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Alberta Energy Regulator

Triassic Spray River Group in Outcrop at Elliott Peak in Clearwater County, Alberta

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Triassic Spray River Group in Outcrop at Elliott Peak in Clearwater County, Alberta

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Abstract

This report provides a summary of the fieldwork that was completed by the Alberta Geological Survey near the hamlet of Nordegg during the summer of 2019. Triassic strata have been studied extensively in Willmore Wilderness Park, Jasper National Park, Banff National Park, and Peter Lougheed Provincial Park, but rarely have strata in Triassic outcrop belts in the area between Jasper and Banff national parks been studied and formally published in the literature. This study of outcrop in Clearwater County focuses on identifying the boundaries of the Spray River Group, which is equivalent to the Montney, Doig, Halfway, and Charlie Lake formations in the subsurface of Alberta. The Spray River Group is subdivided into the Lower and Middle Triassic Sulphur Mountain Formation and the Upper Triassic Whitehorse Formation. These units were studied at a well-exposed outcrop along a ridge below Elliott Peak on Sentinel Mountain. In the study area, the Sulphur Mountain Formation consists of four formally defined members (Phroso Siltstone, Vega Siltstone, Whistler, and Llama) of mixed siliciclastic-carbonate rocks. The overlying Whitehorse Formation in the study area consists of the Starlight Evaporite Member, which is composed of mixed siliciclastic-carbonate to carbonate-dominated rocks as well as interstratified evaporites. A low-resolution stratigraphic column along the ridge of Elliott Peak is provided, with the major boundaries that separate the members marked. Samples were collected at 5 m intervals for future geochemical and sedimentological analyses, which will facilitate future regional correlations to outcrop belts and subsurface units.

1 Introduction

Triassic strata are preserved in outcrop belts in the Rocky Mountains and foothills of Alberta and British Columbia. The Triassic strata comprise an approximately 1200 m thick, westward-thickening, marine succession of mixed siliciclastic-carbonate rocks, which contain a minor amount of evaporites interstratified in the formations (Gibson, 1993; Edwards et al., 1994). The Triassic succession at Elliott Peak in Clearwater County, central Alberta (Figure 1a, b), is placed within the Spray River Group, which is subdivided into the Sulphur Mountain Formation and Whitehorse Formation (Kindle, 1924; Irish, 1954; Gibson, 1971a). In the Clearwater County area, the Sulphur Mountain Formation is subdivided into the Phroso Siltstone, Vega Siltstone, Whistler, and Llama members. The Whitehorse Formation is subdivided into the Starlight Evaporite and Winnifred members, of which the Starlight Evaporite Member is the only member preserved in the study area.

2 Previous Work

2.1 Elliott Peak

The Triassic succession at Elliott Peak has been studied by the Geological Survey of Canada (GSC); an initial study along the ridge at Elliott Peak (referred to as 'South Elliott Peak') was conducted by Gibson (1974). Samples were collected to biostratigraphically constrain the age of the members in the Spray River Group and to create a stratigraphic column for the ridge. This work was then incorporated into GSC Map 1389A of Whiterabbit Creek in 1974 (Mountjoy and Price, 1974; Figure 1c). The map details the extent and location of outcrop in the Clearwater County area.

2.2 Triassic

Triassic sedimentary rocks in Canada were first described by Selwyn (1877) in a Geological Survey of Canada report. The units were observed near Hudson's Hope in British Columbia and contained an abundance of *Monotis* fossils, which had been identified as a Triassic index fossil in previous studies of Triassic rocks in California (Selwyn, 1877; Dawson, 1881). In Alberta, McConnell (1887) informally referred to Triassic deposits as the Upper Banff shales, reddish-weathering calcareous shales and quartzites located near the townsite of Banff. These deposits were initially grouped with Carboniferous strata in the area, until Dowling (1907) proposed a Permian–Triassic age for similar deposits in the Cascade coal basin in Banff National Park. In later studies, fossils obtained from the shales refined the age of the unit to be Triassic (Lambe, 1916).

The first formal nomenclature was proposed for the Triassic by Kindle (1924), referring to the units as the Spray River Formation. Warren (1927) described the Spray River Formation along the Spray River gorge in Banff and proposed in Warren (1945) that this outcrop locality be the type section for the Spray River Formation. Warren (1945) further subdivided the Spray River Formation into the Sulphur Mountain Member and Whitehorse Member due to the distinct lithological contrasts between the two units. The Whitehorse Member in the Willmore Wilderness Park was further defined and described by Best (1958). The Spray River Formation was upgraded to group status by Mountjoy (1960) in a study of the Jasper region. This study subsequently elevated the Sulphur Mountain and Whitehorse members to formation status.

Members for the Sulphur Mountain Formation and Whitehorse Formation were proposed by Gibson (1968a, b). The Sulphur Mountain Formation is lithologically subdivided into the Phroso Siltstone, Vega Siltstone, Whistler, and Llama members. The Whitehorse Formation is lithologically subdivided into the Starlight Evaporite and Winnifred members. The coordinates of the type localities for the Triassic Spray River Group, in Alberta, are summarized in Appendix 1.

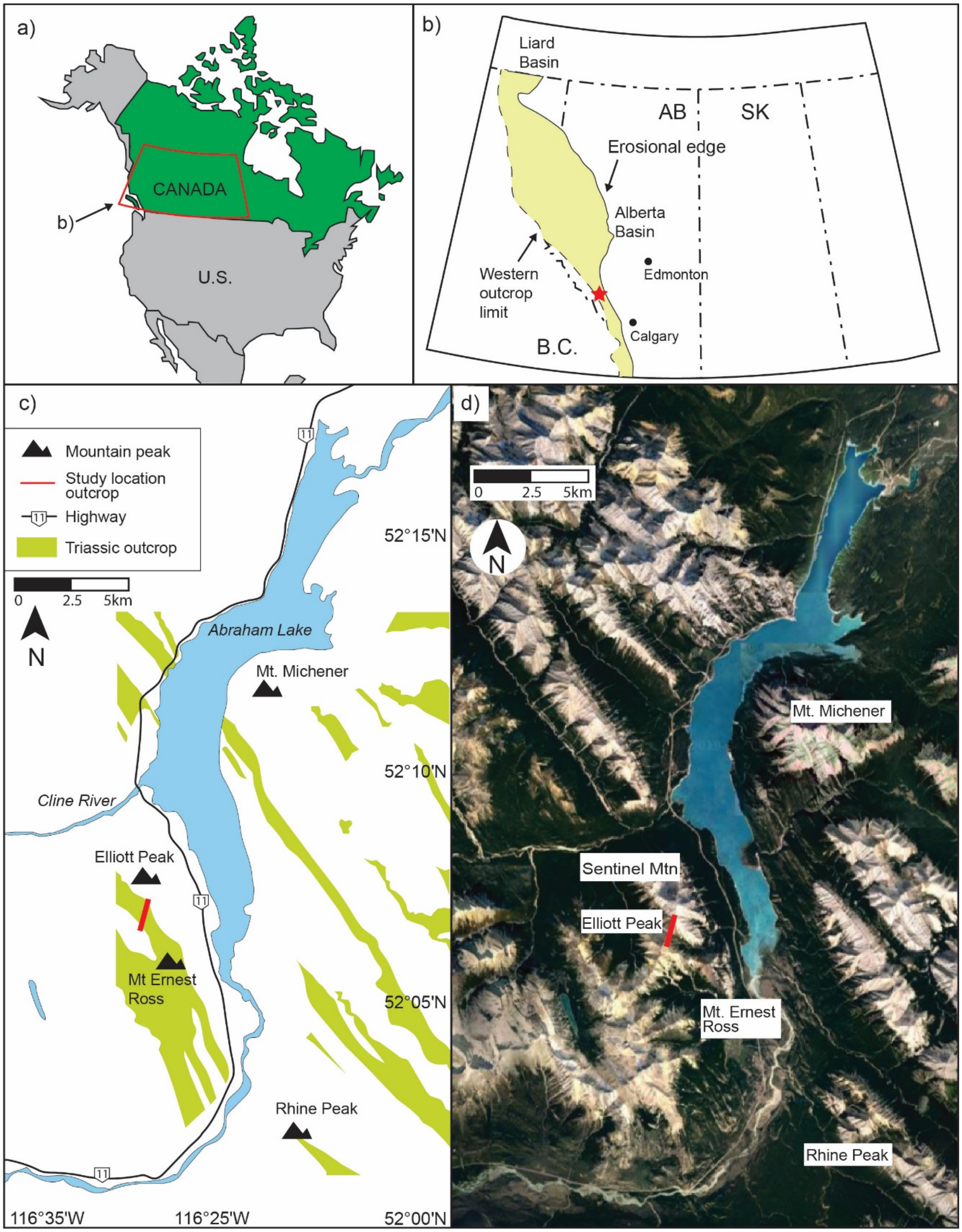

Figure 1. a) General location of study area in North America. The red box represents the extent of the map in b). b) The extent of Triassic strata in the Western Canada Sedimentary Basin in Alberta and British Columbia (modified from Edwards et al., 1994). The red star on the map represents the approximate location of the study area. c) Extent of Triassic outcrop in the study area (Clearwater County; modified from Geological Survey of Canada Map 1389A [Mountjoy and Price, 1974]). The red bar indicates the location of the ridge beneath Elliott Peak that was studied. d) Satellite image of the study area (imagery © TerraMetrics 2019).

2.3 Phroso Siltstone Member of the Sulphur Mountain Formation

The Phroso Siltstone Member was defined by Gibson (1968a, b) to describe a recessive unit of shale and siltstone along the Phroso Creek near its junction with the Sulphur River. Phroso Creek is designated as the type locality for this member and can be viewed in the Willmore Wilderness Park (Figure 2, Appendix 1). The Phroso Siltstone Member is the basal unit of the Triassic succession and is considered to be the outcrop-equivalent to the Grayling Formation in northeastern British Columbia (B.C.). Within west-central Alberta, the Phroso Siltstone Member is age-equivalent to the lower Montney Formation in the subsurface. The member ranges in thickness from 45 m along the eastern outcrop belt to more than 135 m in western outcrop belt localities (Gibson, 1965, 1968a, b).

The Phroso Siltstone Member is a recessive unit composed of planar-laminated and thinly bedded silty shale to siltstone (Orchard and Zonneveld, 2009). The member consists of quartz-rich siltstone and dolomite with mica and pyrite (Gibson, 1968b). Traces of feldspar, rutile, zircon, tourmaline, collophane, and glauconite are distributed throughout the Phroso Siltstone Member (Gibson, 1968b). Sedimentary structures are challenging to identify due to the weathered nature of most outcrops and can usually only be identified in slabbed hand samples.

In many localities the Phroso Siltstone Member unconformably overlies the Permian Ranger Canyon Formation or Mowitch Formation (Orchard and Zonneveld, 2009). The overlying contact with the Vega Siltstone Member is generally a distinct boundary (Gibson and Poulton, 1994; Orchard and Zonneveld, 2009). However, in some study localities, the contact between the members is gradational or the units are observed to interfinger, making it challenging to separate the Phroso Siltstone Member from the Vega Siltstone Member. This generally results in the members being combined and informally referred to as the Vega-Phroso member (Orchard and Zonneveld, 2009; Zelasny et al., 2018).

Invertebrate fossils are observed to occur in the upper portion of the Phroso Siltstone Member, including ammonoid impressions, phyllocarid fossils and bivalves (Tozer, 1967; Orchard and Zonneveld, 2009). Trace fossils are typically not observed in the Phroso Siltstone Member but rare examples of *Helminthopsis* have been found (Orchard and Zonneveld, 2009). Vertebrate fossils are more common in the Phroso Siltstone Member and can include chondrichthyans, palaeoniscids, parasemionotids, and coelacanths (Schaeffer and Mangus, 1976; Mutter and Neumann, 2008). The member is assigned to a Griesbachian age based on conodont biostratigraphy and pelecypod fossils, which serve as an index fossil (Gibson, 1974; Orchard and Tozer, 1997; Henderson et al., 2018).

2.4 Vega Siltstone Member of the Sulphur Mountain Formation

The Vega Siltstone Member is formally defined along Mowitch Creek to the south of Vega Peak (Gibson, 1968a). Mowitch Creek is the type locality for the Vega Siltstone Member and can be viewed in the Willmore Wilderness Park (Figure 2, Appendix 1). The Vega Siltstone Member conformably overlies the Phroso Siltstone Member and is inferred to be age-equivalent to the Toad Formation in outcrop (northeastern B.C.) and to the upper Montney Formation in the subsurface of Alberta. The member ranges in thickness from 50 m in the front ranges of the Rocky Mountains to more than 350 m in the western edge of the outcrop belt (Gibson, 1974).

The unit is characterized by the interbedding of greyish to rusty brown siltstone with muddy siltstone and silty shale (Gibson, 1968b, 1971b). Dolomitic siltstone, silty limestone, and dolomitic sandstone may be intercalated in the member (Gibson, 1974). Planar lamination, cross-bedding, and massive bedding are observed.

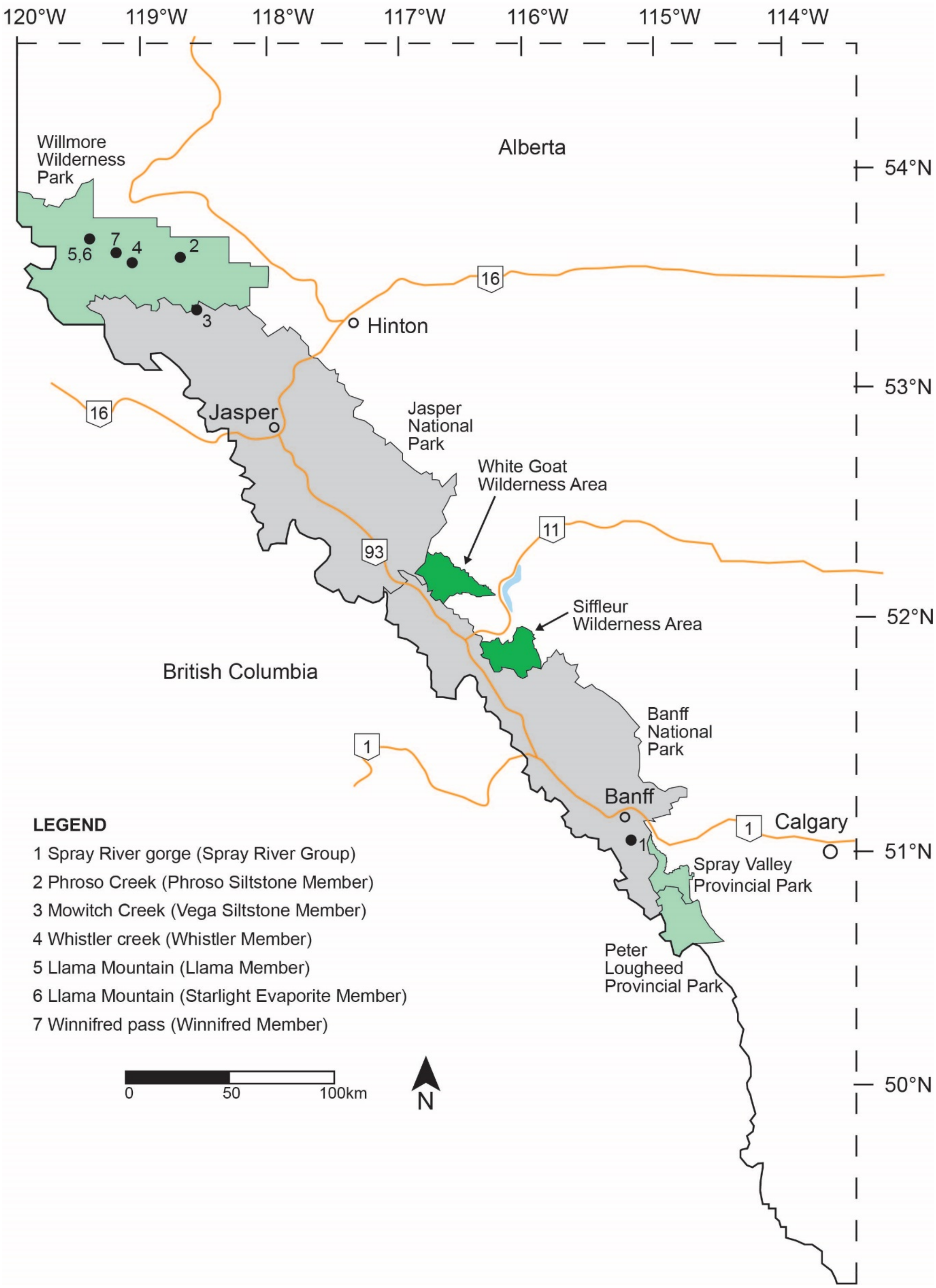

Figure 2. The locations of the type localities for the members of the Spray River Group, central Alberta.

The Vega Siltstone Member's contact with the underlying successions tends to be variable across the basin. In the southern extent of the Rockies, the contact between the Vega and Phroso Siltstone members is indistinguishable leading to the informal Vega-Phroso member classification. In central Alberta, the Vega Siltstone Member conformably overlies the Phroso Siltstone Member (e.g., in this study area). The Vega Siltstone Member may also overlie the Meosin Mountain Member in east-central B.C. and the Mackenzie Dolomite Lentil in the Cadomin area of Alberta (Orchard and Zonneveld, 2009). Both of these units have limited areal extent and as a result were not observed in this study area.

Fossil evidence is less abundant in the Vega Siltstone Member when compared to the underlying Phroso Siltstone Member. Invertebrate fossils include articulated and disarticulated fragments of bivalve shells, fish fragments, and ammonoid impressions (Orchard and Zonneveld, 2009). Trace fossils are typically not observed but where present consist of isolated examples of *Helminthopsis, Thalassinoides*, and *Spongeliomorpha*, which are commonly observed at the base of sandstone beds (Orchard and Zonneveld, 2009). Based on pelecypod and ammonite fossils found in some outcrops, as well as conodont data, a Smithian age is assigned to the Vega Siltstone Member (Gibson, 1974; Orchard and Tozer, 1997; Orchard and Zonneveld, 2009; Henderson et al., 2018).

2.5 Whistler Member of the Sulphur Mountain Formation

The Whistler Member was first referred to as the Black Shale Member by Manko (1960) to describe a unit of dark grey to black silty shales. It was later proposed by Gibson (1968a) to rename the unit as the Whistler Member (based on the mountains near the type locality) in order to avoid confusion by referring to the unit based on lithological characteristics. The member reaches a maximum thickness of approximately 43 m in the west and thins to about 3 m to the east of the Rocky Mountains (Manko, 1960; Gibson, 1968a, b). The type locality for this member occurs at Whistler creek in the Willmore Wilderness Park near the Snake Indian fault at the Wildhay River (Manko, 1960; Gibson, 1968a; Figure 2, Appendix 1).

This member consists of shale, siltstone, and dolomite intervals, which are recessive in nature (Gibson, 1968a, b). The Whistler Member contains thin to massive bedding of siltstone to very fine grained sandstone with some laminations exhibiting a slight crenulation (Gibson, 1968b). Nodular phosphate rock and limestone persist throughout this unit (Manko, 1960).

The basal contact of the Whistler Member ranges from unconformable to conformable with the underlying Vega Siltstone Member (Gibson, 1968a, b). In areas where it is presumed to be unconformable, a phosphatic lag mantles the surface (Orchard and Zonneveld, 2009). The top of the Whistler Member is conformable with the overlying Llama Member.

A significant number of invertebrate fossils were found in the Whistler Member, including ammonites, pelecypods, and brachiopods (Gibson, 1968a, b). The timing of deposition for this member is constrained biostratigraphically to correlate to the Anisian based on *Daonella* sp. fossils that were collected at Elliott Peak by Gibson (1974). This dating has been supported by earlier outcrop studies in the Willmore Wilderness Park (Manko, 1960) and by later conodont studies (Orchard and Tozer, 1997).

2.6 Llama Member of the Sulphur Mountain Formation

The Llama Member was described by Irish (1954) near the Smoky River and was first referred to as the Upper Siltstone member by Manko (1960). The term Llama Member was formally proposed by Gibson (1968a) to describe a calcareous/dolomitic sandstone to siltstone unit near Llama Mountain in Willmore Provincial Park. The Llama Member is age-equivalent to the subsurface Doig and Halfway formations in Alberta and B.C. The type locality for this member is located at Llama Mountain on the northeastern margin of the Muddywater River in Willmore Wilderness Park (Gibson, 1968a; Figure 2, Appendix 1). The member ranges in thickness from 8 m along the eastern margin of the foothills to more than 150 m in the B.C. mountain ranges.

The basal contact of the Llama Member is conformable with the underlying Whistler Member. The contact may also be unconformable when the Llama Member overlies the Vega Siltstone Member (Gibson, 1968a, b).

The member contains a sparse number of fossils and trace fossils (Manko, 1960; Gibson, 1968a, b). The most common invertebrate fossils found are brachiopods (*Spiriferina*), which are used as an index fossil for biostratigraphic correlations (Gibson, 1968a, b). Other fossils that may be identified include lingulids and pelecypods. The Llama Member is inferred to have been deposited during the Middle or early Late Triassic (Manko, 1960; Orchard and Tozer, 1997).

2.7 Starlight Evaporite Member of the Whitehorse Formation

The Starlight Evaporite Member is the basal unit of the Whitehorse Formation and was first formally defined by Gibson (1968a) in a study of the outcrop exposed at Llama Mountain (Figure 2, Appendix 1). The unit was initially referred to as the Evaporitic Member by Manko (1960), but was renamed by Gibson (1968a). The member was renamed in order to reflect the location of the type locality, rather than the lithological name proposed by Manko (1960). This member is age-equivalent to the Charlie Lake Formation in northeastern B.C. and the subsurface of west-central Alberta.

The strata are composed of dolostone, limestone, sandstone, siltstone, and collapse breccia (Gibson and Poulton, 1994). These deposits range in colour from white to grey to red, which are observed as interbedded units. The member ranges in thickness from 47 to over 275 m.

Collapse breccia is a highly diagnostic feature of the Starlight Evaporite Member. The collapse features formed due to the dissolution of anhydrite and gypsum deposits within the member following deposition. The collapse features are well preserved and exposed in the Wilmore Wilderness Park at Llama Mountain (Figure 2, Appendix 1), as well as the Mowitch Creek and Blue Creek outcrop sections (Manko, 1960; Gibson, 1968a).

Fossils are uncommon in the Starlight Evaporite Member but there are rare examples of gastropods, rhynchonelloid brachiopods, and pelecypods (Gibson, 1974). Based on the few species of pelecypods that were identified, it was suggested that the Starlight Evaporite Member is Middle to Late Triassic in age (Gibson, 1974).

2.8 Winnifred Member of the Whitehorse Formation

The Winnifred Member is the uppermost strata of the Whitehorse Formation and was formally named by Gibson (1968a) at the type locality near Winnifred pass (Figure 2, Appendix 1). The unit was described by Manko (1960) near Blue Creek as the Carbonate Member, a package of thick dark grey carbonate rocks. The member ranges from 3 m in the east to over 225 m in the west (Gibson, 1968a, b).

The Winnifred Member conformably overlies the Starlight Evaporite Member, with the contact ranging from gradational to sharp (Manko, 1960). The top of the Winnifred Member is unconformable with the overlying Jurassic Fernie Formation.

This member consists of thin to thick interbeds of sandy to silty calcareous dolomite with dolomitic siltstone to sandstone (Gibson, 1974). Thin lenses of dolomitic conglomerate were found in some outcrop localities, but the distribution tends to be isolated to the outcrops near Jasper and in northeastern B.C. (Gibson, 1974). Pyrite nodules and chert lenses and nodules are abundant and common in the basal section of the unit (Manko, 1960).

3 Methods

3.1 Outcrop Locality

Fieldwork was conducted in Clearwater County in July 2019, approximately 50 km southwest of the hamlet of Nordegg along Highway 11 (Figure 1c, d). The outcrop at Elliott Peak, below Sentinel Mountain, is accessible by a short 10-minute helicopter ride from a helicopter base (Rockies Heli Canada) near the Cline River, which feeds into Abraham Lake. The base of the Triassic succession that was measured along Elliott Peak begins at latitude 52°07'09.2"N, longitude 116°28'42.6"W.

The outcrop section includes Permian, Triassic, and Jurassic deposits; the section is capped by overthrust, cliff-forming, Cambrian units, which overlie the Jurassic shales (Figure 3a, b). The strata dip fairly uniformly between 75° and 80°. The Permian–Triassic contact, visible as a sharp lithology change from chert to siltstone, was used as the datum and designated 0 m, with Permian deposits below being assigned negative values. The ridge was measured to a maximum value of 1159 m, with the upper boundary reflecting an unconformity between the Jurassic and Cambrian strata (Figure 4). In order to estimate the thickness of the Permian and Cambrian units, Google Earth satellite images were used.

3.2 Sampling

Three samples were collected below the Permian–Triassic contact (at half metre intervals) and 239 samples were collected above the contact (primarily at 5 m intervals). Within certain highly variable sections of the Whistler Member, samples were collected at 2.5 m intervals in order to capture the heterogeneity of the outcrop. Individual sample size and weight varied, but provided enough material for geochemical studies and thin section creation. Analyses of these samples are currently underway and will be released at a later date. Lithological descriptions of each member measured are included in this report.

4 Results

The Spray River Group outcrop section in Clearwater County, Alberta, contains a complete succession of the Triassic. However, within the study area, the Winnifred Member carbonate-dominated unit is not observed. This member has a limited extent in the central Alberta outcrop belt and is observed to pinch out in areas along the eastern margin of the Triassic outcrop belt.

4.1 Ranger Canyon Formation

The Permian Ranger Canyon Formation forms large cliffs beneath the summit of Elliott Peak (Figure 5a–c). The unit consists of blocky, dark grey to black chert deposits. The thickness of this unit in the study area is approximately 75 to 125 m thick (as measured from Google Earth images). For this study, the top 3 m of the formation was studied in order to understand the nature of the contact between the Permian and Triassic.

4.2 Phroso Siltstone Member

The Phroso Siltstone Member comprises the basal unit of the Triassic succession at Elliott Peak. The member unconformably overlies the Permian Ranger Canyon Formation and is conformably overlain by the Vega Siltstone Member (Figure 5a, b). Approximately 140 m of the Phroso Siltstone Member is preserved at Elliott Peak. The contact between the Vega and Phroso Siltstone members was selected based on changes in lithology and fossil suites. Future work on the geochemistry of the ridge at Elliott Peak will assist with confirming the location of the contact.

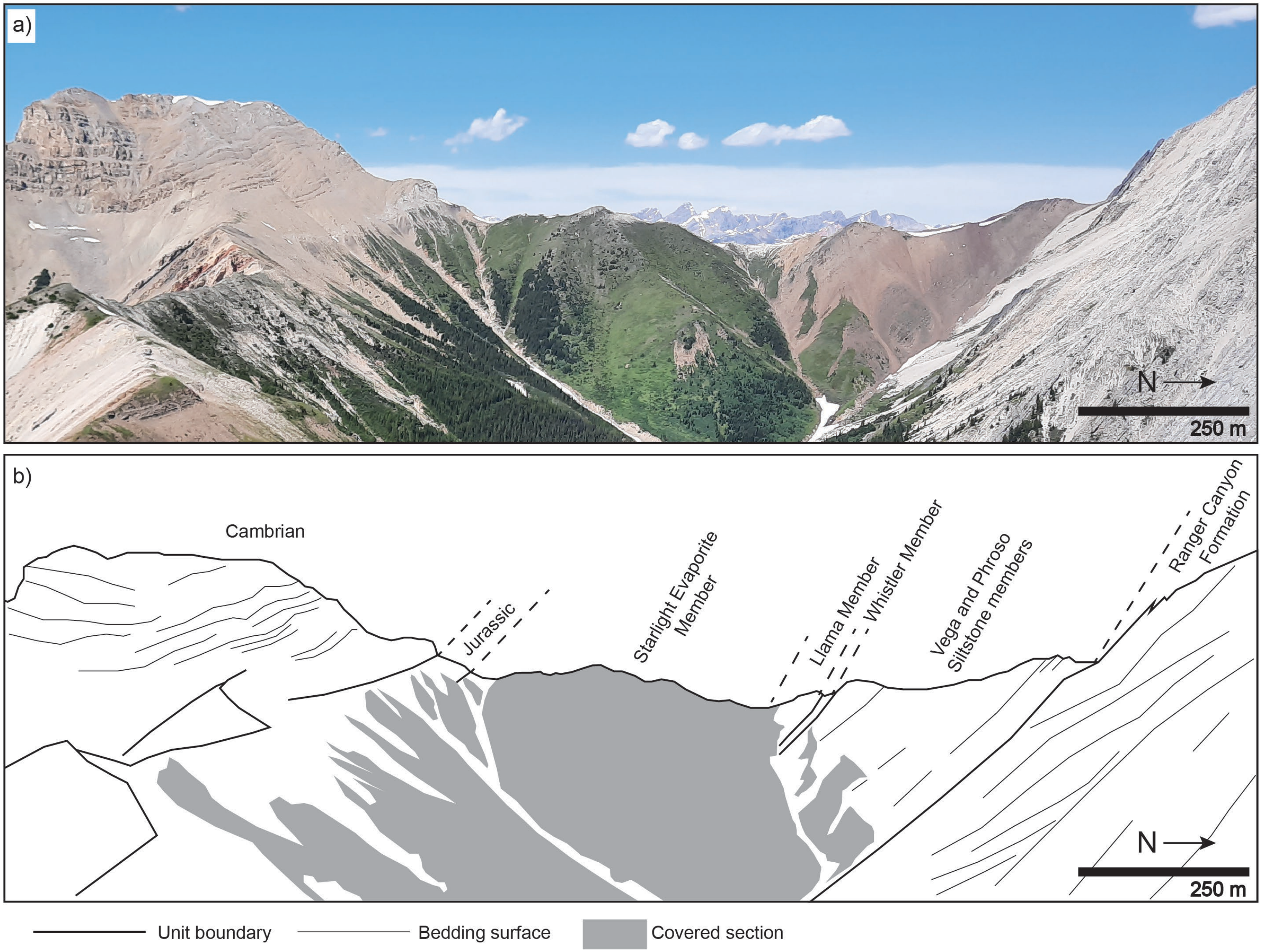

Figure 3. a) The ridge at Elliott Peak photographed from the peak of Mount Ernest Ross (facing northwest), central Alberta. b) Outcrop sketch of Elliott Peak documenting the breaks between the members of the Triassic Sulphur Mountain and Whitehorse formations (Spray River Group).

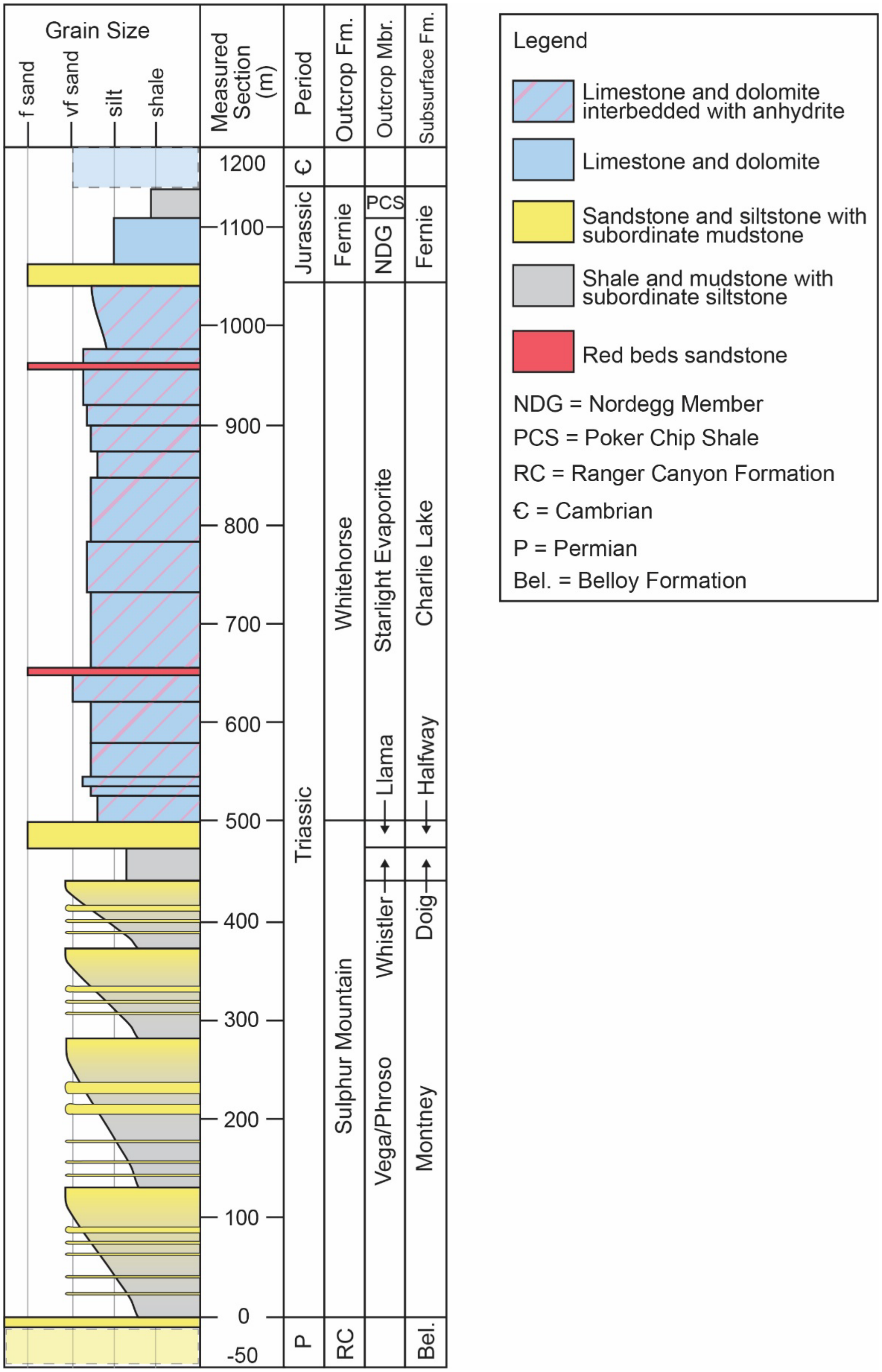

Figure 4. Stratigraphic log for the Spray River Group at Elliott Peak, central Alberta. Abbreviations: f, fine; vf, very fine.

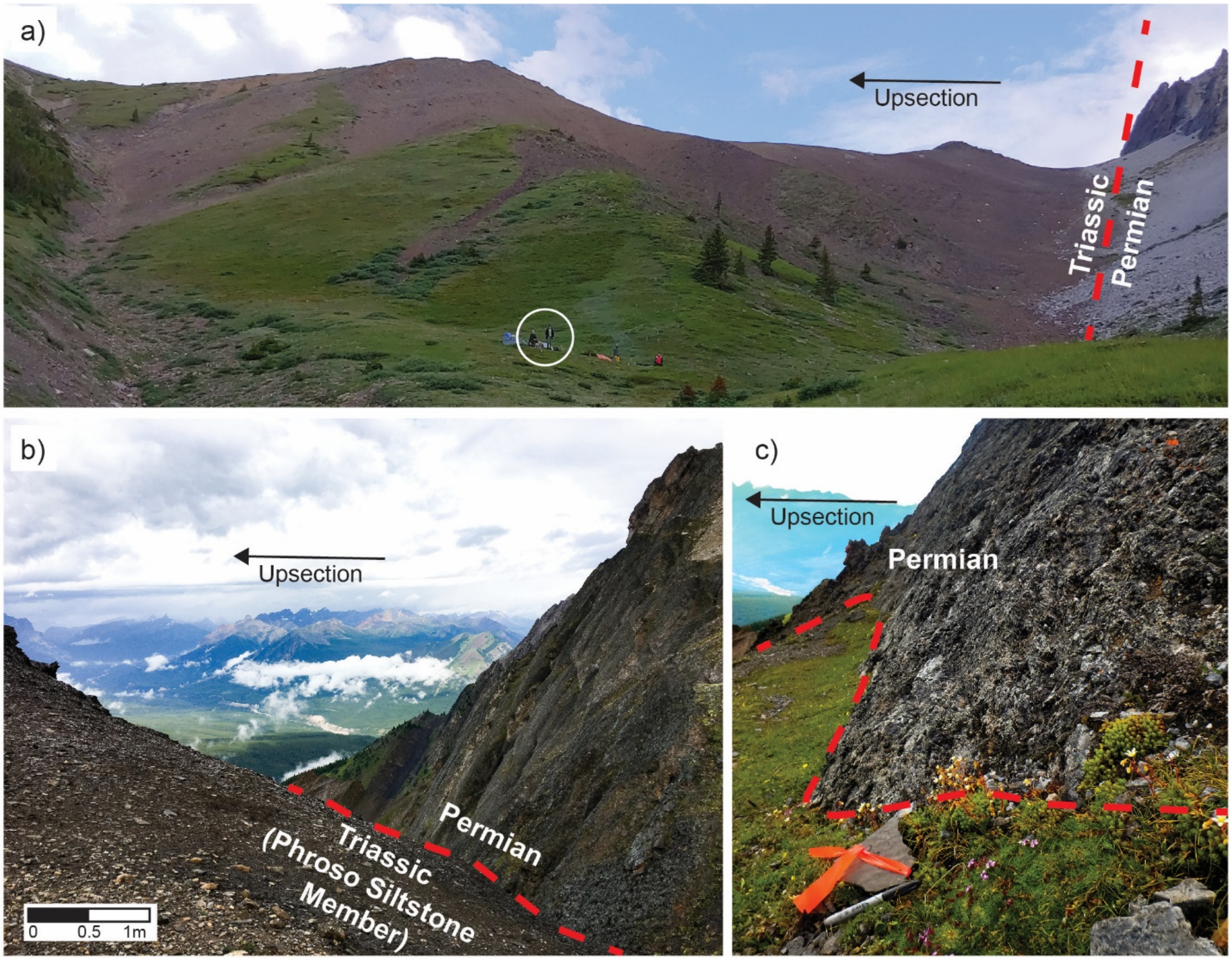

Figure 5. Examples of the Permian–Triassic boundary at Elliott Peak, central Alberta. The black to dark grey cliff-forming deposits belong to the Permian Ranger Canyon Formation. a) View of the Permian–Triassic contact from base camp farther down the mountain; field crew for scale. b) View of the contact near the base of the succession looking north-northwest. c) Close-up view of the contact; permanent marker for scale.

The Phroso Siltstone Member is composed of interbedded sandstone and siltstone beds. The sandstone beds of this unit are relatively thin, giving the outcrop a fissile appearance (Figure 6b). Low-angle, planar lamination and wavy lamination are common (best observed in slabbed samples). This unit is dolomite-rich, with limited calcite cement observed. The basal 20 m of this unit contains heavily fractured deposits that are infilled with dolomite or silica cement. Vuggy porosity that has been infilled with calcite and dolomite is common.

Minor amounts of bioturbation were recorded in this unit, and included examples of *Palaeophycus*, *Planolites*, and *Thalassinoides*. Fossil impressions of ammonoids were common, however, suture patterns were not visible.

4.3 Vega Siltstone Member

The Vega Siltstone Member conformably overlies the Phroso Siltstone Member (Figure 6a, c). The contact with the overlying Whistler Member is a conformable, sharp, lithological boundary between the two units. The thickness of this member is approximately 315 m.

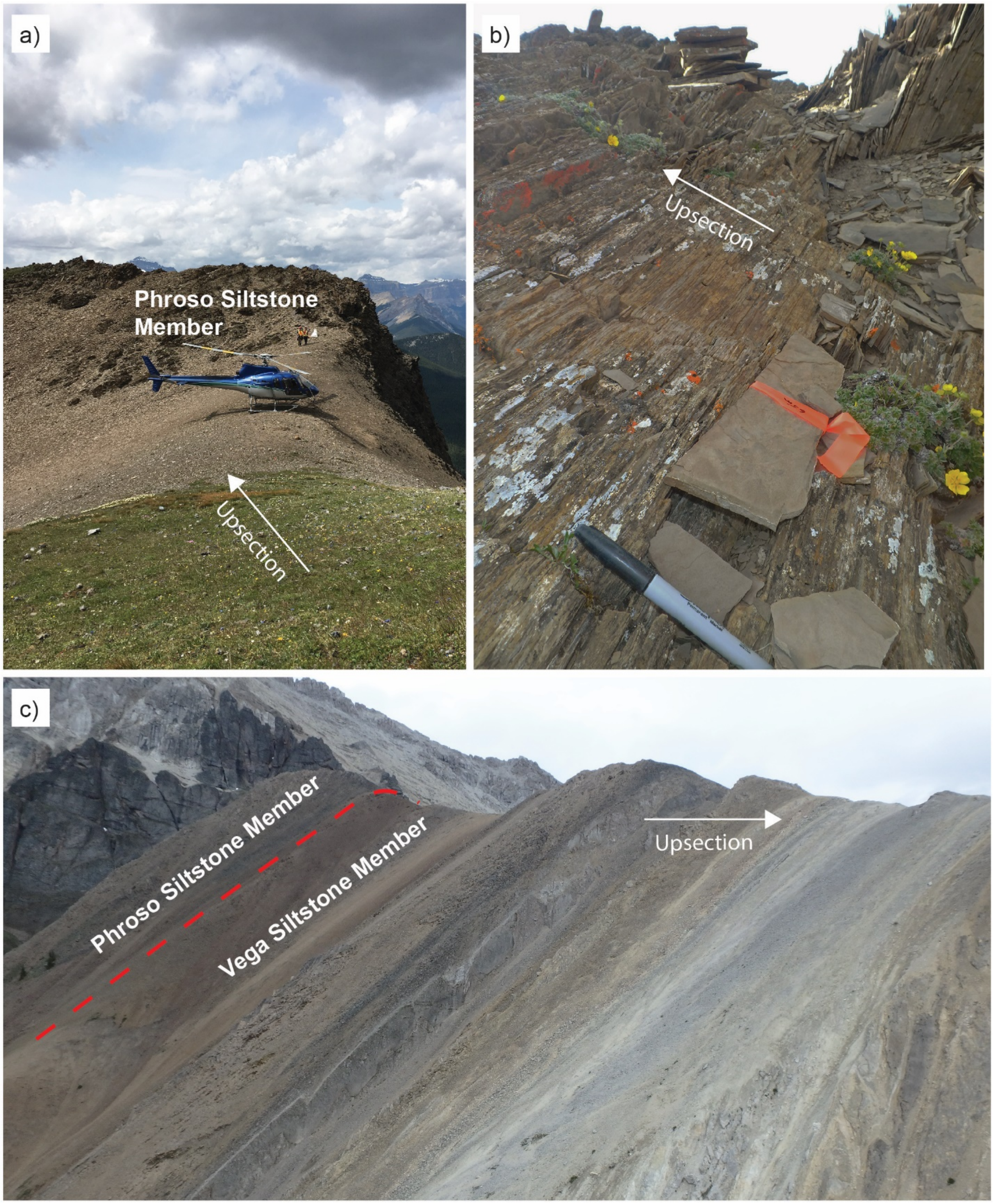

Figure 6. Examples of the Phroso and Vega Siltstone members, central Alberta: a) the basal section of the Triassic; helicopter for scale; b) fissile-bedded turbidite of the Phroso Siltstone Member; permanent marker for scale; c) view of the Phroso and Vega Siltstone members from the helicopter.

The Vega Siltstone Member is composed of interbedded sandstone and siltstone beds, which consist of packages of sharp-based, massive sandstones that fine upwards into planar- and ripple-laminated siltstones. These fining-upwards packages repeat throughout the succession and tend to be blockier than those of the underlying Phroso Siltstone Member. Low-angle planar lamination and wavy lamination and low-amplitude wave ripples are common in the sandier sections. Thin, discontinuous lenses of medium-grained sandstone are observed in the blocky sandstone. The sandstones tend to be calcite cemented, with most samples strongly effervescing when HCl is applied.

Bioturbation is not observed in this unit. Invertebrate fossils are uncommon, and ammonoid impressions are not observed.

4.4 Whistler Member

The Whistler Member conformably overlies the Vega Siltstone Member and is denoted by a distinct lithological change from the underlying siltstone and sandstone beds to the overlying siltstone-dominated succession. The upper contact with the Llama Member was also observable as a distinct lithological change from the siltstone-dominated Whistler Member to the sandstone-dominated Llama Member (Figure 7a, b). The basal contact of the member occurs at 455 m above the Permian–Triassic contact. The thickness of this member is approximately 30 m.

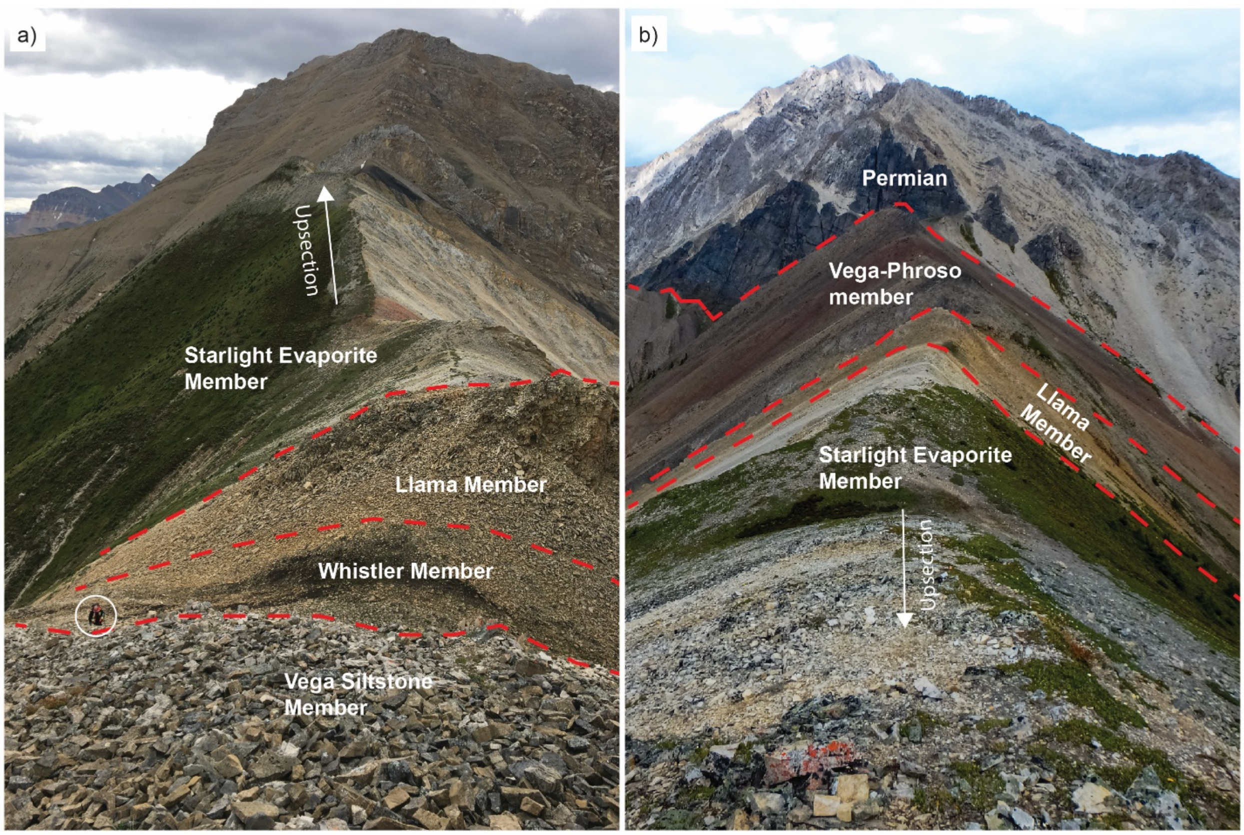

Figure 7. Examples of the Whistler, Llama, and Starlight Evaporite members, central Alberta. a) View of the members looking upsection towards the Jurassic units (southwest). Field crew member for scale. b) A view of the members looking downsection towards the Permian units (northeast).

The Whistler Member consists of dark grey to black siltstone, which appears heavily weathered along the outcrop succession. The unit is cemented dominantly by dolomite and silica, with minor instances of calcite cement in the upper sections of the unit. Interparticle pores ranging in thickness from 0.5 to 2 mm are infilled by dolomite.

Although no fossils were observed within this member in this study, previous studies by Gibson (1974) at Elliott Peak indicated that rare ammonites, pelecypods, and brachiopods have been observed within the Whistler Member. Trace fossils are generally absent throughout much of the succession, however, near the top of the Whistler Member some instances of diminutive *Planolites* were identified.

4.5 Llama Member

The Llama Member overlies the Whistler Member and is the uppermost unit of the Sulphur Mountain Formation. The thickness of this unit is approximately 15 m, with the basal contact with the Whistler Member occurring at 485 m above the Permian–Triassic boundary and the upper contact occurring at 500 m above the Permian–Triassic boundary at the contact with the overlying Starlight Evaporite Member (Figure 7a, b).

The Llama Member is composed of very porous sandstone that is cemented by calcite. Unweathered sections appear pale yellow to light grey. The unit is massive to crudely cross-stratified. There were no fossils collected in this unit. Bioturbation is minor and includes rare and diminutive examples of *Palaeophycus* and *Planolites*.

4.6 Starlight Evaporite Member

The Starlight Evaporite Member unconformably overlies the Llama Member of the Sulphur Mountain Formation and was deposited following the erosion of the Sulphur Mountain Formation. This member is overlain unconformably by the Jurassic Nordegg Member of the Fernie Formation. The Starlight Evaporite Member is approximately 530 m thick (Figure 7a, b).

This member is highly variable and includes limestone, dolostone, and siltstone. Fractures are variable throughout the unit and range from vertical to horizontal in aspect and are often irregular; fractures are typically infilled by calcite or dolomite. Large vugs (0.5 to 2 cm) are present throughout and are infilled by calcite and dolomite. Thick beds of sandstone (20–30 m) are preserved throughout the succession and are bright red.

Fossil material is not common in the Starlight Evaporite Member. Rare disarticulated shelly debris, replaced by calcite and dolomite, was observed. Trace fossils are absent.

4.7 Nordegg Member

The Nordegg Member of the Fernie Formation is 75 m thick and unconformably overlies the Starlight Evaporite Member of the Spray River Group. The basal 20 m of the Nordegg Member is a thinly bedded siltstone and sandstone, which contains abundant fossil debris. Large ammonites and bivalves are preserved, but specific taxonomic identification of the samples has not been completed. The upper 55 m of the Nordegg Member is composed of limestone and black to grey chert (Figure 8a, b), which makes it lithologically distinct from the lower unit. The contact between the two is conformable and appears as a distinct lithological contact between the lower siltstone/sandstone and overlying carbonate deposits. Fossils and trace fossils were not observed in the upper carbonate unit.

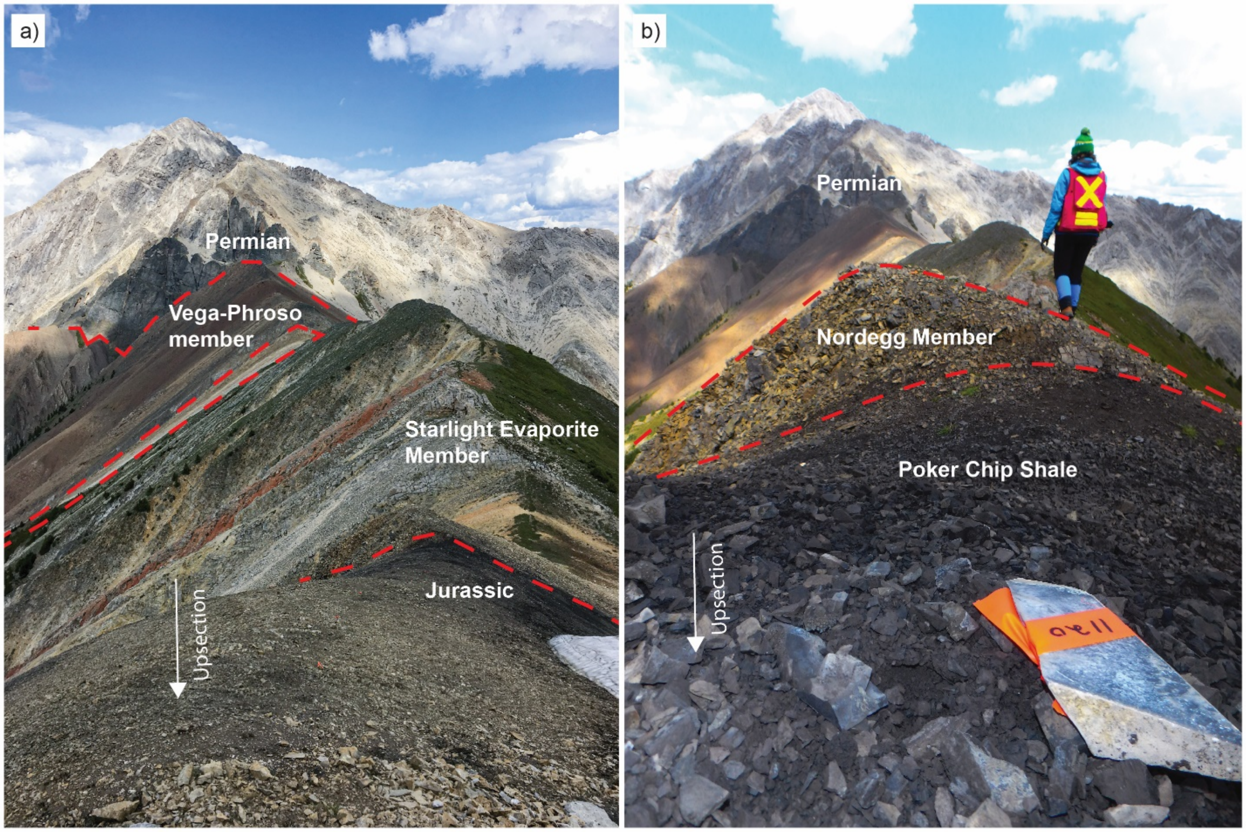

Figure 8. Examples of the Jurassic units, central Alberta. a) Looking downsection towards the Permian from the top of the succession. The Jurassic is predominantly represented by the Poker Chip Shale of the Fernie Formation. b) Example of the Nordegg Member of the Fernie Formation. Field crew member for scale.

4.8 Poker Chip Shale

The Poker Chip Shale of the Fernie Formation is the uppermost unit along the ridge and is approximately 45 m thick. The member is unconformably overlain by a Cambrian deposit, which is a significant cliff-forming unit in the area (Figure 8b). The member ranges from shale to silty mudstone and consists of black to dark grey rocks. Sedimentary structures, trace fossils, and fossils were not observed in the study area.

5 Conclusions

The Triassic is observable at a number of well-exposed outcrop sections throughout the outcrop belts of Alberta. Correlation of these outcrop sections with the subsurface can be aided by using chemostratigraphic methods, including the collection of samples for geochemical analysis. Although primarily an opportunity to collect samples for such analysis, the work completed at Elliott Peak is also an initial analysis into the stratigraphic relationships between the members of the Spray River Group. Samples collected will be geochemically analyzed and thin sections will be created. The intent of this report is to illustrate the general stratigraphic framework observable at Elliott Peak.

Future studies will refine observable facies and contacts. Additionally, chemostratigraphic analysis of this outcrop section will allow for broad correlations to be extended into the subsurface, where Triassic-age core have been recovered and then analyzed by X-ray fluorescence. This work will confirm the location of contacts between members, which will refine the stratigraphic column along the ridge.

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Appendix 1 – Type Localities for the Triassic Spray River Group, Alberta

Number (see Figure 2)	Outcrop Location	Latitude	Longitude	Park	Group/Member
1	Spray River gorge	51°05'54.0"N	115°30'35.0"W	Banff National Park	Spray River Group
2	Phroso Creek	53°37'20.5"N	118°56'03.9"W	Willmore Wilderness Park	Phroso Siltstone Member
3	Mowitch Creek	53°22'59.0"N	118°35'17.3"W	Jasper National Park	Vega Siltstone Member
4	Whistler creek / Wildhay River	53°36'42.9"N	119°06'21.6"W	Willmore Wilderness Park	Whistler Member
5	Llama Mountain	53°48'30.9"N	119°29'06.7"W	Willmore Wilderness Park	Llama Member
6	Llama Mountain	53°48'30.9"N	119°29'06.7"W	Willmore Wilderness Park	Starlight Evaporite Member
7	Winnifred pass	53°38'07.3"N	119°12'00.9"W	Willmore Wilderness Park	Winnifred Member

Note: Coordinates for the outcrop sections were found by integrating the map from Gibson's (1966) thesis with Google Maps. Data was compiled from Warren (1945) and Gibson (1966, 1968a, b, 1969, 1971a, b, 1972, 1974, 1975).