Jurassic stratigraphy and tectonic evolution of the Whitehorse trough, central Yukon: Project outline and preliminary field results

L.H. van Drecht, L.P. Beranek*
Department of Earth Sciences, Memorial University of Newfoundland

M. Hutchison
Yukon Geological Survey

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ABSTRACT

Lower to Middle Jurassic strata of the Laberge Group define the Whitehorse trough and preserve syntectonic sedimentation in central Yukon during the exhumation of adjacent terranes. A two-year project was initiated in summer 2016 to investigate Laberge Group stratigraphy and test the relationships between the timing of exhumation, sedimentation, and terrane accretion in the northern Canadian Cordillera. Field studies along the Robert Campbell and North Klondike highways near Carmacks targeted marginal marine, tidal and fluvial-dominated strata of the Tanglefoot formation that were likely deposited in semi-arid environments. Studied outcrops of fan-delta conglomerate and turbiditic strata of the Richthofen formation along the eastern shoreline of Lake Laberge and on Mount Laurier are consistent with the south-directed deepening of the Whitehorse trough. Field observations will be integrated with detrital zircon (U-Pb and Hf isotope) studies to constrain the provenance of the Laberge Group and reconstruct source-to-sink pathways in the Whitehorse trough.

* *lberanek@mun.ca*

INTRODUCTION

The Intermontane terranes of the Canadian Cordillera (*e.g.*, Slide Mountain, Yukon-Tanana, Stikinia) accreted to the western margin of Laurentia during the late Paleozoic to mid-Mesozoic (*e.g.*, Nelson *et al.*, 2013). The early growth of the northern Canadian Cordillera is in part recorded by the Whitehorse trough, a sedimentary basin that developed on top of the Intermontane terranes during Early to Middle Jurassic closure of the Cache Creek Ocean and accretion of Stikinia (Nelson *et al.*, 2013; Colpron *et al.*, 2015). The Whitehorse trough (Fig. 1) is a regionally significant depocentre that extends over 600 km from the Carmacks region of central Yukon to the Dease Lake region of northern British Columbia. Synorogenic strata of the Laberge Group filled the Whitehorse trough in central Yukon (*e.g.*, Tempelman-Kluit, 1984; Lowey *et al.*, 2009) and were most likely sourced from exhumed basement units of the Yukon-Tanana, Stikinia and Quesnellia terranes (*e.g.*, Dickie and Hein, 1995; Hart *et al.*, 1995; Colpron *et al.*, 2015). The northern apex of the Whitehorse trough near Carmacks consists of marginal marine to fluvial strata of the Tanglefoot formation, whereas the middle parts of the trough near Lake Laberge contain turbiditic strata of the Richthofen formation (Tempelman-Kluit, 1984; Lowey, 2004; Lowey *et al.*, 2009). Mass-flow fan-delta conglomerate is present in both formations (Tempelman-Kluit, 1984; Lowey, 2004). North-to-south, longitudinal changes in sedimentary facies imply a deepening of the Whitehorse trough to the south (Lowey, 2004; Lowey *et al.*, 2009).

Despite recent advances in understanding the sedimentology and depositional setting of Laberge Group strata (*e.g.*, Lowey *et al.*, 2009; Bordet, 2016; Colpron *et al.*, 2016), comparatively few investigations have addressed the stratigraphic responses of Jurassic unroofing or tested relationships between the timing of exhumation, sedimentation and terrane accretion (*e.g.*, Hart *et al.*, 1995; Colpron *et al.*, 2015). For example, Colpron *et al.* (2015) used detrital zircon U-Pb ages to suggest that basal Laberge Group strata young from northeast (Rhaetian-Hettangian) to southwest (Pleinsbachian-Toarcian) across the Whitehorse trough in central Yukon. The westward younging of basal Laberge Group strata may indicate that subsidence followed uplift of the western shoulder of the Whitehorse trough (Colpron *et al.*, 2015). The cause of subsidence is uncertain, but in some regions may be connected to tectonic loading and west-directed emplacement of the Cache Creek terrane on top of Stikinia (*e.g.*, Mihalynuk *et al.*, 1994, 2004). A two-year project was initiated in summer 2016 to test these hypotheses and constrain the field geology and detrital zircon (U-Pb and Hf isotope) provenance signatures of Laberge Group strata. The short-term objectives of the project, which in part are presented in this report, are to define the physical stratigraphy, depositional setting and basal contact relationships of Laberge Group strata along the Robert Campbell and North Klondike highways, the eastern shoreline of Lake Laberge, and near Mount Laurier. The long-term objectives of the project are to constrain the source-to-sink pathways and paleodrainage systems of the Whitehorse trough in central Yukon and link the timing and nature of Laberge Group sedimentation to the Jurassic exhumation of the Intermontane terranes.

TECTONIC SETTING

The western edge of Laurentia was an accretionary margin that underwent several collisional events during the late Paleozoic to Mesozoic. In Late Triassic-Jurassic time, arc sequences of the Yukon-Tanana, Stikinia and Quesnellia terranes evolved along a tectonically complex margin. The most popular model for the Late Triassic-Jurassic margin involves the collision of the Kutcho arc, counterclockwise bending of the Intermontane terranes, and subsequent entrapment of oceanic rock units assigned to the Cache Creek terrane (Mihalynuk *et al.*, 1994; Logan and Mihalynuk, 2014; Colpron *et al.*, 2015). During the Late Triassic to Early Jurassic, pluton emplacement accompanied counterclockwise bending and rapid exhumation of the Yukon-Tanana, Stikinia and Quesnellia terranes in central Yukon (*e.g.*, Johnston *et al.*, 1996). Lower to Middle Jurassic strata of the Laberge Group were shed into the Whitehorse trough during regional tectonism and likely sourced from these exhumed basement rocks. Unconformable contact relationships between the Laberge Group and underlying rock units of the Lewes River Group (Fig. 2; Mesozoic Stikinia) suggest that block faulting pre-dated Early to Middle Jurassic sedimentation in central Yukon (Hart *et al.*, 1995; Colpron *et al.*, 2007, 2015).

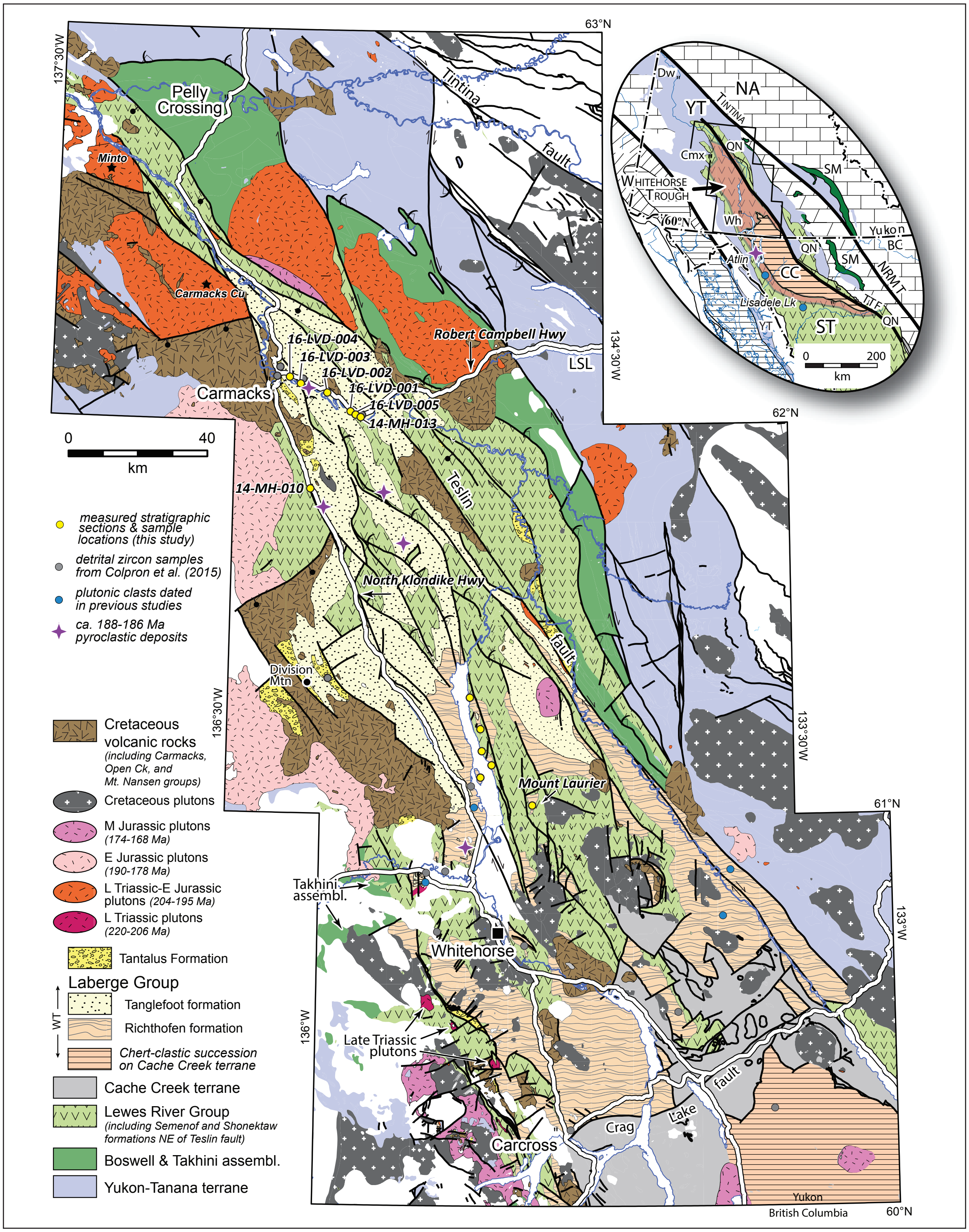

Figure 1. *Regional geology of the Whitehorse trough area modified from Colpron et al. (2015). Locations of 2016 field sites are shown by yellow dots. Field locations on the Robert Campbell Highway represent measured stratigraphic sections. Locations on Lake Laberge and Mount Laurier indicate sampling locations. Grey and blue dots denote detrital zircon sample locations of Colpron et al. (2015) and previously dated plutonic clasts. The inset map shows Intermontane terranes and their present geometry. Abbreviations: CC=Cache Creek terrane; CMx=Carmacks; Dw=Dawson; LSL=Little Salmon Lake; NA=rocks of ancestral North America; NRMT=Northern Rocky Mountain Trench fault; QN=Quesnellia; SM=Slide Mountain terrane; ST=Stikinia; TTF=Teslin-Thibert fault; Wh=Whitehorse; and YT=Yukon-Tanana terrane.*

STRATIGRAPHIC FRAMEWORK

LEWES RIVER GROUP

The Lewes River Group of Stikinia is a 3000 m-thick assemblage of basalt and andesite, flow breccia, crystal tuff, conglomerate, greywacke, limestone and shale (Fig. 2; Tempelman-Kluit, 1984; Dickie and Hein, 1995; Hart, 1997). The Povoas formation (Carnian) represents the main volcanic unit of the Lewes River Group and is characterized by lava flows, volcanic breccia, tuff and agglomerate (Tempelman-Kluit, 1984, 2009). The Aksala formation represents a volcanic lull following Carnian magmatism and consists of the Casca (Carnian-Norian), Hancock (Norian-Rhaetian) and Mandanna (Rhaetian) members (Fig. 3; Tempelman-Kluit, 2009). The Casca member comprises lithic sandstone, argillite and conglomerate, the Hancock member is a reefal limestone and the Mandanna member is a maroon lithic sandstone, mudstone and conglomeratic sequence that locally interfingers with the Hancock member (Tempelman-Kluit, 1984; Dickie and Hein, 1995).

LABERGE GROUP

The Whitehorse trough contains ~3000 m of siliciclastic strata assigned to the Laberge Group (Dickie and Hein, 1995). In central Yukon, the Laberge Group is divided into the Tanglefoot formation, Richthofen formation and Nordenskiöld dacite (Tempelman-Kluit, 1984). Field mapping and seismic surveys indicate that southwest-verging fold and thrust faults structurally characterize the Whitehorse trough (Colpron *et al*., 2007; White *et al*., 2012). Upper Jurassic to Lower Cretaceous fluviodeltaic rocks of the Tantalus Formation unconformably overlie the Laberge Group (Hart and Radloff, 1990; Dickie and Hein, 1995).

Tanglefoot formation

The Tanglefoot formation (Fig. 2) is restricted to the northern half of the Whitehorse trough and characterized by interbedded Sinemurian-Bajocian sandstone and mudstone, matrix-supported conglomerate, pebbly sandstone, coal and abundant terrestrial plant and marginal marine fossils (Lowey, 2004). Previously, all mappable conglomerate in the Whitehorse trough was included in a 'Conglomerate formation' (Tempelman-Kluit, 1984). However, conglomerate is present in both of Tanglefoot and Richthofen formations (Lowey, 2004).

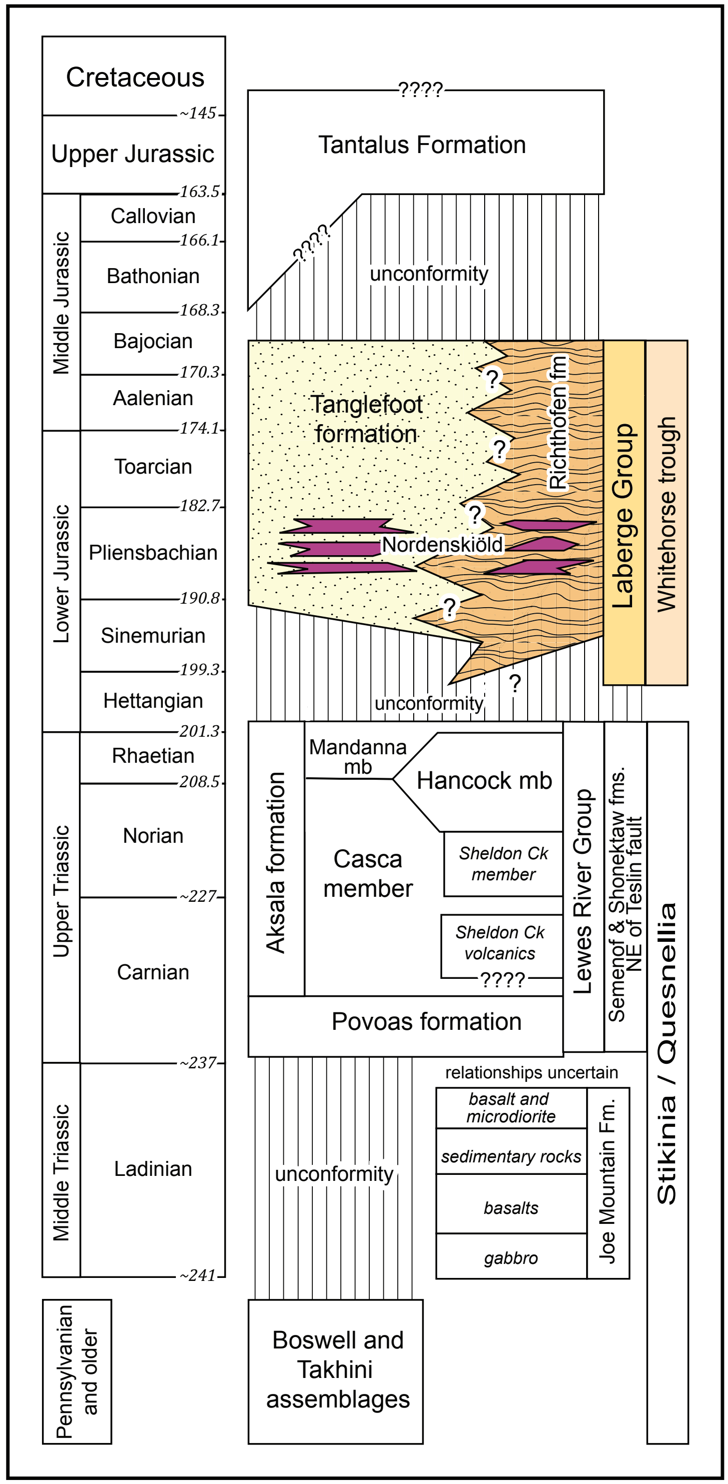

Figure 2. *Schematic stratigraphy of Stikinia, Quesnellia and the Whitehorse trough as compiled by Colpron et al. (2015).*

Richthofen formation

The Richthofen formation consists of Sinemurian-Bajocian graded siltstone to very fine grained sandstone and mudstone couplets or thin-bedded turbidite (Lowey, 2004) that are associated with mass-flow conglomerate. Pebbly sandstone, massive sandstone, volcaniclastic rocks and minor limestone are also present in the Richthofen formation (Lowey *et al.*, 2009). The type area is located along the west shore of Lake Laberge where the Richthofen formation crops out along the beach beside the Lake Laberge campground boat launch (Tempelman-Kluit, 1984; Lowey, 2004).

Nordenskiöld dacite

The Nordenskiöld dacite consists of epiclastic and primary dacitic tuff and flows (Tempelman-Kluit, 1984) that have been identified at three stratigraphic levels in the Tanglefoot and Richthofen formations (Colpron *et al.*, 2007). Zircon U-Pb ages of 188.1 ± 0.4 Ma, 187. 2 ± 0.4 Ma, and 186.5 ± 0.3 Ma indicate that the Nordenskiöld dacite preserves several eruptive events during the Early Jurassic (Colpron and Friedman, 2008).

2016 FIELD STUDIES

The Whitehorse trough was studied in four areas during summer 2016. Stratigraphic sections of the Laberge Group were measured or described at seven locations along the Robert Campbell and North Klondike highways (Fig. 1). Laberge Group rocks were regionally mapped along the east shore of Lake Laberge and at Mount Laurier because of the lack of continuous sections in these areas.

ROBERT CAMPBELL HIGHWAY

The Tanglefoot formation is well exposed along the Robert Campbell Highway east of Carmacks (Fig. 1). Six stratigraphic sections were measured between Carmacks and Frenchman Road and range from 12 to 96 m thick (Fig. 3).

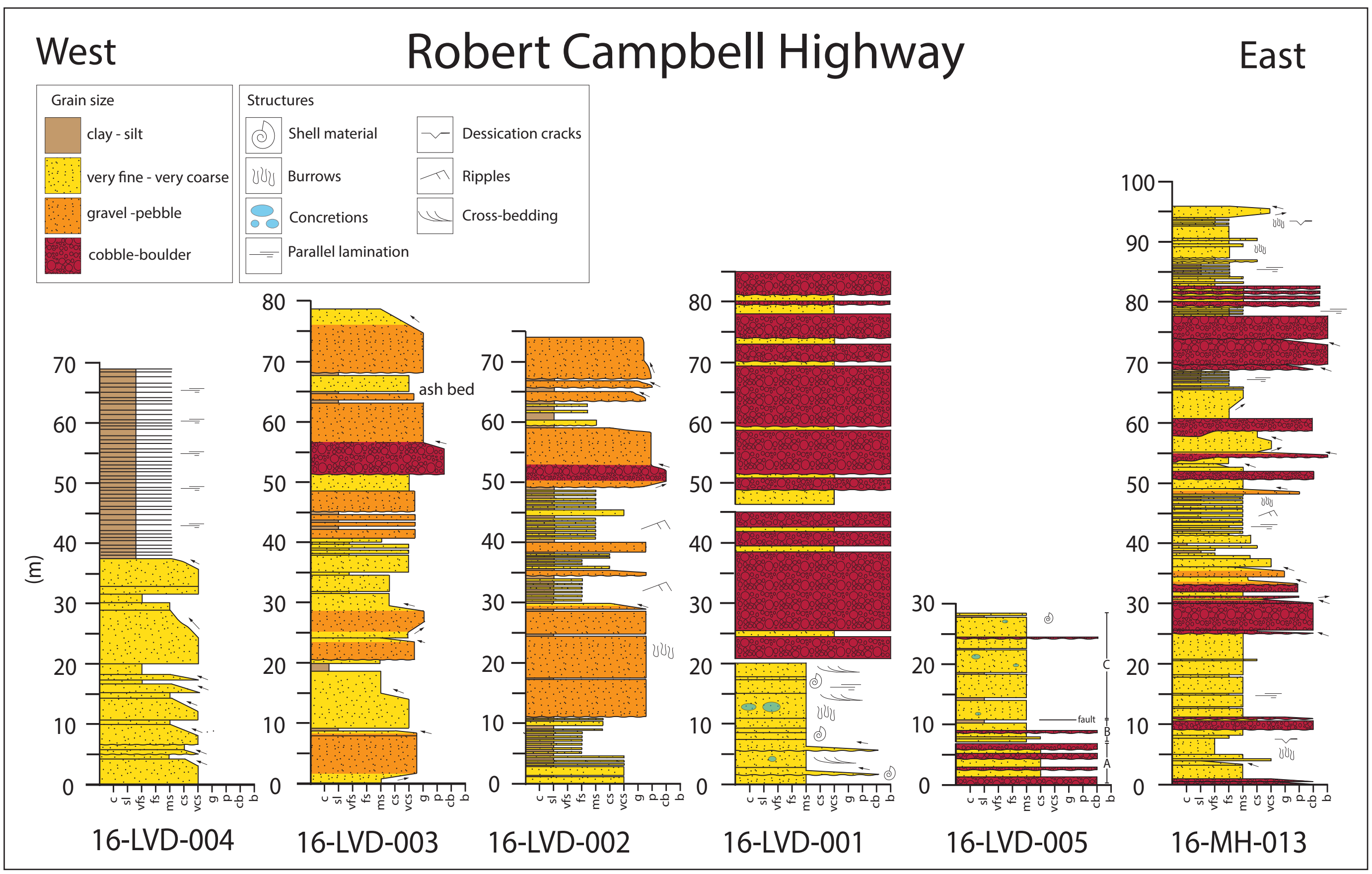

Figure 3. *Measured stratigraphic sections from the Robert Campbell Highway. Sections young from east to west. Arrows indicate fining upward or coarsening upward. Grain size abbreviations: c = clay, sl = silt, vfs = very fine grained, fs = fine-grained, ms = medium-grained, cs = coarse-grained, vcs = very coarse grained, g = granule, p = pebble, cb = cobble, and b = boulder.*

LOCALITY 1: 14-MH-013 (EAGLES NEST BLUFF)

Ninety-six metres of Tanglefoot formation crop out on the north side of the Robert Campbell Highway, 25 km east of Carmacks (base of section: zone 08V 456959E 6877113N NAD83; Figs. 3 and 4a). Immediately west of this section, a prominent bluff of Hancock member limestone is exposed. This section comprises maroon and grey, medium-grained sandstone with mud drapes and mudstone/siltstone interbeds that alternate with pebble to boulder conglomerate. Shallow cross-bedding, ripples, burrows, desiccation cracks (Fig. 4b), rain-drop impressions and reduction halos characterize the medium-grained sandstone. These beds have blocky weathering patterns and generally fine-upwards, with the exception of few beds that coarsen up. Conglomeratic beds are composed of subrounded to rounded, poorly sorted, matrix-supported, polymictic clasts (Fig. 4c) and are typically associated with coarsening upward beds. The matrix is composed of poorly-sorted, medium to coarse-grained sandstone and the clasts consist of plutonic rocks, volcanic rocks, limestone and mudstone. The bases of the conglomerate beds are erosional and typically have the largest clasts at the bottom and fine upwards into very coarse sandstone that incorporates floating pebbles. Some conglomerate units cut channel scours (Fig. 4d) into the beds below. Overturned beds dip steeply (75°) to the west and young to the east. Detrital zircon U-Pb data are consistent with Hettangian to Sinemurian depositional ages at this locality (Colpron *et al*., 2015).

Figure 4. *Field photographs of section 14-MH-013 on the Robert Campbell Highway.* ***(a)*** *steeply dipping beds change from maroon beds with abundant desiccation cracks to buff coloured beds;* ***(b)*** *desiccation cracks;* ***(c)*** *poorly sorted, polymictic conglomerate bed; and* ***(d)*** *channel scour with pebble to boulder fill.*

LOCALITY 2: 16-LVD-005

Section 16-LVD-005 is ~0.6 km to the west of Eagles Nest Bluff (Fig. 1). Thirty-six metres of west-dipping rocks were measured in three parts (A, B, C) due to the discontinuity of beds and truncation by faults (base of section: zone 08V 456074E 6877576N NAD83). Fracturing and weathered surfaces made it difficult to observe small-scale sedimentary structures. The stratigraphic younging direction of this section was challenging to determine and therefore units are referred to in cardinal directions.

The eastern most unit (A) comprises seven metres of pebble to boulder, subrounded to rounded, poorly sorted, matrix-supported conglomerate and coarse-grained sandstone with floating pebbles. Plutonic, volcanic, limestone and mudstone clasts are present in the conglomerate. Unit B (11.5 m thick) is dominated by medium to coarse-grained sandstone, with minor conglomerate beds and mudstone/siltstone towards the top of the section. Unit C (western most) comprises 17.5 m of laminated, blue-grey to green, medium-grained, well-sorted sandstone. Large concretions (9-15 cm diameter) are present throughout this unit (Fig. 5a), and a gastropod cast was collected near the top of the section at 17 m (Fig. 5b). Cross-beds are rarely preserved throughout the section, which may be due to the weathered and fractured surface making identification difficult.

LOCALITY 3: 16-LVD-001 (COLUMBIA DISASTER)

A westward-dipping and westward-younging section was measured along the north bank of the Yukon River to the west of Eagles Nest Bluff. The section is 80 m-thick and is divided into two distinct units (base of section: zone 08V 455577E 6877512N NAD83). The lower 20 m consists of green-buff, medium-grained, well-sorted sandstone. The upper section contains thick beds of pebble to boulder conglomerate interbedded with coarse to very coarse grained sandstone. Sixty metres of the upper section were measured along the river, but an approximate 120+ m of stratigraphy is present (Fig. 6a).

Low-angle cross-beds, concretions (up to 50 cm; Fig. 6b), abundant shell material and burrows characterize the lower sandstone unit. Erosional surfaces followed by a pebble lag are present throughout this unit and typically include shell material. At 1.6 m from the base of this section a 5 cm gastropod shell (Fig. 6c) was incorporated in a pebble lag. This macrofossil is intact and has matrix within its whorls indicating that it is not *in situ*, but has probably been transported a short distance. Multiple bivalve-rich beds are present and range in thickness from 3-10 cm (Fig. 6d). The upper 15 m of the stratigraphy is covered by overburden. Conglomeratic beds can be observed cropping out below this unit when river levels are low.

Above the overburden, the upper unit consists of thickly bedded, poorly-sorted conglomerate that ranges in thickness from 0.5 to 5 m. Interbeds of coarse to very coarse grained sandstone range from 30 cm to 2 m thick and typically have floating pebbles and boulders (Fig. 6e).

Figure 5. *Field photographs of section 16-LVD-005 on the Robert Campbell Highway.* ***(a)*** *concretion in medium-grained, well-sorted sandstone; and* ***(b)*** *cast of gastropod macrofossil at 17 m.*

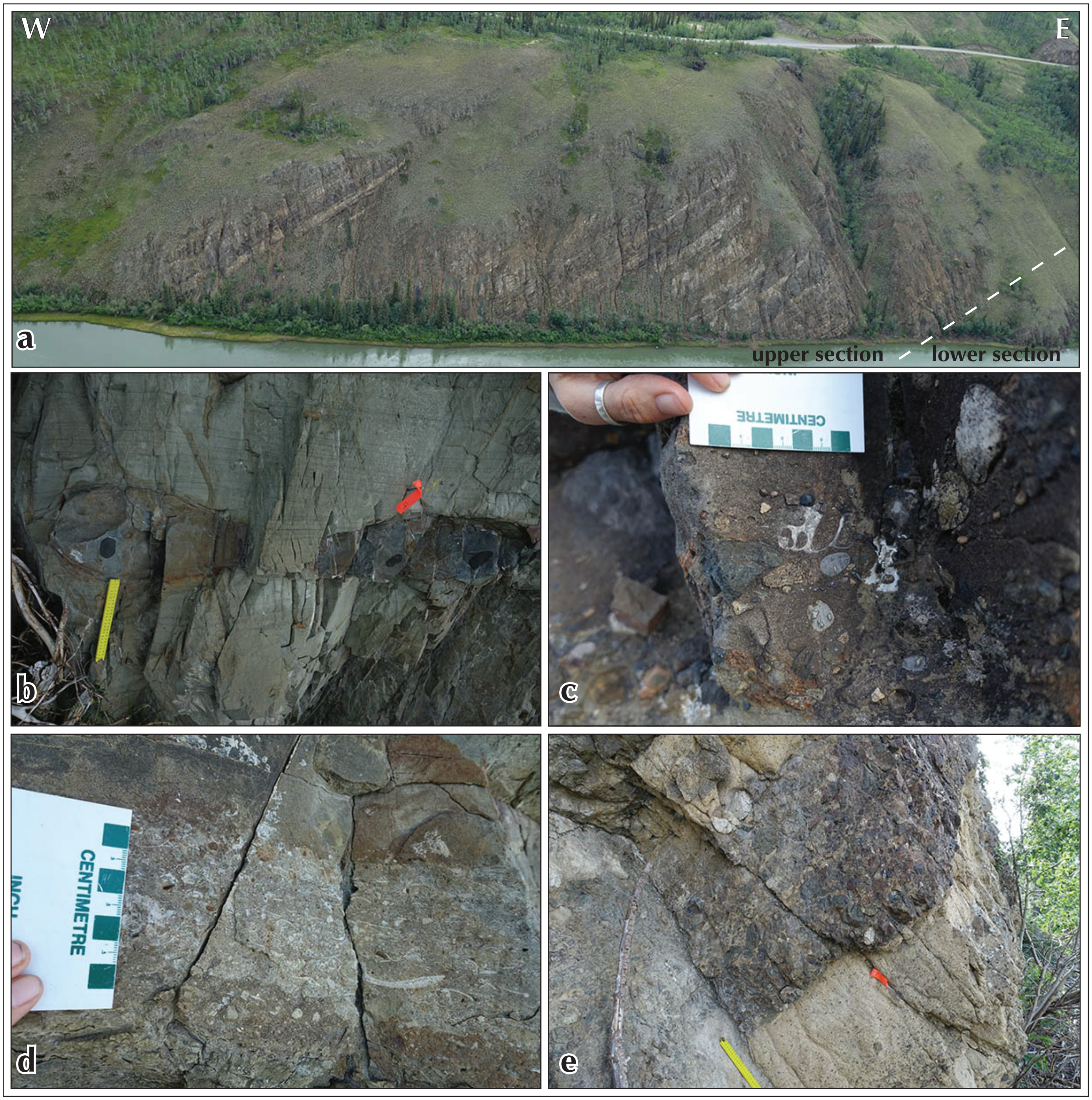

Figure 6. *Field photographs of section 16-LVD-001 on the Robert Campbell Highway.* ***(a)*** *Overall view of the section along the Yukon River. Dark beds represent conglomeratic beds and buff coloured beds represent medium to coarse-grained beds. The lower unit is located on the far right and strata young to the left (west);* ***(b)*** *two aligned concretions in medium-grained, well sorted sandstone;* ***(c)*** *gastropod shell at 1.6 m;* ***(d)*** *macrofossil rich bed; and* ***(e)*** *pebble to boulder, poorly sorted, polymictic conglomerate and medium to coarse-grained sandstone.*

LOCALITY 4: 16-LVD-002 OR (14-MH-016):

This 74 m-thick section comprises massive, very thickly bedded, very coarse to gravel sandstone, pebble to cobble conglomerate and interbedded fine to medium-grained sandstone and mudstone/siltstone that dip to the west (base of section: zone 08V 441784E 6885870N NAD83). Buff coloured, very coarse grained sandstone is massive and very thickly bedded (1-10 m) and incorporates angular mud rip-up clasts and floating pebbles (Fig. 7a). These beds typically have erosional bases with pebble lags. An example of burrowing (Fig. 7b) is found in the lower half of this section and interpreted as *Psilonichnus* (Colpron *et al.*, 2016). Poorly sorted pebble to cobble conglomerate beds fine-upwards and are associated with very coarse grained beds.

Three units (6-8 m) of interbedded, fine to medium-grained sandstone and brown-black mudstone/siltstone punctuate massive sandstone units (Fig. 3). Planar lamination, rootlets, rare charcoal, wave-rippled bed tops and flame structures (Fig. 7c) characterize these rocks. Mottled beds of rusty orange, medium-grained sandstone and clay beds occur throughout these units. Compressional deformation is displayed in interbedded fine to medium-grained sandstone and mudstone/siltstone (Fig. 7d).

LOCALITY 5: 16-LVD-003

Section 16-LVD-003 is 77 m-thick and exposed along a road cut ~10 km east of Carmacks (base of section: zone 08V 441317E 6886180N NAD83). The stratigraphic section was measured on the north side of the road because of better outcrop quality. This section is dominated by thickly bedded (0.5 to 8 m), buff coloured, very coarse and granule, poorly sorted, massive sandstone interbedded with medium-grained sandstone and mudstone. Medium-grained sandstone beds are characterized by parallel laminations and mud rip-up clasts (1 mm to 2 cm). Medium to thickly bedded medium-grained sandstone beds are interbedded with mottled black mudstone and poorly lithified white sandstone.

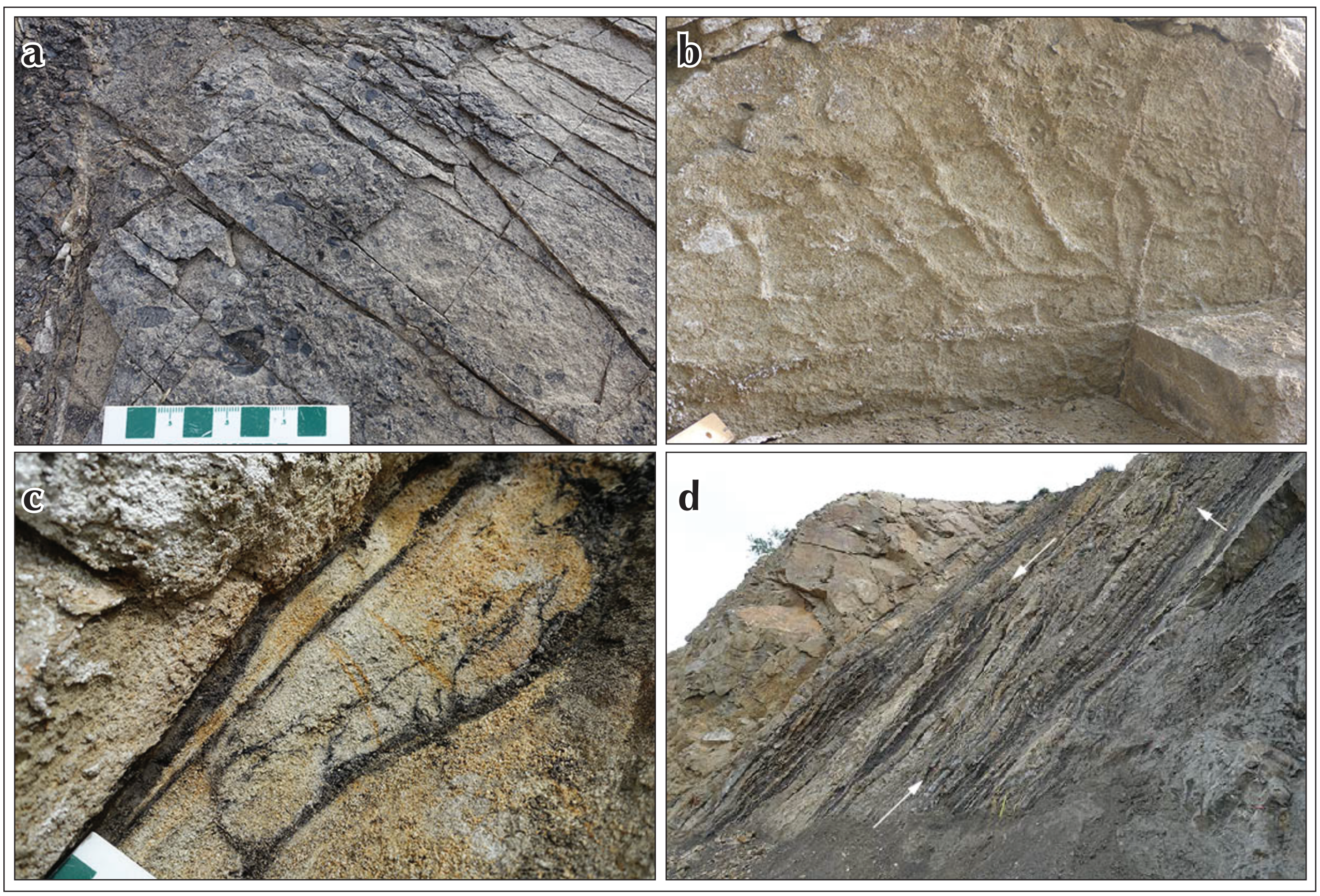

Figure 7. *Field photographs of section 16-LVD-002 on the Robert Campbell Highway.* ***(a)*** *Surface of a rip-up mud clasts rich bed;* ***(b)*** *burrows interpreted to be Psilonichnus;* ***(c)*** *flames structures; and* ***(d)*** *compressional structures indicated by arrows.*

One 3 m-thick bed of pebble to cobble, matrix-supported conglomerate is present with an erosive base that grades into granular sandstone. A Pliensbachian ash bed occurs at 65 m (Colpron *et al*., 2015) on the south side of the road.

LOCALITY 6: 16-LVD-004 (CARMACKS AIRPORT)

This section crops outs near the Carmacks airport and is the westernmost section measured on the Robert Campbell Highway. The stratigraphy has a total thickness of 67 m and is divided into two west-dipping conformable units (Fig. 8a; base of section: zone 08V 436493E 6888370N NAD83). The lower unit is dominated by buff coloured, very coarse-grained sandstone (Fig. 8b) interbedded with medium to thickly bedded (1- 5 cm) silt to medium-grained sandstone. Finer grained interbeds have parallel lamination, faint cross-bedding, possible wave ripples, flame structures (Fig. 8c), and mud rip-up clasts. Very coarse grained beds are typically massive with localized wave ripples and erosional bases that fine-upwards to medium to coarse-grained sandstone. A shift to medium-grained sandstone interbedded with very fine grained sandstone occurs at 38 m (Fig. 8d). This upper unit has an overall dark brown-blue appearance with thin (1 cm) white fine to medium-grained sandstone beds and mud rip-up clasts. The medium-grained sandstone beds are typically 0.5 to 2 cm thick, but 20 to 30 cm-thick beds are also present. Fine-grained sandstone beds are 0.3 to 1 cm thick.

NORTH KLONDIKE HIGHWAY

A 12-m thick section (14-MH-10) was measured on the east side of the North Klondike Highway, 20 km south of Carmacks (Fig. 9; base of section: zone 08V 457323E 6865678N NAD83). It is characterized by dark grey-brown, thinly bedded, fine to medium-grained sandstone and mudstone/siltstone and a sharp transition to white-buff, very coarse grained sandstone at 5 m (Fig. 10a).

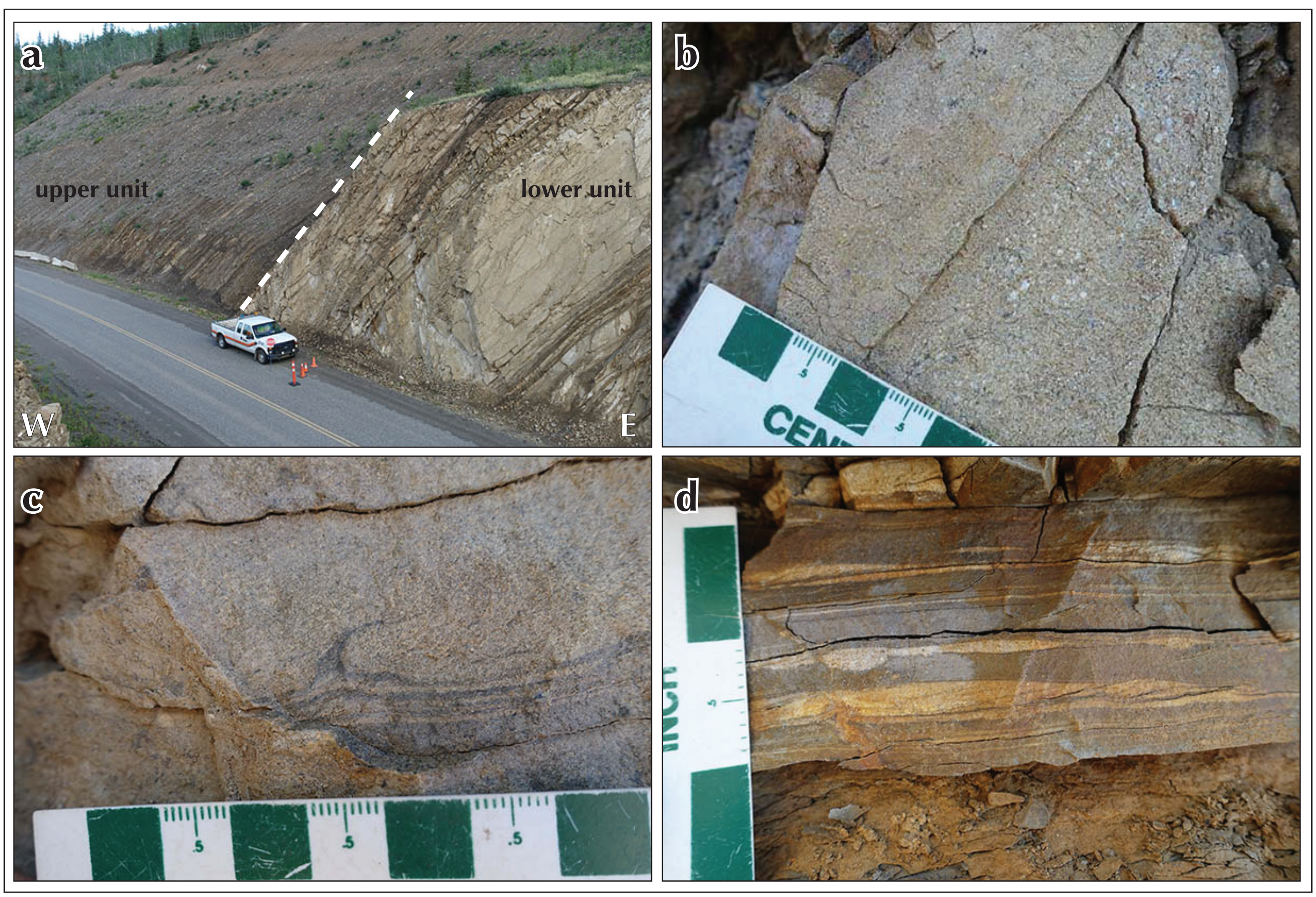

Figure 8. *Field photographs of section 16-LVD-004 on the Robert Campbell Highway.* ***(a)*** *Overall view of the section which has two units;* ***(b)*** *parallel laminations in the lower half of the section;* ***(c)*** *flame structure in the lower half of the section; and* ***(d)*** *thinly bedded, wavy sandstone.*

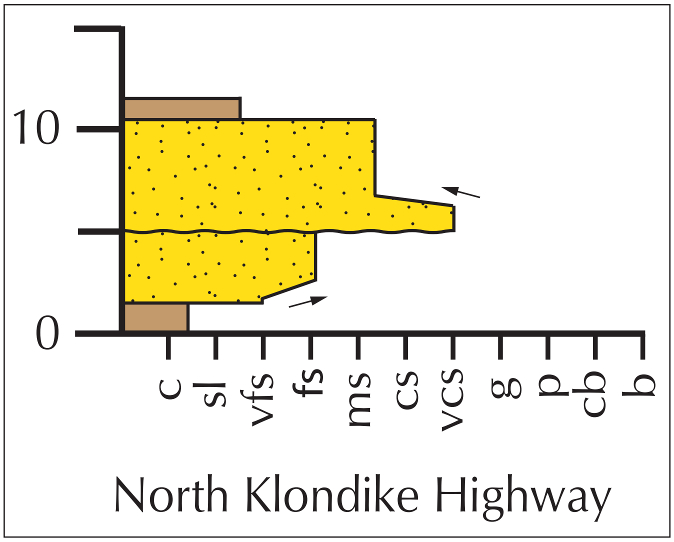

Figure 9. *Measured stratigraphic section 14-MH-010 from the North Klondike Highway just south of Carmacks. This section is potentially a key to tie the Robert Campbell sections to Division Mountain stratigraphy. See figure 3 for legend and grain size abbreviations.*

A flame structure (Fig. 10b) along this contact shows that strata are right way up and young northward. Coarsening upward trends are seen at the bed and section scale. Fine to medium-grained sandstone is internally massive, but some beds show cross-bedding and wave ripples (Fig. 10c). Sedimentary structures are not easily seen in the weathered mudstone beds, but their thickness and frequency decreases up section. Very coarse grained sandstone units (Fig. 10d) have abundant cross-bedding, wavy lamination and large plant fragment represented by coaly stringers. Abundant mica is present in both fine and coarse-grained sandstone.

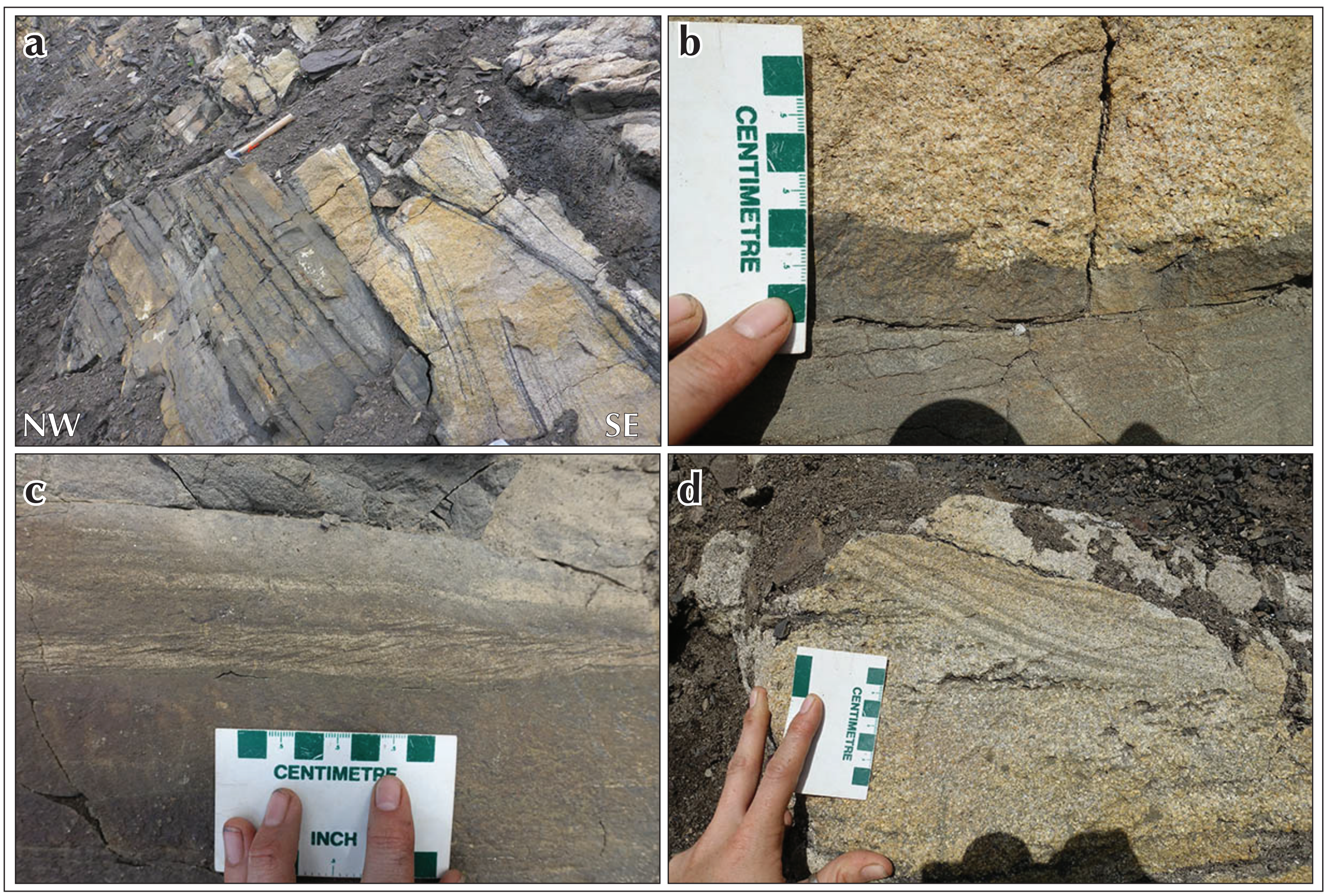

Figure 10. *Field photographs of section 14-MH-010 on the North Klondike Highway.* ***(a)*** *Contact between dark brown fine-grained sandstone to buff coloured coarse-grained sandstone;* ***(b)*** *flame structure at the contact indicated stratigraphic up direction;* ***(c)*** *dark brown fine-grained sandstone with cross-bedding; and* ***(d)*** *buff coloured coarse-grained sandstone.*

LAKE LABERGE

The Lewes River Group and basal Laberge rocks (Richthofen formation) crop out along the east side of Lake Laberge and are included in a multi-year regional mapping project initiated by the Yukon Geological Survey in 2015 (Bordet, 2016). The contact between the resistant Hancock member limestone, which forms prominent north to south-trending ridges, and Richthofen formation rocks was targeted during 2016 field investigations. The similar lithologies of the upper stratigraphic level of the Lewes River Group and overlying Richthofen formation make differentiation of these strata difficult. Due to these similarities, contact relationships with Hancock member limestone are also difficult to constrain. Where Laberge Group is positively identified, it unconformably overlies the Lewes River Group.

Small-scale sedimentary structures were difficult to distinguish in vegetated, inland areas because of the recessive nature of Richthofen formation mudstone/siltstone and fine-grained sandstone. Rocks that crop out along the shoreline of Lake Laberge therefore provide the best type of exposures to document such features. Interbedded mudstone and fine-grained sandstone of the Richthofen formation are continuous along ~11 km of the Lake Laberge shoreline by the mouth of Laurier Creek. Small-scale faulting affects some shoreline exposures (Fig. 11a). Some thin-bedded units have burrowed beds (Fig. 11b), flame structures, cm-scale concretions (Fig. 11c), soft-sediment deformation and are intermittently slightly calcareous. Massive, medium-grained sandstone beds have rare burrows, floating pebbles and are interbedded with mudstone and fine-grained sandstone. Soft sediment deformation, mudstone rip-up clasts (Fig. 11d), and limestone clasts (Fig. 11e) are also abundant south of Laurier Creek. Richthofen formation rocks in proximity to limestone are either pale green-blue, fine to medium-grained sandstone and have aligned concretions or interbedded fine-grained sandstone and mudstone that incorporates subangular to subrounded limestone clasts (3 cm to 1 m). Rare monomictic limestone conglomerate of the Lewes River Group is also present throughout the field area (Fig. 11f).

The eastern shoreline of Richthofen Island exposes west dipping, thin-bedded mudstone/siltstone and fine-grained sandstone, fine to medium-grained sandstone with floating pebbles and matrix-supported pebble to boulder conglomerate with sedimentary, plutonic and volcanic clasts. Brown-black mudstone and buff fine-grained sandstone are rhythmically bedded and display synsedimentary deformation. Buff coloured, fine to medium-grained sandstone is massive and incorporates floating pebbles to cobbles, which include mudstone and limestone clasts. An unusually large limestone clast measuring ~20 by 20 m was observed on Richthofen Island.

MOUNT LAURIER

Mount Laurier is located northeast of Whitehorse between Lake Laberge and Teslin Mountain. This area is underlain by west-dipping Hancock member limestone and overlying strata of the basal Laberge Group (Bordet, 2016; Figs. 12 and 13a). Mount Laurier was visited in 2016 as part of this project to study Laberge Group strata in greater detail. Laminated, thinly bedded, dark brown-black mudstone and blue-grey, very fine to fine-grained sandstone were observed to unconformably overlie the massive limestone. Brown, matrix-supported pebble to boulder polymictic conglomerate (Fig. 13b) overlies finer grained units and makes up the ridge of Mount Laurier (Figs. 5 and 13c). Poorly-sorted, subrounded to rounded, sedimentary clasts (mudstone, limestone and rare chert), and intrusive and volcanic clasts constitute the conglomerate. The clasts range in size from 2 to 15 cm with rare larger clasts (20 to 60 cm). Buff coloured fine to medium-grained sandstone beds and lenses occur throughout the conglomerate (Fig. 12) and have cross-beds, climbing ripples and soft sediment deformation (Fig. 13d,e).

PRELIMINARY CONCLUSIONS

New stratigraphic observations and field mapping in 2016 helped to constrain the depositional history of the northern Whitehorse trough. Maroon coloured Tanglefoot formation rock units at the lower Robert Campbell Highway section (14-MH-013) are consistent with a semi-arid climate (desiccation cracks and oxidization) that was punctuated with intervening fan-delta conglomeratic sedimentation and may indicate a marginal marine to fluvial environment. Section 16-LVD-005, west of Eagles Nest Bluff, likely preserves a shift to shallow-marine sedimentation with the occurrences of cross-beds, concretions and rare fossils. Farther west, at locality 16-LVD-001, strata also are consistent with a shallow marine environment, but at this locality, abundant shell material is present and suggests proximity to the Hancock reef. This depositional setting is then disrupted

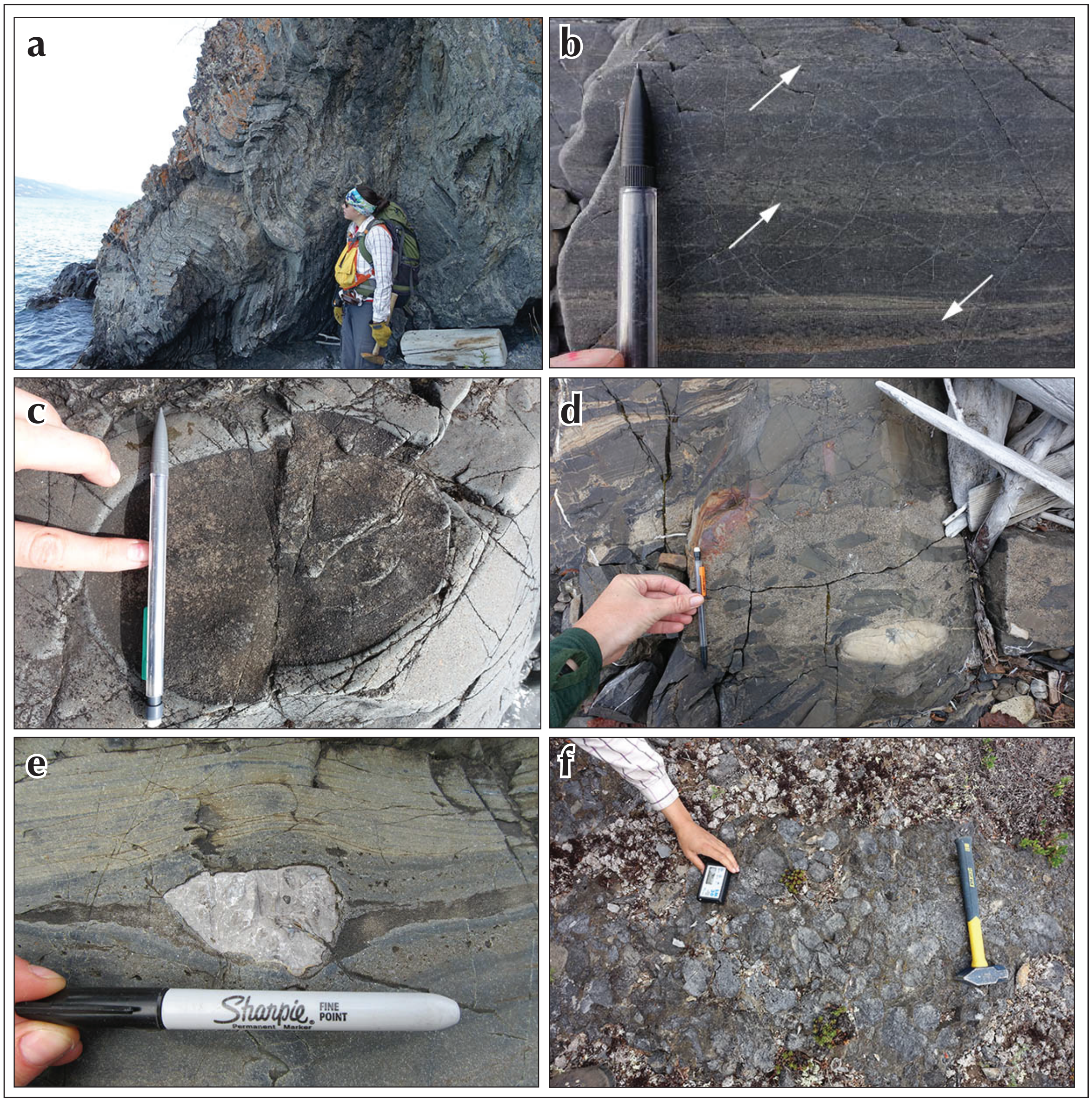

Figure 11. *Field photographs of Laberge Group strata, Lake Laberge.* ***(a)*** *Folding in fine-grained thinly bedded sandstone and mudstone interpreted to be Richthofen formation;* ***(b)*** *thinly bedded burrowed beds on the shoreline of Lake Laberge;* ***(c)*** *faulted concretion in interpreted Richthofen formation strata;* ***(d)*** *angular mudstone rip-up clasts in a medium to coarse-grained matrix;* ***(e)*** *small limestone clast within Richthofen formation strata; and* ***(f)*** *monomictic limestone conglomerate of Lewes River Group.*

by the emplacement of thick beds of pebble to boulder conglomerate that could be fan-delta deposits. At section 16-LVD-002, *Psilonichnus* burrows and wave-rippled beds suggest a shift to an estuarine or tidal delta depositional environment. Section 16-LVD-003 and the lower half of section 16-LVD-004 appear to be a continuation of this depositional environment, with coarse sedimentation dominating. A decrease in energy of the depositional system occurs at 37 m in section 16-LVD-004 and is comparable to the packages of thinly interbedded sandstone and mudstone in section 16-LVD-002. On the North Klondike Highway, the coarsening upward, wave-rippled bed tops and coal fragments of section 14-MH-010 are consistent with a tidal delta or estuarine depositional environment. This section may represent an important tie between the Robert Campbell Highway sections and coal deposits at Division Mountain ~80 km south of Carmacks. The sharp boundary in this section is also

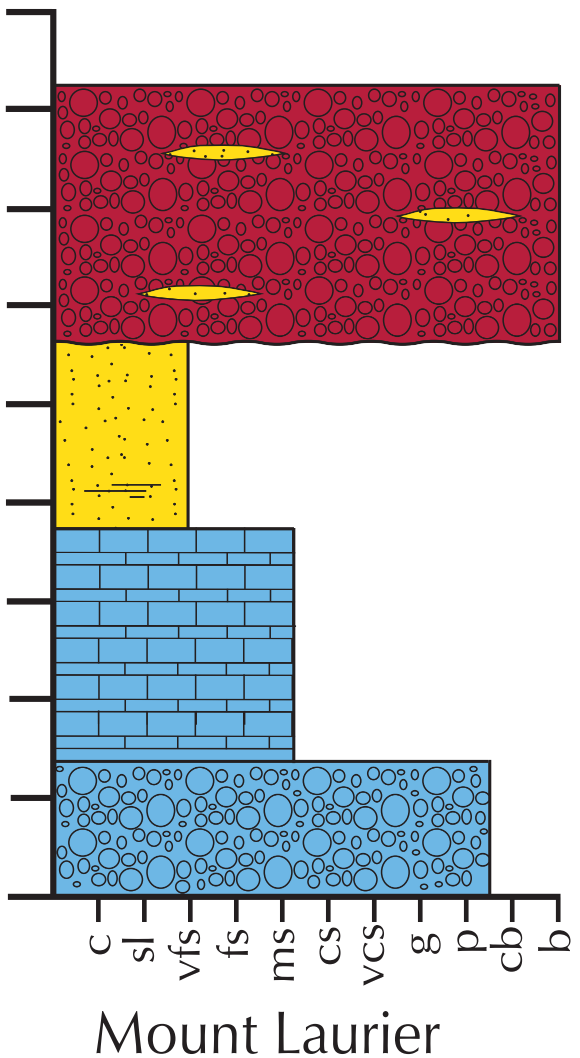

Figure 12. *Schematic stratigraphic section of Mount Laurier stratigraphy. See figure 3 for legend and grain size abbreviations. Blue=limestone, yellow=fine to very coarse grained sandstone, and red=pebble to boulder conglomerate.*

observed at Division Mountain and is associated with the change from coal-barren to coal-bearing strata (Colpron *et al.*, 2016). During summer 2016, Tanglefoot formation strata were only observed along the Robert Campbell and North Klondike highways, which is consistent with the observation that these rocks are restricted to the northern Whitehorse trough (*e.g.*, Lowey, 2004).

On the east side of Lake Laberge, finely bedded sandstone and mudstone packages are preliminarily interpreted to be Richthofen formation as they resemble rock units at the type section near the Lake Laberge campground. At Mount Laurier, thinly bedded sandstone and mudstone of the Richthofen formation are overlain by conglomerate that may represent submarine fan deposits. Sedimentary successions at both locations are indicative of turbiditic facies and likely indicate a deepening of the depositional environment from the Robert Campbell Highway in the north to Lake Laberge in the south. Limestone clasts included in Richthofen formation strata are probably eroded from Hancock member reef facies. In these areas, there are stratigraphic, and potentially structural, contacts between Lewes River and Laberge group strata that will be the focus of future field and laboratory investigations. For example, uncertain contact relationships will be informed by detrital zircon U-Pb studies that seek to discriminate upper Lewes River Group strata from basal Laberge Group strata.

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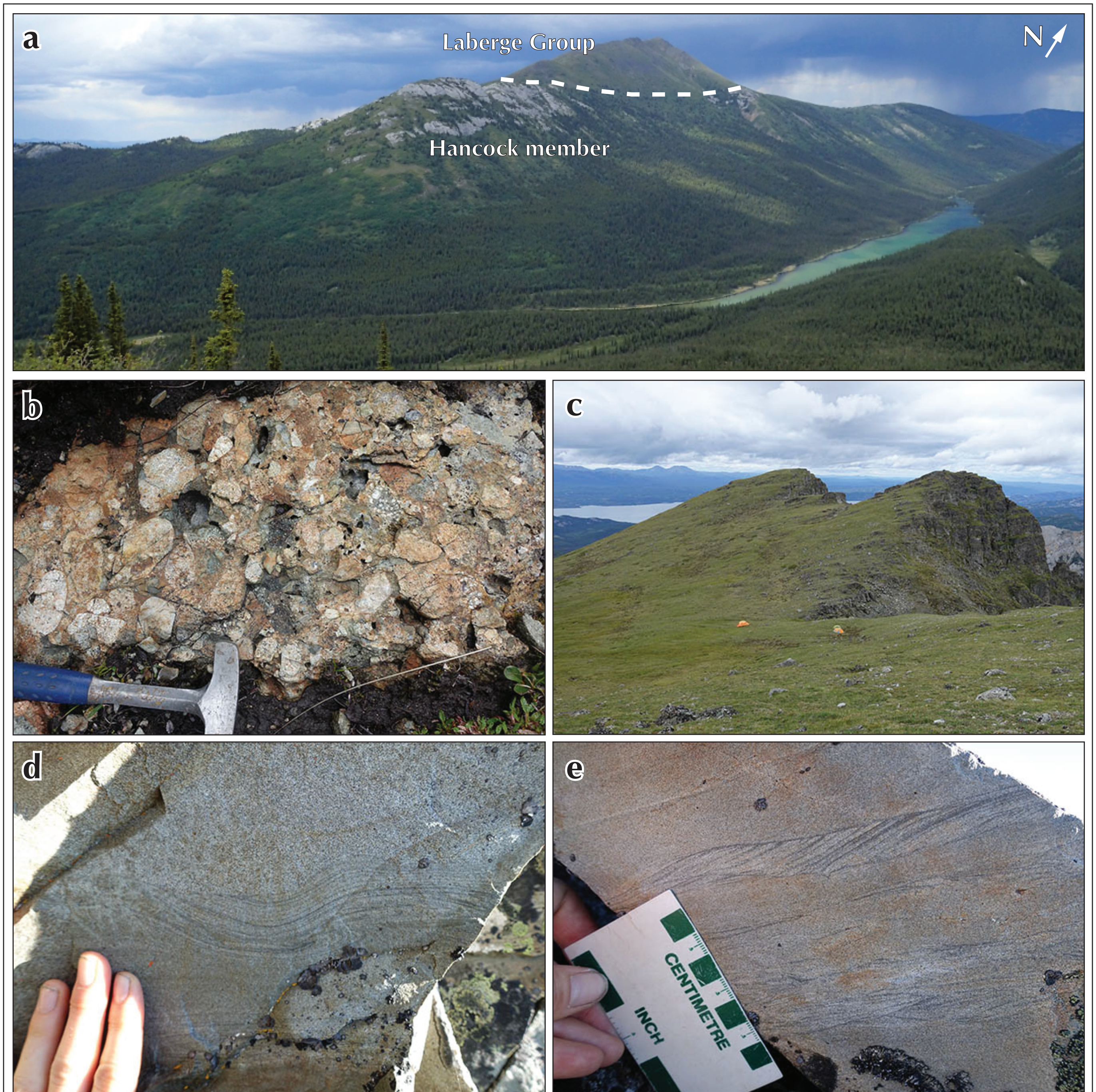

Figure 13. *Field photographs of Laberge Group strata, Mount Laurier.* ***(a)*** *Laberge Group overlying Hancock member limestone at Mount Laurier;* ***(b)*** *subrounded to rounded, poorly-sorted, polymictic conglomerate;* ***(c)*** *Mount Laurier ridge dominated by Laberge Group conglomerate;* ***(d)*** *truncated soft sediment deformation in fine to medium-grained sandstone; and* ***(e)*** *climbing ripples in fine to medium-grained sandstone.*

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