the deformed belt) and from Township 29 in the south to Township 113 in the north (Figure 1). Wells were selected based on depth of penetration, with those reaching the Watt Mountain Formation and deeper preferred. Vertical wells were used for correlation, with a few exceptions for areas in need of well control. In areas of dense well distribution, those with modern (post-1980) log suites were preferentially chosen. Such areas are tied to hydrocarbon exploration and production within the Elk Point and Beaverhill Lake groups and include the Swan Hills region of west-central Alberta (production from the Swan Hills Formation) and the Peace River region where production occurs from the Slave Point Formation and the underlying siliciclastics shed from the PRA (Gilwood Member and Granite Wash lithosome). Another area of relatively dense well distribution penetrating the Beaverhill Lake Group is in northwestern Alberta, where oil and gas is produced from the underlying Keg River Formation of the Elk Point Group. The oil sands region of northeastern Alberta has significant well control for the top of the Beaverhill Lake Group, but rarely do these wells span the full Beaverhill Lake Group succession; however, a small number of wells, associated with pre-1950s salt exploration in this area and to the east of Edmonton, have significant core coverage in the Beaverhill Lake Group (Crockford, 1949).

A small number of cores were reviewed for verification of stratigraphic tops and the presence or absence of formations due to depositional pinch-out. The Bear Biltmore No. 1 core (07-11-087-17W4) was reviewed for a previous study (Schneider et al., in press) and provided a continuous section through the Beaverhill Lake Group and into the over- and underlying Woodbend and Elk Point groups, respectively. The relationship between well-log signature and the rocks therein provided the basis for correlation within the eastern portion of the study area. As no well log was run for the Bear Biltmore well, the rocks were compared to the nearby log from the 04-13-087-17W4 well. Two additional wells were reviewed along

the southeastern flank of the PRA to determine the maximum extent of the Fort Vermilion Formation and the associated wireline log expression (cores from wells 11-21-077-15W5 and 12-03-079-08W5).

Correlation of the Beaverhill Lake Group was accomplished with a suite of well logs—gamma ray, density-neutron, bulk density, resistivity, photoelectric effect, and sonic—using IHS Petra analysis software. Correlation within the study area was based on a grid of seven regional stratigraphic cross-sections: three dip-oriented and four strike-oriented (Figure 1). Cross-sections are constructed using the gamma-ray curve of digital log files (LAS format), and where such files are missing, raster images of the wireline logs. The type of curves on the raster images are noted on the cross-sections. The majority of log raster images are sonic logs. The top of the Watt Mountain Formation was used as the datum for the cross-sections (base of the Beaverhill Lake Group). Cross-sections C–C′ and E–E′, which traverse the PRA, have inset figures in which the top of the Waterways Formation was used for a datum. The top of the Waterways Formation (top of the Beaverhill Lake Group) was used to better illustrate depositional onlap onto the PRA during a time when it was an emergent structural high. The arch is an enigmatic cratonic structure that remained a paleotopographic high until Late Devonian–Early Mississippian time. This feature remained exposed during deposition of the strata under review but subsequently became a faulted paleotopographic low known as the Peace River Embayment during the Carboniferous (O'Connell et al., 1990). The Mississippian subsidence resulted in downwarping of stratal terminations of sediments deposited prior to the collapse of the PRA. The top of the Waterways Formation was used as a datum to back out the Carboniferous subsidence patterns and restore the interpreted paleotopography in the basin during deposition of the Beaverhill Lake Group—which is represented in the stratigraphic correlation chart of Figure 2.

To supplement the limited number of cores reviewed to verify picks, pertinent work—notably the excellent regional study of the Beaverhill Lake Group by Wendte and Uyeno (2005) in central and southern Alberta—was used to aid in correlation. Regional syntheses of this extent, which contain accessible well picks, otherwise do not exist for the Beaverhill Lake Group.

The following subsurface reference sections for the formations of the Beaverhill Lake Group were used:

1) Fort Vermilion (between 1350.0 and 1357.0 m) and Slave Point formations (between 1301.5 and 1350.0 m), 02-22-117-05W6;
2) Swan Hills Formation (between 2489.3 and 2590.8 m), 10-10-067-10W5; and
3) Waterways Formation (between 299.0 and 513.0 m), 07-11-087-17W4 (Bear Biltmore No. 1 core; this has been tied to the log of nearby well 04-13-087-17W4).

Given the wide regional extent of the formations within the Beaverhill Lake Group and the varying thickness and depositional expressions of these formations across different geographic areas, the subsurface reference sections are only representative for a limited portion of the formations' geographic extents within the study area.

4 Results: Representative Wells

Five wells were chosen to illustrate in detail the picks for the Beaverhill Lake Group. These wells were chosen based on geographic location and the availability of digital logs (LAS) within that location. When attempting to correlate strata over an extensive geographic area, efforts are hampered by facies changes associated with varying depositional systems. The following sections will illustrate the picking criteria used for regional correlation within the study area.

4.1 Southern Alberta (02-02-042-14W4)

In this well, the Beaverhill Lake Group is 208 m thick. The Beaverhill Lake Group is underlain by shales of the Watt Mountain Formation of the Elk Point Group and overlain by the thick platform carbonates of the Cooking Lake Formation (Figure 4). The Fort Vermilion Formation is absent this far south in the basin. As such, the basal unit of the Beaverhill Lake Group is represented by the thin carbonates of the Slave Point Formation, which have a relatively clean gamma-ray signature and a much higher resistivity than the underlying Watt Mountain shales. The transition from the Slave Point Formation to the overlying shales of the Firebag Member of the Waterways Formation is marked by an increase in gamma-ray counts. The Firebag Member in this area has a conspicuous serrated log response owing to a number of alternating shales and argillaceous carbonates. The remaining members of the Waterways Formation are easy to distinguish in this area due to the clean gamma-ray signatures of the Calumet and Moberly members, which form the main carbonate platform elements of the Eastern Platform (Figure 3). The top of the Waterways Formation in the area (top of the Mildred Member and the Beaverhill Lake Group) is marked by a sharp contact between the argillaceous carbonates of the Mildred Member and the clean carbonates of the Cooking Lake Formation.

4.2 Swan Hills (13-22-063-10W5)

In this well, the Beaverhill Lake Group is 139 m thick, with over 67% of that thickness comprising the shallow-water carbonates of the Swan Hills Formation. This well penetrates an isolated bioherm that forms the Judy Creek Field.

In the Swan Hills area, the Beaverhill Lake Group overlies the shales and sandstones of the Watt Mountain Formation. The sandstones (Gilwood Member) are generally arkosic and therefore have high gamma counts. The Fort Vermilion Formation makes up the basal unit of the Beaverhill Lake Group, but is very thin and therefore difficult to pick, relying largely on identifying the presence of anhydrite on wireline logs (Figure 5). The anhydrites of the Fort Vermilion Formation have a high density reading on bulk-density logs and a very low density-porosity signature (Figure 5). If these logs are unavailable, then the presence of the Fort Vermilion is difficult to determine without verification from core. The overlying Swan Hills carbonates have a clean gamma-ray signature and, where they are limestone, a photoelectric effect reading of 5 barns/electron (3 for dolomite) (Figure 5). The transition to the overlying argillaceous carbonates of the Waterways Formation is typically sharp, with gamma-ray and neutron-porosity readings increasing significantly.

The contact between the Waterways Formation (top of the Beaverhill Lake Group) and the overlying Woodbend Group can be difficult to determine in the Swan Hills area. The sequence stratigraphic work of Wendte and Uyeno (2005) aided in making this pick. In their study, the top of the Beaverhill Lake Group was not picked explicitly, but rather formed part of a transgressive-regressive (T-R) sequence within the Beaverhill Lake Sequence (Wendte and Uyeno, 2005). The top of the Beaverhill Lake Group (Waterways Formation) falls within their T-R sequence H (Wendte and Uyeno, 2005, Figure 4), which includes the lower portion of the Cooking Lake Formation. Where the Cooking Lake Platform is present, picking the top of the Beaverhill Lake Group is straightforward, but where it is absent—such as in the Swan Hills area—the pick is more difficult to make. Beyond the Cooking Lake Platform edge, which approximates the eastern edge of the Waterways sub-basin, the upper portion of T-R sequence H of Wendte and Uyeno (2005), is a conspicuous argillaceous carbonate considered equivalent to the lower part of the Cooking Lake Formation. In central Alberta, the top of the Beaverhill Lake Group was picked at the base of this unit, which has a distinctive high resistivity and low gamma-ray signature (Figure 5). Herein this ‘marker’ has been termed the ‘Cooking Lake equivalent.’

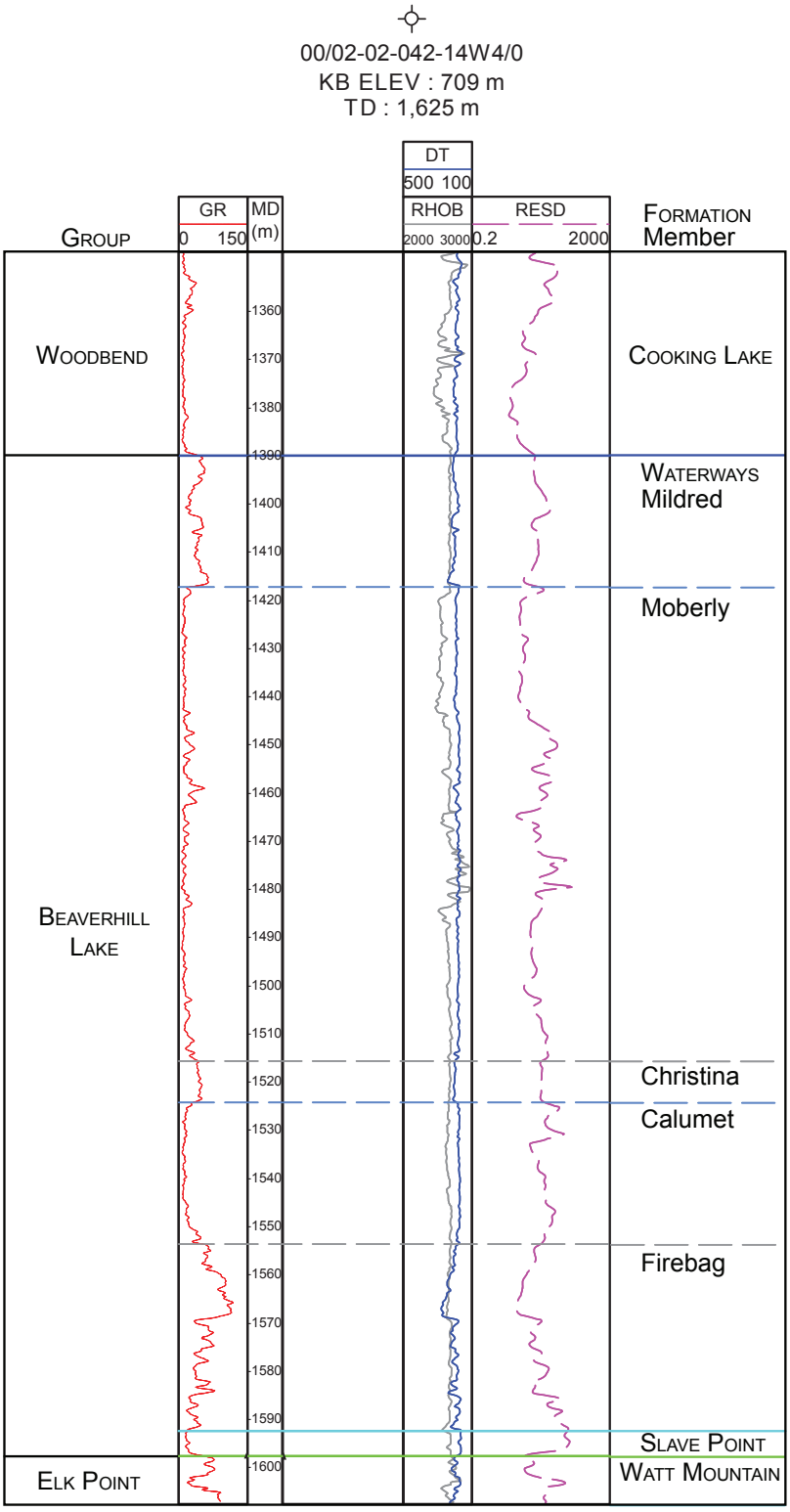


Figure 4. Representative well for the Beaverhill Lake Group in southern Alberta (see Figure 1). In this location, the majority of the Beaverhill Lake succession comprises the Waterways Formation and its constituent members. The Fort Vermilion Formation is absent this far south in the basin. Abbreviations: KB ELEV, kelly bushing elevation; TD, total depth; GR, gamma ray (API units); MD, measured depth; DT, sonic travel time (µs/m); RHOB, bulk density (g/cm3); RESD, deep resistivity (ohm-m).

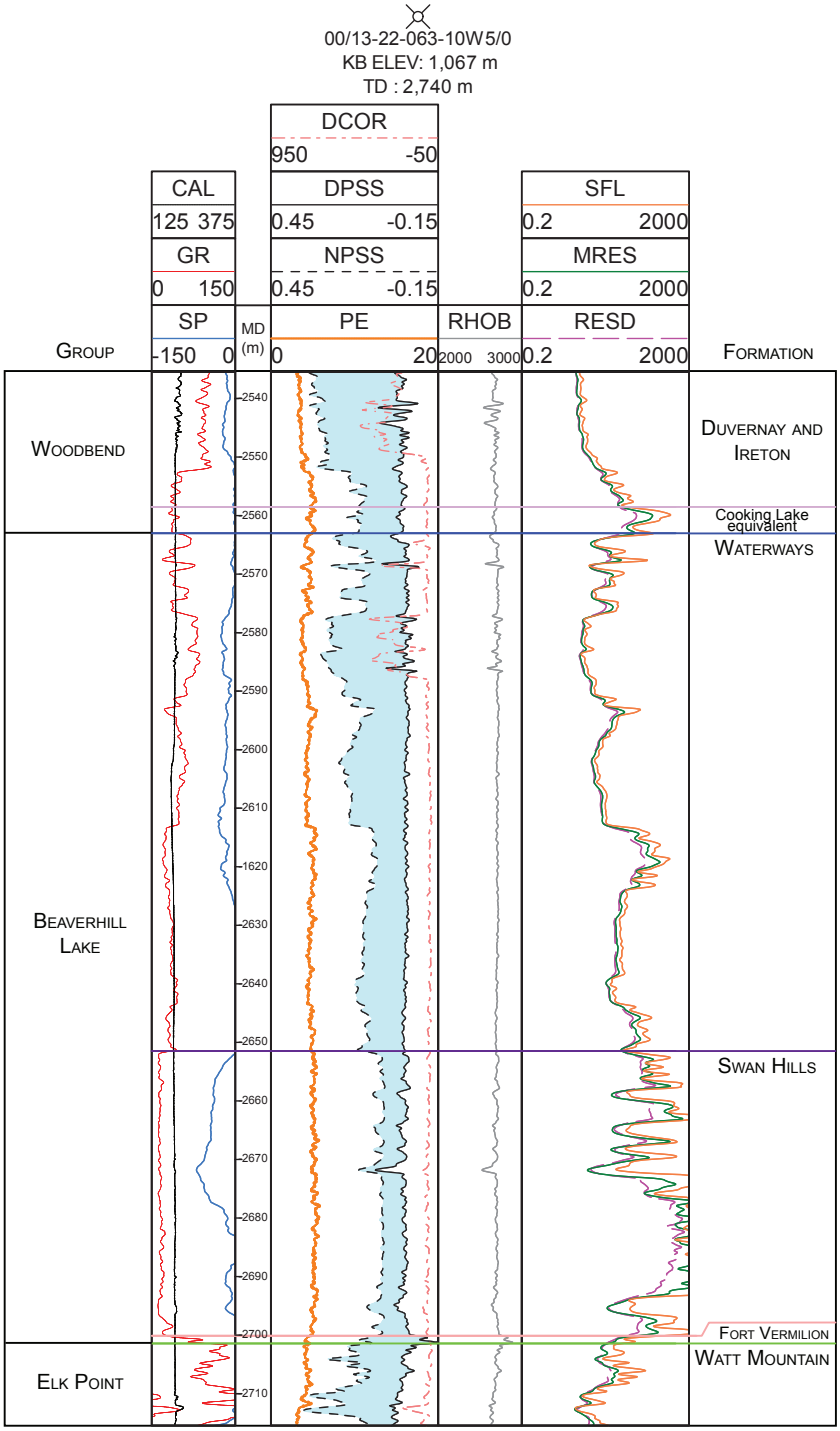


Figure 5. Representative well for the Beaverhill Lake Group in the Swan Hills area (see Figure 1). In this location, the Swan Hills Formation overlies a thin Fort Vermilion Formation. The Swan Hills Formation comprises both the Swan Hills Platform and the overlying Swan Hills isolated reef succession (Judy Creek). Abbreviations: KB ELEV, kelly bushing elevation; TD, total depth; CAL, caliper (mm); GR, gamma ray (API); SP, spontaneous potential (mV); MD, measured depth; DCOR, density correction (g/cm3); DPSS, density porosity (sandstone matrix, v/v); NPSS, neutron porosity (sandstone matrix v/v); PE, photoelectric effect (barns/electron); RHOB, bulk density (g/cm3); SFL, spherically focused log (shallow resistivity, ohm-m); MRES, medium resistivity (ohm-m); RESD, deep resistivity (ohm-m).

4.3 Eastern Platform (07-31-074-12W4)

In east-central Alberta, east of the Swan Hills area, the Beaverhill Lake Group is similar to that shown in the representative well from southern Alberta (Figure 4), with the exception of the presence of the Fort Vermilion Formation. The Beaverhill Lake Group is 227 m thick in the representative well for the Eastern Platform in east-central Alberta (Figure 6). In this area, the Fort Vermilion is recognized by its high bulk-density and low density-porosity readings. In the absence of these logs, a high resistivity reading can also be typical of the anhydrites of the Fort Vermilion (Figure 6).

The criteria used for identifying members within the Waterways Formation are similar to those used in southern Alberta (Figure 4). The Firebag, Christina, and Mildred members are thicker in this area, such that the Waterways Formation section contains significantly more argillaceous carbonates and calcareous shales. This area was closer to the source and influx of terrigenous clastics during deposition of the Waterways Formation (Wendte and Uyeno, 2005). This also results in a 'dirtier' gamma-ray signature throughout the Calumet and Moberly members (Figure 6).

4.4 Peace River Arch Fringing Platform (08-24-087-13W5)

The representative well from the Peace River area is part of the Evi Field, which produces oil from a Slave Point carbonate buildup flanking the PRA (Gosselin et al., 1989). A thin interval of Elk Point Group strata separates the Beaverhill Lake Group from the Precambrian basement rock (Figure 7). The Beaverhill Lake succession is 125 m thick in this well, nearly 67% of which comprises the combined Slave Point and Fort Vermilion formations. The anhydrites of the Fort Vermilion are easily distinguished from the overlying Slave Point carbonates by high bulk-density and density-porosity readings (Figure 7). The contact between the Slave Point Formation and overlying Waterways Formation can be difficult to identify in areas where carbonate-rich strata from the Eastern Platform downlap the Slave Point carbonates. Generally, such Waterways strata are more argillaceous, resulting in higher neutron-porosity and gamma-ray readings and lower resistivity readings (Figure 7). Determining the contact between the Waterways Formation and the overlying Cooking Lake Formation of the Woodbend Group is challenging in this area and usually requires detailed correlation from the Eastern Platform—where the Cooking Lake carbonates are better developed—westwards towards the PRA.

4.5 Hay River Platform (10-15-103-08W6)

The representative well for the Hay River Platform is located west of the depositional edge of the Fort Vermilion Formation and occupies an area of dense well distribution due to hydrocarbon production from Elk Point Group carbonates in the area. The Beaverhill Lake Group is 209 m thick, 82 m of which comprises Slave Point carbonates (Figure 8).

The Beaverhill Lake Group (Slave Point Formation) is underlain by a thin interval of Watt Mountain Formation shale, which in turn is underlain by a thin interval of Sulphur Point Formation dolostone (Figure 8). The Slave Point Formation in this area is predominantly limestone with a photoelectric effect (PE) of 5, although associated dolostone, which in this well occurs as distinct beds towards the base of the formation, exhibits a PE of 3 (Figure 8). Areas of dolomitization can also be determined from neutron-density separation when these logs are run on limestone scales (such as in Figure 8). The contact of the Slave Point Formation with the Waterways Formation is typically sharp in this area due to the Waterways Formation becoming increasingly argillaceous this far north and west—abrupt changes in gamma-ray, PE, and resistivity readings are evident (Figure 8). As mentioned, the Waterways Formation is typically quite argillaceous in this area, but units with cleaner gamma-ray responses persist and can be traced east- and southwards towards their source on the Eastern Platform. The contact between the Waterways Formation

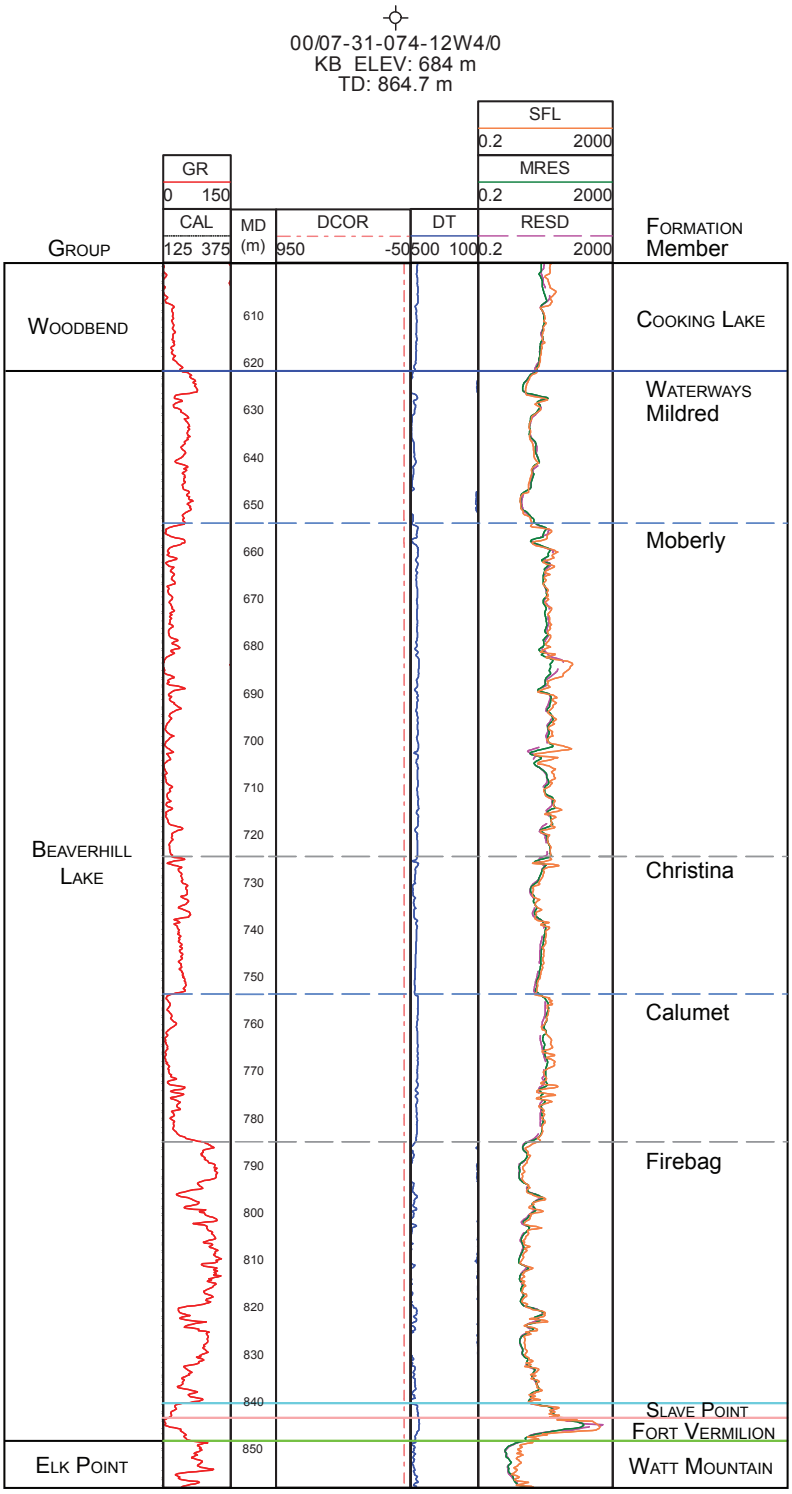


Figure 6. Representative well for the Beaverhill Lake Group in the Eastern Platform of east-central Alberta (see Figure 1). In this location, the majority of the Beaverhill Lake succession comprises the Waterways Formation and its constituent members. Abbreviations: KB ELEV, kelly bushing elevation; TD, total depth; CAL, caliper (mm); GR, gamma ray (API); MD, measured depth; DCOR, density correction (g/cm3); DT; sonic travel time (µs/m); SFL, spherically focused log (shallow resistivity, ohm-m); MRES, medium resistivity (ohm-m); RESD, deep resistivity (ohm-m).

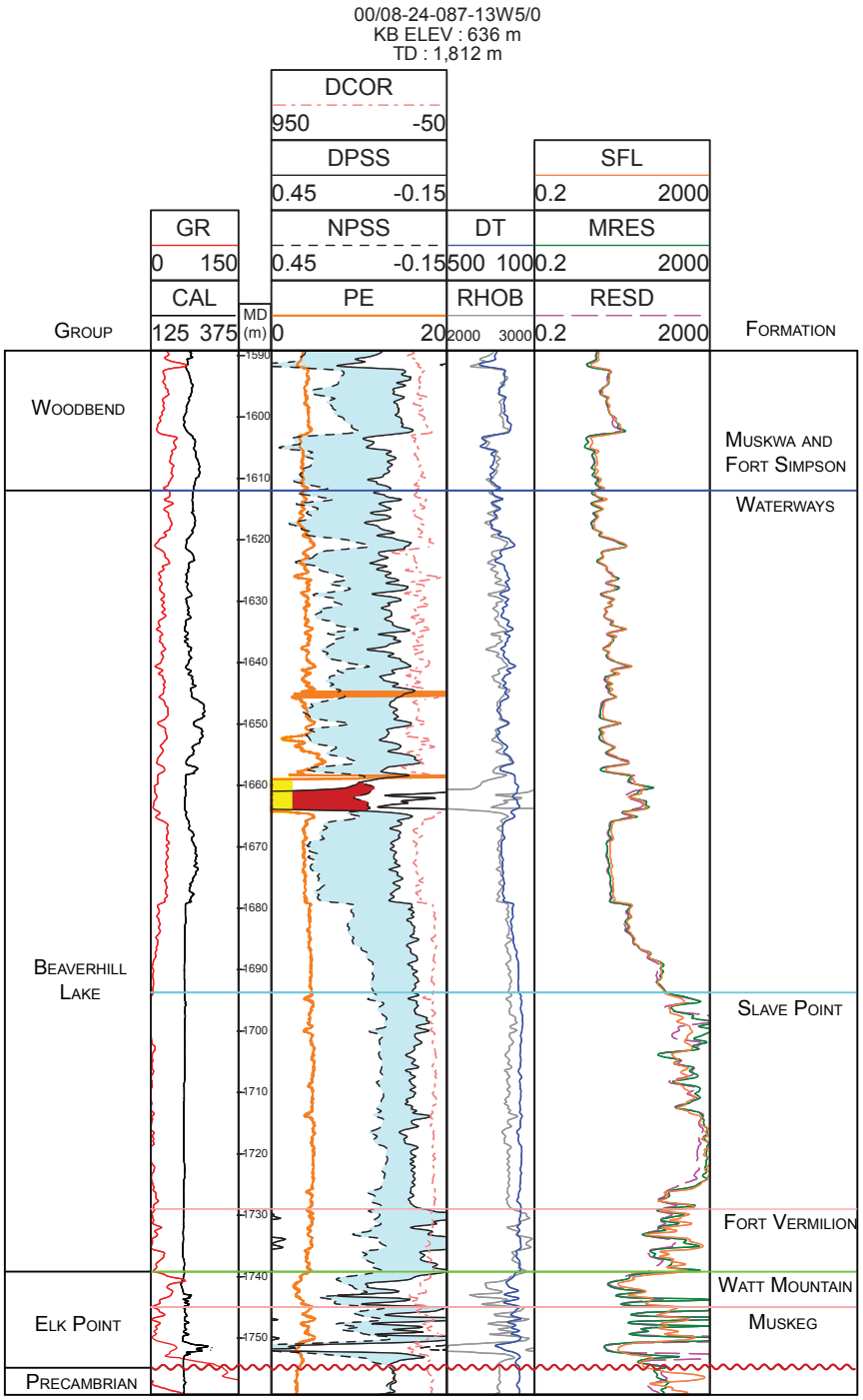


Figure 7. Representative well for the Beaverhill Lake Group on the Peace River Arch fringing platform of the Peace River area of Alberta (see Figure 1). In this location the Slave Point forms a shallow-water carbonate buildup and is part of the oil-producing Evi Field. The yellow and red colouration on the logs represent an area of significant density correction (DCOR), possibly due to borehole washout. Abbreviations: KB ELEV, kelly bushing elevation; TD, total depth; CAL, caliper (mm); GR, gamma ray (API); MD, measured depth; DCOR, density correction (g/cm3); DPSS, density porosity (sandstone matrix, v/v); NPSS, neutron porosity (sandstone matrix v/v); PE, photoelectric effect (barns/electron); DT; sonic travel time (µs/m); RHOB, bulk density (g/cm3); SFL, spherically focused log (shallow resistivity, ohm-m); MRES, medium resistivity (ohm-m); RESD, deep resistivity (ohm-m).

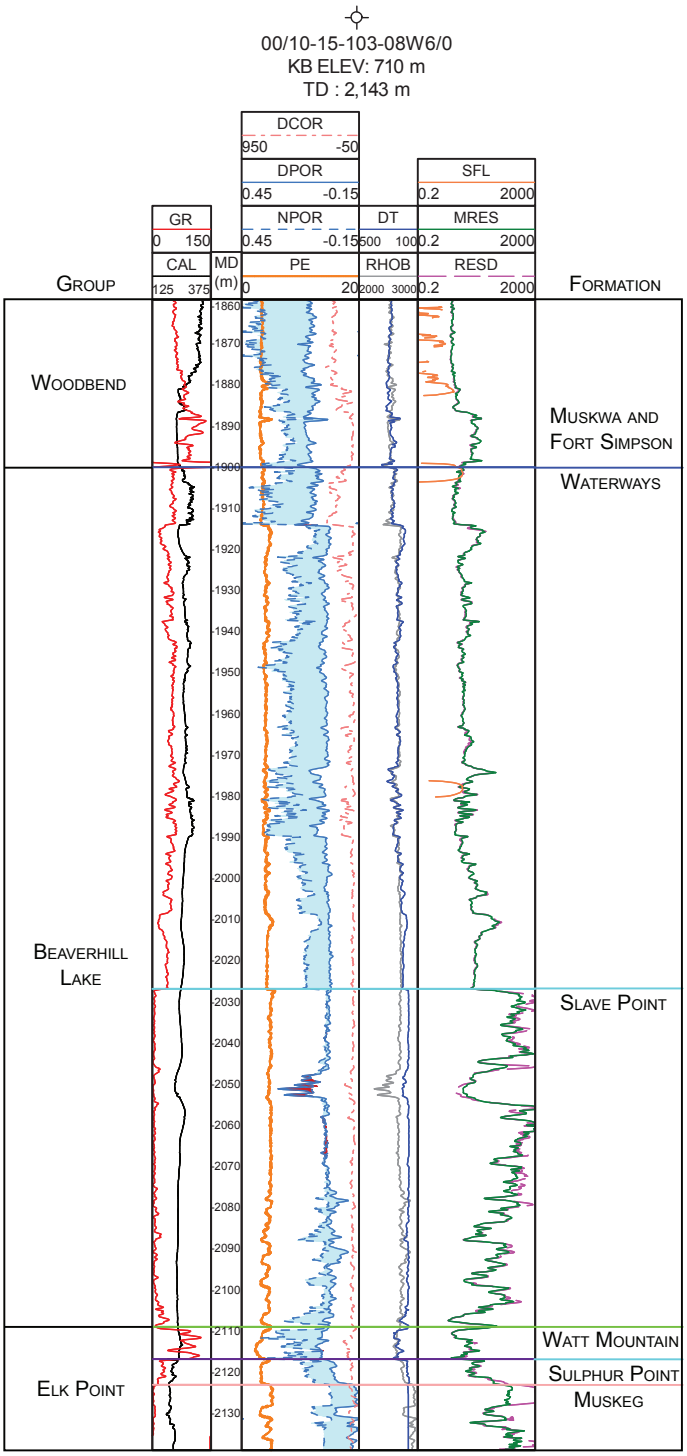


Figure 8. Representative well for the Beaverhill Lake Group on the Hay River Platform of northwestern Alberta (see Figure 1). In this location, the Slave Point Formation forms a thick shallow-water carbonate buildup that is an eastern extension of the Presqu'ile Barrier Reef to the northwest (Figure 3). Abbreviations: KB ELEV, kelly bushing elevation; TD, total depth; CAL, caliper (mm); GR, gamma ray (API); MD, measured depth; DCOR, density correction (g/cm3); DPOR, density porosity (limestone matrix, v/v); NPOR, neutron porosity (limestone matrix v/v); PE, photoelectric effect (barns/electron); DT; sonic travel time (µs/m); RHOB, bulk density (g/cm3); SFL, spherically focused log (shallow resistivity, ohm-m); MRES, medium resistivity (ohm-m); RESD, deep resistivity (ohm-m).

and the overlying Woodbend Group is sharp in this area due to the development of radioactivity in the shales of the Muskwa Formation; however, further north, the top of the Beaverhill Lake Group occurs at some depth below the first significant radioactive response within the Muskwa Formation.

5 Results: Stratigraphic Cross-Sections

Seven regional stratigraphic cross-sections are shown below to illustrate the correlation of Beaverhill Lake Group strata within the study area. The location of the lines of cross-section can be found on Figure 1, and the reader is referred to Figure 3 for the various depositional realms during deposition of the Beaverhill Lake Group covered by the cross-sections. Colours within the cross-sections do not represent a specific lithology, but rather they are employed to emphasize specific formations within the section.

5.1 Cross-Section A–A′

Cross-section A–A′ (Figure 9) is strike oriented and runs along the length of the study area in the east, just west of the subcrop edge (Figure 1). South of well 10-11-067-12W4, the Fort Vermilion Formation is unrecognizable on logs and is considered to depositionally pinch out (Figure 9). The unit thickens considerably northwards of this well, reaching a thickness of up to 31 m in well 07-29-101-01W5 (Figure 9). This well is located within a depocentre for Fort Vermilion evaporites, which begins roughly north of Township 93.

The Slave Point Formation is consistently less than 5 m thick and is usually closer to 3 m thick in the eastern portion of the study area. It thickens appreciably northwards beginning at Township 107 (Figure 9). The Slave Point Formation is more readily differentiated from the overlying Waterways Formation where the Waterways Formation comprises a higher proportion of shale (e.g., well 10-11-067-12W4, Figure 9). In the south, the Slave Point Formation can be more difficult to differentiate from the overlying clean carbonates, where the Eastern Platform is well developed (e.g., well 07-23-048-11W4, Figure 9).

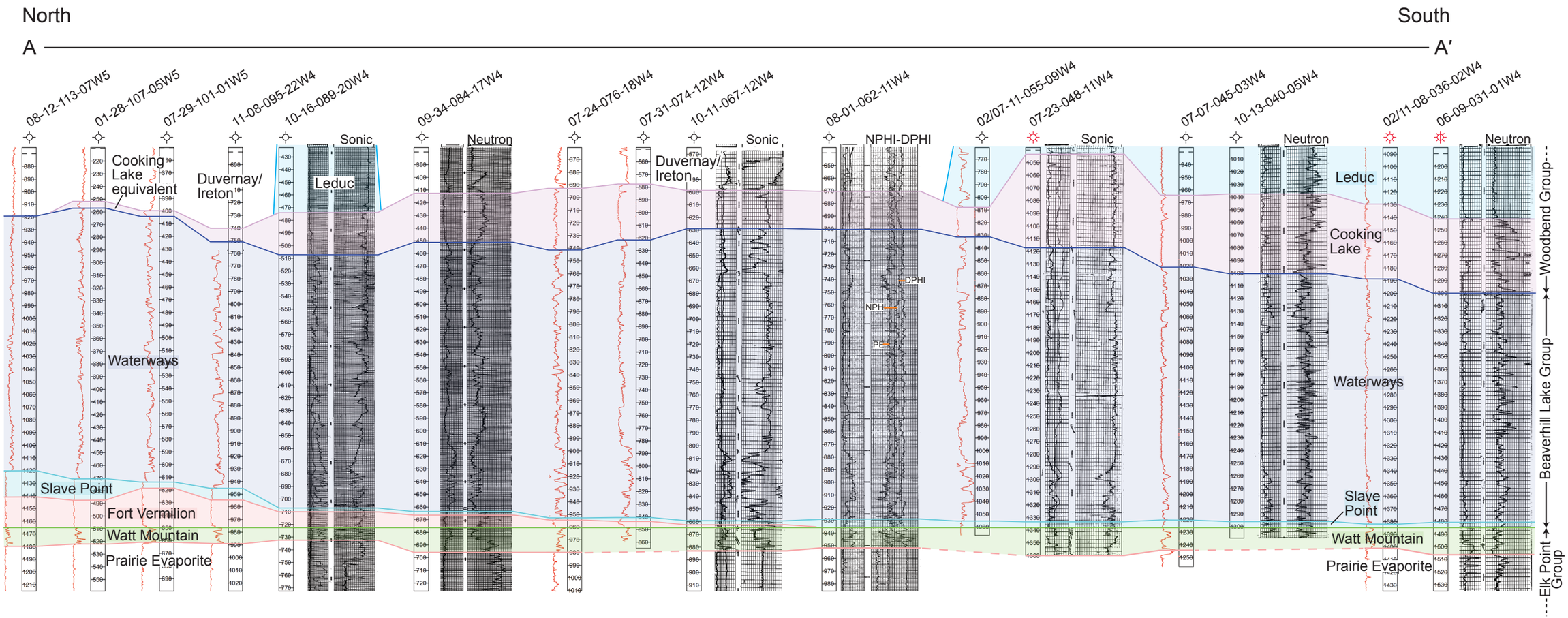
The Waterways Formation is uniformly thick throughout Figure 9. Therein a marked increase in argillaceous carbonates and calcareous shales can be observed from the south towards the north, marking the transition from the Eastern Platform into the Waterways sub-basin (Figure 3). The top of the Waterways Formation is typically easy to differentiate from the overlying Cooking Lake Formation of the Woodbend Group; however, beyond the edge of the Cooking Lake Platform, the correlation relies on recognition of the Cooking Lake equivalent (Figure 9).

5.2 Cross-Section B–B′

The strike-oriented stratigraphic cross-section B–B′ (Figure 10) runs north–south through the middle of the study area (Figure 1). The Fort Vermilion Formation is absent south of well 10-06-061-24W4, beyond which it was not deposited. Much like in cross-section A–A′, the Fort Vermilion Formation thickens appreciably northwards towards an evaporite depocentre (well 10-03-101-15W5) and then thins northwards where the Slave Point Formation thickens in a reciprocal manner (Figure 10).

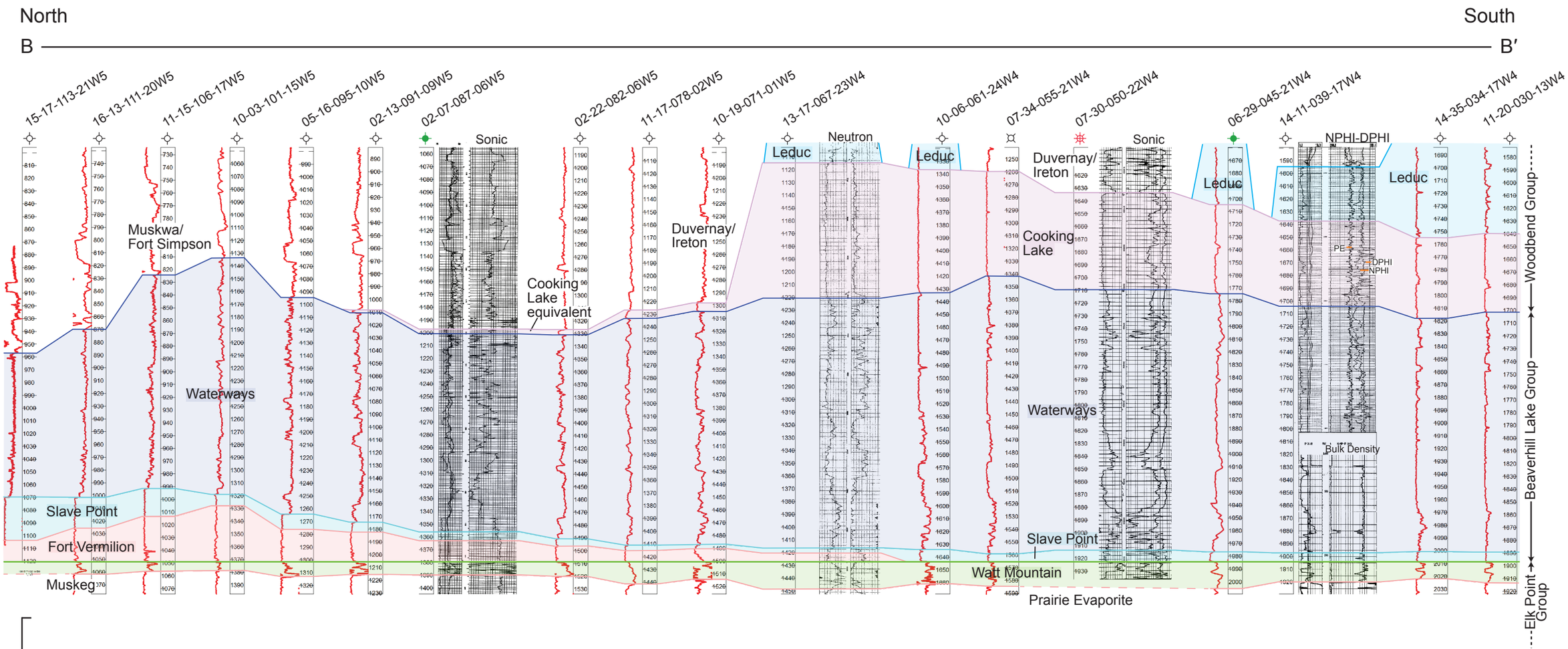
The Slave Point Formation is thin along the majority of cross-section B–B′ but thickens up to 34 m in well 15-17-113-21W5 (Figure 10). This location corresponds to the northeastern-most part of the Hay River Platform (Figure 3).

The Waterways Formation thins slightly over the eastern axis of the PRA (Figure 3) and again in the far north over the Hay River Platform (Figure 10). The Waterways Formation becomes much more



Datum: Watt Mountain Formation
Horizontal scale: equal spacing
Vertical exaggeration: 133.3x

Figure 9. Strike-oriented stratigraphic cross-section A-A′. See Figure 1 for location.



Datum: Watt Mountain Formation
Horizontal scale: equal spacing
Vertical exaggeration: 133.3x

Figure 10. Strike-oriented stratigraphic cross-section B–B′. See Figure 1 for location.

argillaceous north of well 10-19-071-01W5 (Figure 10) and is characterized by increasingly higher gamma-ray counts, which correspond roughly to the transition from the Eastern Platform to the Waterways sub-basin (Figure 3). The contact between the Waterways Formation (Beaverhill Lake Group) and the overlying Woodbend Group depends on the presence or absence of the Cooking Lake and Muskwa formations along this cross-section. In the south, the carbonates of the Cooking Lake Formation are marked by a cleaner gamma-ray response, which transitions to the Cooking Lake equivalent north of the Cooking Lake Platform edge (Figure 10). Where the Cooking Lake equivalent pinches out, the Waterways is overlain by argillaceous shales of the Fort Simpson Formation (Ireton Formation equivalent). Further north and west, the Waterways Formation is overlain by the radioactive bituminous shales of the Muskwa Formation (e.g., well 16-13-111-20W5, Figure 10).

5.3 Cross-Section C–C′

The strike-oriented stratigraphic cross-section C–C′ (Figure 11) runs north–south along the western portion of the study area (Figure 1). This section traverses the PRA, over which the Beaverhill Lake Group is missing. Sediments of the Beaverhill Lake Group thin perceptibly over the arch and eventually onlap the structure, which was an emergent landmass during the Devonian (Figure 11). The PRA was an asymmetrical feature with a more steeply dipping northern flank (O'Connell, 1994), which is evidenced by a thicker Beaverhill Lake Group succession (Figure 11).

Cross-section C–C′ runs along the western limit of the Fort Vermilion Formation, resulting in what appears to be localized distributions north and south of the PRA (Figure 11). The Fort Vermilion Formation is absent south of well 16-27-063-09W5.

The cross-section runs through the Swan Hills area where the shallow-water carbonates of the Swan Hills Formation formed (Figure 3). The three wells that traverse the carbonate buildups fall within the platform succession of the lower Swan Hills Formation. The platform is intersected by an embayment separating the area where the isolated Judy Creek and Swan Hills bioherms nucleated from the area where the Snipe Lake bioherm nucleated (well 10-22-066-12W5, Figure 11). Where the Swan Hills platform and overlying bank and isolated bioherms developed, the Swan Hills Formation is undifferentiated from the Slave Point Formation, the latter of which is considered to comprise a more open-marine facies succession in interplatform areas surrounding the Swan Hills platform (Oldale and Munday, 1994). This open-marine facies changes once again to the shallow-water facies of the Slave Point Formation fringing the PRA. The Swan Hills Formation represents a thicker—and longer lived—succession of shallow-water carbonates than the Slave Point Formation buildups flanking the PRA (Oldale and Munday, 1994). East of the Swan Hills area, the Slave Point Formation is represented by a thin carbonate recognizable by a relatively clean gamma-ray signature. North of the PRA, the Slave Point Formation thickens significantly where it forms the Hay River Platform (Figure 3 and Figure 11).

In the south, the Waterways Formation is differentiated from the overlying Cooking Lake Formation of the Woodbend Group by a sharp decrease in gamma-ray counts where the Cooking Lake Platform or the Cooking Lake equivalent is developed. Towards the southern flank of the PRA, the Waterways Formation is overlain by bituminous or argillaceous shales of the Duvernay Formation. Here, the Waterways Formation thins as it onlaps the Slave Point carbonates and eventually the PRA (Figure 11). North of the PRA, the Waterways Formation is overlain by the bituminous shales of the Muskwa Formation (Duvernay Formation equivalent). The Waterways Formation thins again northwards where it onlaps the Hay River Platform (Figure 11).

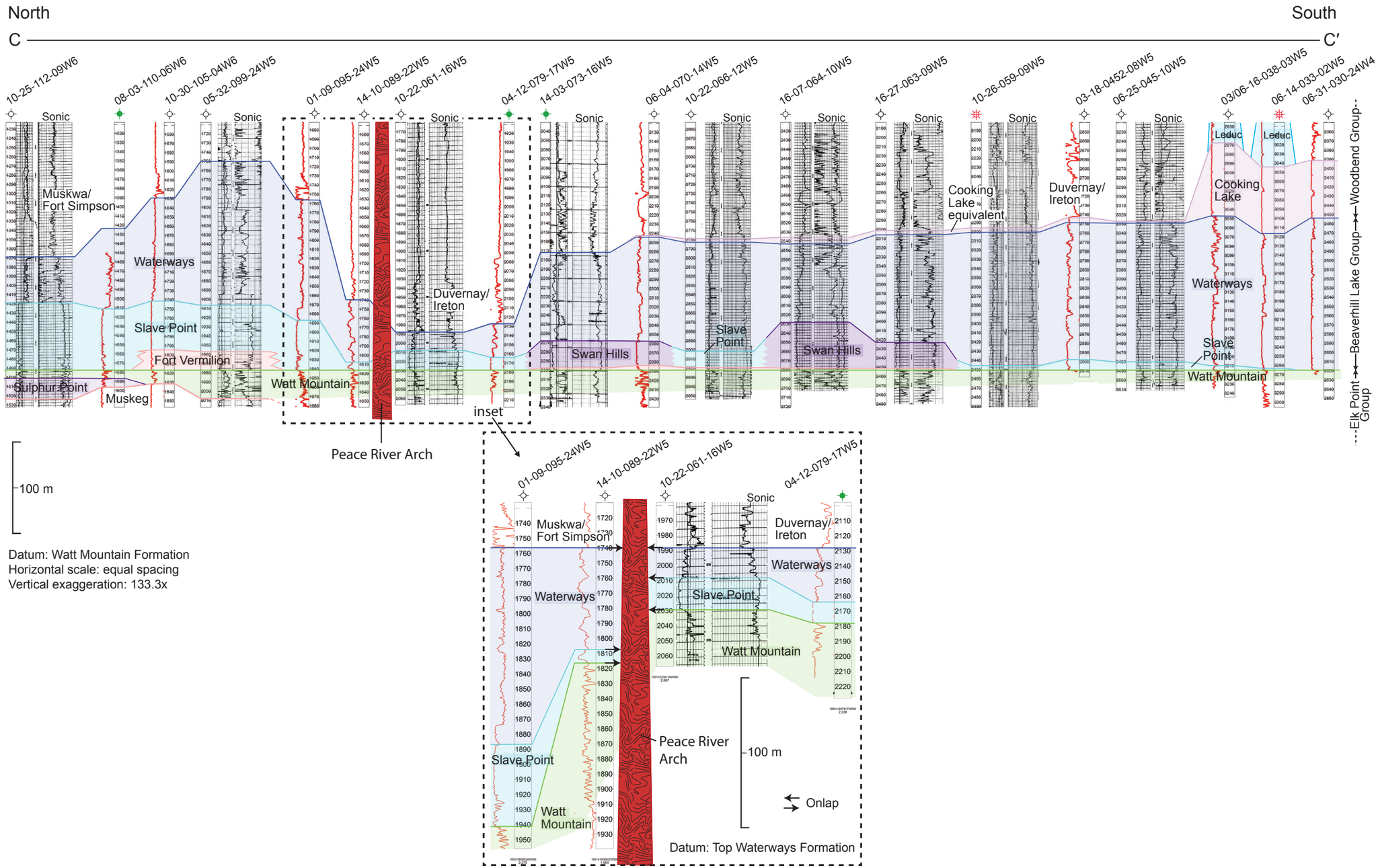


Figure 11. Strike-oriented stratigraphic cross-section C–C′. See Figure 1 for location.

5.4 Cross-Section D–D′

The dip-oriented stratigraphic cross-section D–D′ (Figure 12) runs west–east through the northern part of the study area, north of the PRA (Figure 1). The section runs directly through the centre of the Fort Vermilion Formation depocentre in the north of the study area, where the Fort Vermilion Formation can be more than 44 m thick (well 10-03-101-15W5, Figure 12). The Fort Vermilion Formation eventually interfingers with and pinches out in the Slave Point Formation carbonates in the Hay River Platform. The Slave Point Formation is thin in the eastern portion of cross-section D–D′ and thickens at the expense of the Fort Vermilion Formation towards the Hay River Platform.

The Waterways Formation thins westwards towards the Hay River Platform, which it onlaps and eventually buries west of the study area in British Columbia. The Waterways Formation is overlain by a thin Cooking Lake Platform succession in the east, by argillaceous shales of the Ireton Formation and its equivalent Fort Simpson Formation in the west, and eventually by the bituminous shales of the Muskwa Formation overlying the Hay River Platform (Figure 12).

5.5 Cross-Section E–E′

The dip-oriented stratigraphic cross-section E–E′ (Figure 13) runs west–east in the study area, traversing a portion of the southern flank of the PRA (Figure 1). In the east, the Waterways Formation is truncated by the sub-Cretaceous unconformity, which is overlain by siliciclastics of the Lower Cretaceous Mannville Group (Figure 13).

The Fort Vermilion Formation is uniform in thickness across the cross-section until it pinches out west of well 03-20-083-10W5 (Figure 13). Overlying the Fort Vermilion Formation, the Slave Point Formation carbonates are thin but increase in thickness towards the PRA, where they reach nearly 50 m in thick (well 12-16-082-12W5, Figure 13). Here the Slave Point Formation forms the PRA fringing platform (Figure 3). The Slave Point Formation thins again westwards where accommodation decreases and eventually onlaps the PRA beyond the line of section.

Strata of the Waterways Formation thin dramatically westwards towards the PRA, where they onlap and eventually bury the Slave Point Formation. Waterways Formation strata thin due to decreased accommodation space over the PRA (Figure 13). Tracing of individual markers (tops of T-R cycles) within the Waterways Formation reveals downlap of the Slave Point Formation in the Waterways sub-basin and onlap of the Slave Point Formation where it forms the PRA fringing platform (Figure 3). The Waterways Formation is overlain by the Cooking Lake Formation in the east (west of the subcrop), by the Cooking Lake equivalent west of the Cooking Lake Platform edge, by the Ireton Formation west of the Cooking Lake equivalent, and eventually by the bituminous shales of the Duvernay Formation (Figure 13).

5.6 Cross-Section F–F′

The dip-oriented stratigraphic cross-section F–F′ (Figure 14) runs roughly west–east through the centre of the study area, from the Swan Hills region towards the Eastern Platform and Beaverhill Lake subcrop (Figure 1). In the east, the Waterways Formation is truncated by the sub-Cretaceous unconformity, which is overlain by siliciclastics of the Lower Cretaceous Mannville Group.

At the base of the Beaverhill Lake Group, the Fort Vermilion Formation forms a thin unit that pinches out westwards beneath the Swan Hills Formation buildups (well 02-28-063-11W5, Figure 14). East of these buildups, the Fort Vermilion Formation is overlain by a thin unit of Slave Point Formation carbonates. West of well 10-15-063-04W5, the Slave Point Formation grades into similar open-marine carbonates

West

East

D

D′

03-14-094-13W6

10-01-095-11W6

06-04-095-24W6

11-25-096-05W6

13-14-098-03W6

05-32-099-24W5

06-18-100-21W5

10-24-100-18W5

10-03-101-15W5

07-24-101-12W5

06-32-103-08W5

16-22-104-05W5

11-21-104-03W5

08-17-105-01W5

Sonic

Sonic

Sonic

Muskwa/
Fort Simpson

Duvernay/
Ireton

Cooking Lake

Waterways

Waterways

Slave Point

Slave
Point

Fort Vermilion

Watt Mountain

Prairie Evaporite

Woodbend Group

Beaverhill Lake Group

Elk Point
Group

100 m

Datum: Watt Mountain Formation
Horizontal scale: equal spacing
Vertical exaggeration: 133.3x

Figure 12. Dip-oriented stratigraphic cross-section D–D′. See Figure 1 for location.

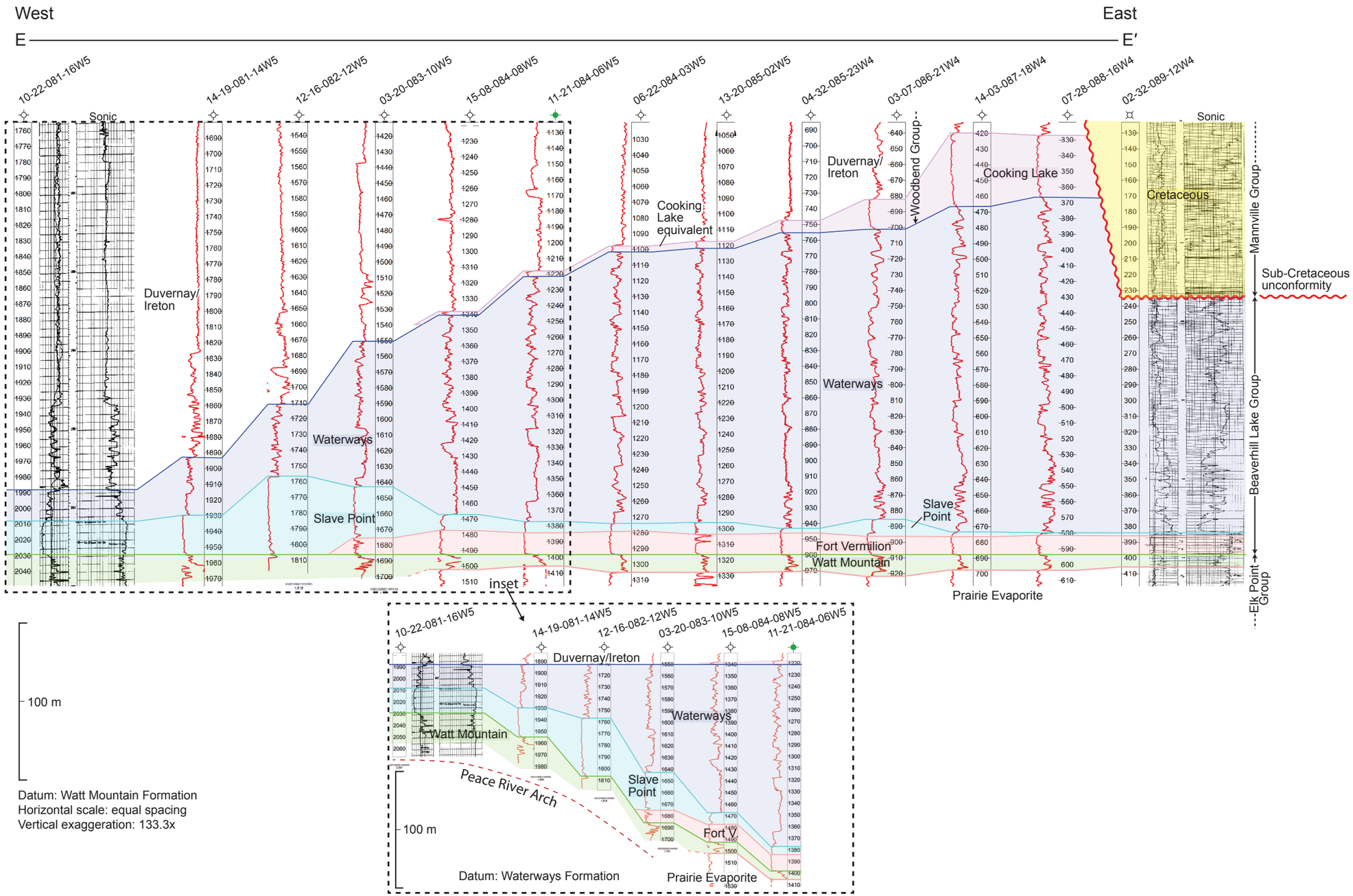


Figure 13. Dip-oriented stratigraphic cross-section E–E′. See Figure 1 for location.

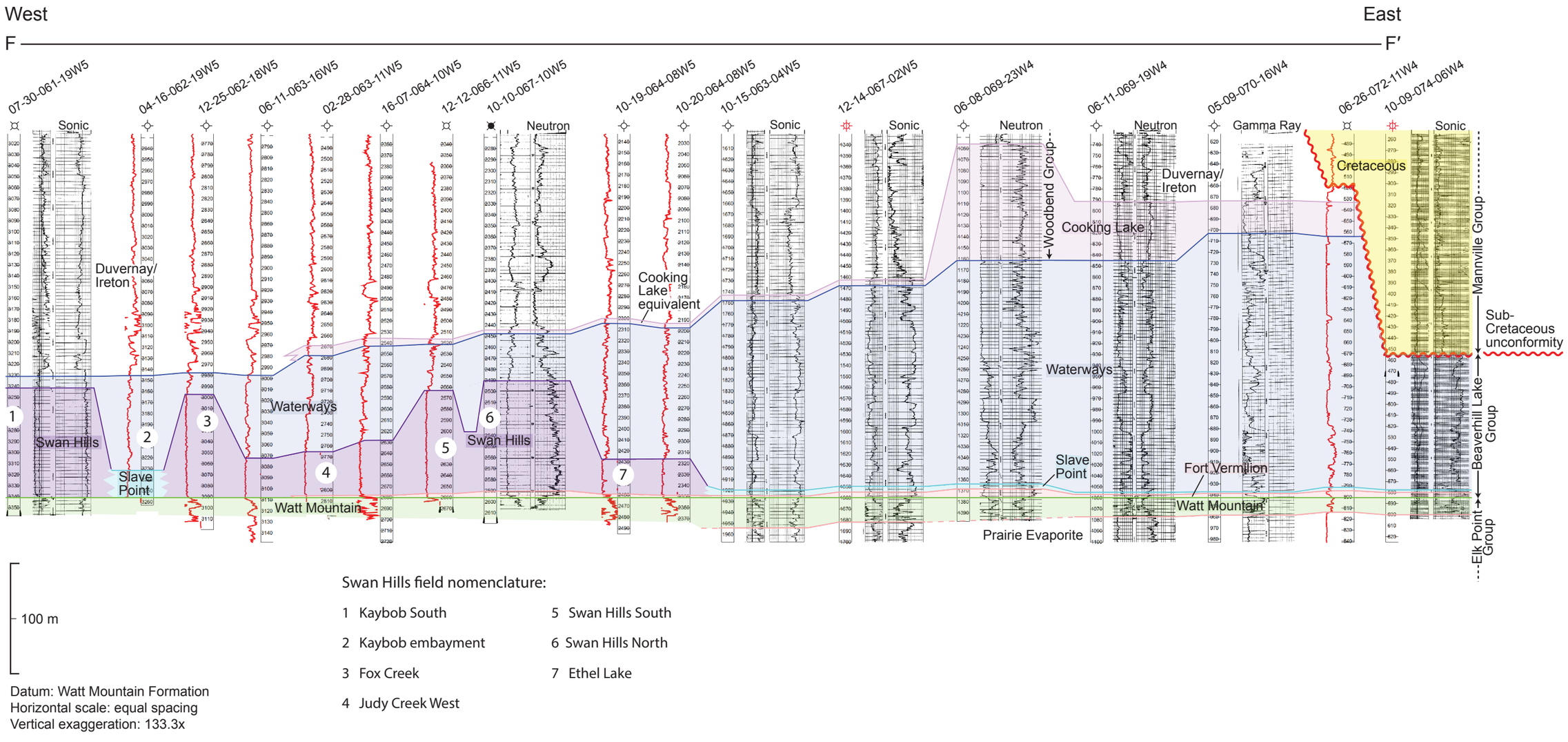


Figure 14. Dip-oriented stratigraphic cross-section F–F′. See Figure 1 for location.

recognized as the basal part of the Swan Hills Formation (Figure 14). As mentioned previously, Fischbuch (1968) recognized nine divisions within the Swan Hills Formation. Fischbuch interpreted Division I as being biostromal, not having much relief, and therefore likely depositionally similar to the equivalent open-marine, biostromal Slave Point Formation. The shallow-water carbonates of the Swan Hills Formation comprise a thick and complex succession of platform, bank, and isolated bioherm deposits (Fischbuch, 1968) that accumulated in an overall transgressive setting, resulting in aggradation and backstepping (Wendte and Uyeno, 2005). Numerous reefal elements at various stratigraphic levels host producible hydrocarbons (Figure 14). In the west, the Swan Hills platform and overlying bank are intersected by an open-marine incursion that separates the Kaybob South and Fox Creek fields, in which open-marine carbonates assigned to the Slave Point Formation were deposited (well 04-16-062-19W5, Figure 14). The Swan Hills Formation carbonates are onlapped by, and eventually buried by, the argillaceous carbonates and shales of the Waterways Formation.

East of the Swan Hills region, the Waterways Formation is a thick succession of argillaceous carbonates and shales in the Waterways sub-basin, which transition eastwards into the biostrome carbonates of the Eastern Platform (Figure 3). In the eastern portion of the cross-section, the Waterways Formation is overlain by the platform carbonates of the Cooking Lake Formation. West of this platform edge, the Waterways Formation is overlain by the Cooking Lake equivalent, which becomes unrecognizable past well 02-28-063-11W5 (Figure 14). West of this well the Waterways Formation is overlain by bituminous shales of the Duvernay Formation.

5.7 Cross-Section G–G′

Dip-oriented stratigraphic cross-section G–G′ (Figure 15) runs west–east in the southern part of the study area (Figure 1), from Swan Hills Formation buildups in the west, flanking the West Alberta Ridge (Figure 3), to the Alberta-Saskatchewan border. Wendte and Uyeno (2005) referred to these buildups as the southwest Swan Hills Platform and bank.

The anhydrites of the Fort Vermilion Formation are missing this far south in the basin, such that either the Slave Point or the Swan Hills Formation make up the basal unit of the Beaverhill Lake Group. The Slave Point Formation is a thin open-marine carbonate resting on the Watt Mountain Formation of the Elk Point Group. West of well 03/06-16-038-03W5, the Slave Point transitions into the shallow-water carbonates of the Swan Hills Formation in the southwest Swan Hills platform and overlying bank (Figure 15).

The Waterways Formation is much less argillaceous this far south in the basin, with a large portion of the cross-section in the east comprising the platform carbonates of the Eastern Platform (Wendte and Uyeno, 2005). Similar to the Swan Hills area to the north, the Waterways Formation onlaps and buries the Swan Hills Formation carbonates in the west, seen on cross-section G–G′ (Figure 15). The Cooking Lake Platform of the overlying Woodbend Group is well developed this far south in the basin, which makes identifying the contact between the Beaverhill Lake and Woodbend groups straightforward. The contact is characterized by argillaceous carbonates with higher gamma-ray counts, grading upwards to platform carbonates with lower gamma-ray counts. The contact can be abrupt or gradational (Figure 15).

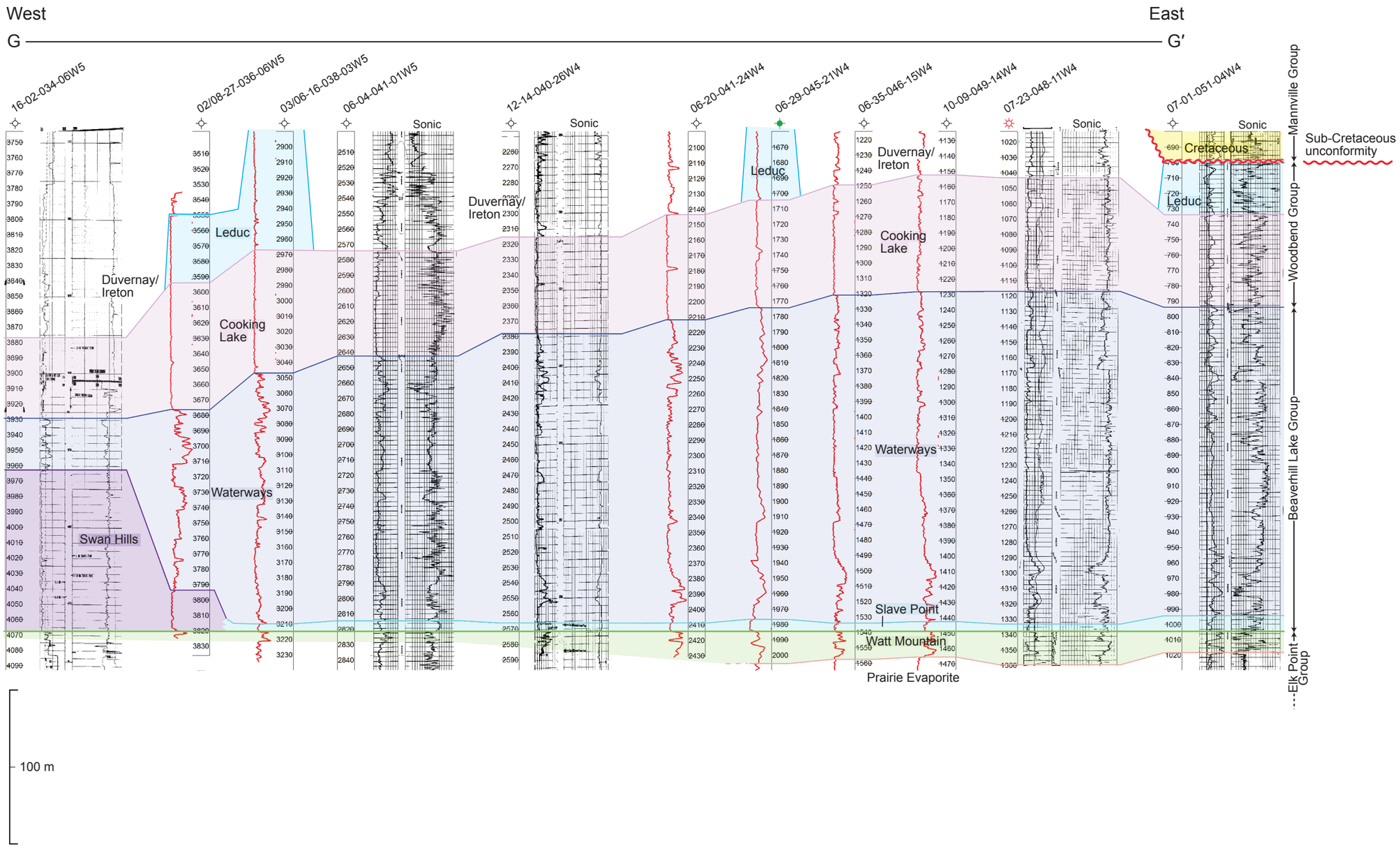


Figure 15. Dip-oriented stratigraphic cross-section G–G′. See Figure 1 for location.

6 Summary

Strata of the Middle to Upper Devonian Beaverhill Lake Group in the subsurface of Alberta represent an economically important succession of carbonates, argillaceous carbonates, calcareous shales, evaporites, and lesser, areally restricted sandstones. A number of distinct and economically important paleogeographic domains occur within the study area. These domains are characterized by the growth of shallow-water carbonates that nucleated on antecedent topographic highs in a number of locations within the basin: (1) the Swan Hills Formation carbonate complex on the West Alberta Ridge, (2) the Slave Point Formation carbonate complex fringing the PRA, and (3) the Slave Point Formation of the Hay River Platform that forms an eastern extension of the Presqu'ile barrier complex—a long-lived barrier to the open ocean to the northwest (Figure 3).

Concomitant with the growth of shallow-water carbonate complexes in the northwestern part of the study area (northern flank of the PRA and Hay River Platform), evaporites of the Fort Vermilion Formation accumulated in restricted settings to the south and east of the carbonate complexes. Restricted conditions ceased during a period of accelerated relative sea-level rise, during which time carbonate complexes on the southern flank of the PRA and in the Swan Hills area began to accumulate, and an extensive, but thin, blanket of open-marine carbonates of the Slave Point Formation developed outboard of the carbonate complexes.

The introduction of large volumes of very fine terrigenous clastics terminated Slave Point Formation carbonate accumulation outboard of the carbonate complexes. Progradational clinoforms of the Waterways Formation began to fill the Waterways sub-basin from the east towards the west (Figure 3). The landward expression of these clinoforms is part of another distinct carbonate complex known as the Eastern Platform, which developed during this time on the eastern side of the basin (Wendte and Uyeno, 2005; Figure 3). Part of the Eastern Platform developed coeval with the carbonate complexes of the western side of the basin (Keith, 1990; Wendte and Uyeno, 2005). Eventually the argillaceous carbonates of the Waterways Formation buried all but a very few of the components of the western carbonate complexes as the basin began to fill. Continued transgression resulted in the deposition of the thick overlying Woodbend Group succession.

Correlation of Beaverhill Lake Group stratigraphy in the study area covers all the aforementioned depositional realms in the form of strike- and dip-oriented stratigraphic cross-sections. A number of representative wells from distinct geographic areas detail criteria used for correlation of the Beaverhill Lake Group strata. The associated picks from the cross-sections are included in an associated data release, DIG 2014-0024.

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