MEASURED STRATIGRAPHIC SECTION, LOWER NANUSHUK FORMATION (ALBIAN), SLOPE MOUNTAIN (MARMOT SYNCLINE), ALASKA

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Preliminary Interpretive Report 2022-1

View toward the northeast showing a thick coarsening-upward succession in the Nanushuk Formation from approximately 88 m to 125 m on sheet 1 (top of PS4 and all of PS5).

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MEASURED STRATIGRAPHIC SECTION, LOWER NANUSHUK FORMATION (ALBIAN), SLOPE MOUNTAIN (MARMOT SYNCLINE), ALASKA

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INTRODUCTION

LePain and others (2009) presented a detailed analysis of Nanushuk depositional systems in the eastern part of its outcrop belt. They presented detailed snippets of larger measured sections in the body of the report to illustrate facies associations and included more complete, although simplified, versions of measured stratigraphic sections from key locations in an appendix. The purpose of this brief report is to present a detailed measured section through the lower marine part of the Nanushuk exposed on the southeast face of Slope Mountain (figs. 1–3 and sheet 1). Shoreface and delta front parasequences documented in this report, particularly the basal Nanushuk sandstone body, serve as outcrop analogues for marine parasequences in the lower part of the formation in an exploration fairway that extends from a short distance south of Umiat to the Beaufort Sea and from an ultimate Nanushuk shelf margin east of the Colville River to the Chukchi Sea coast. This report is timely as several large oil discoveries have been announced in the past eight years in the eastern part of this fairway in shoreface-delta front reservoirs near the base of the Nanushuk. Not surprisingly, the area is the focus of significant exploration interest and development activities are underway in at least two of the recent discoveries (Willow and Pikka; see fig. 1).

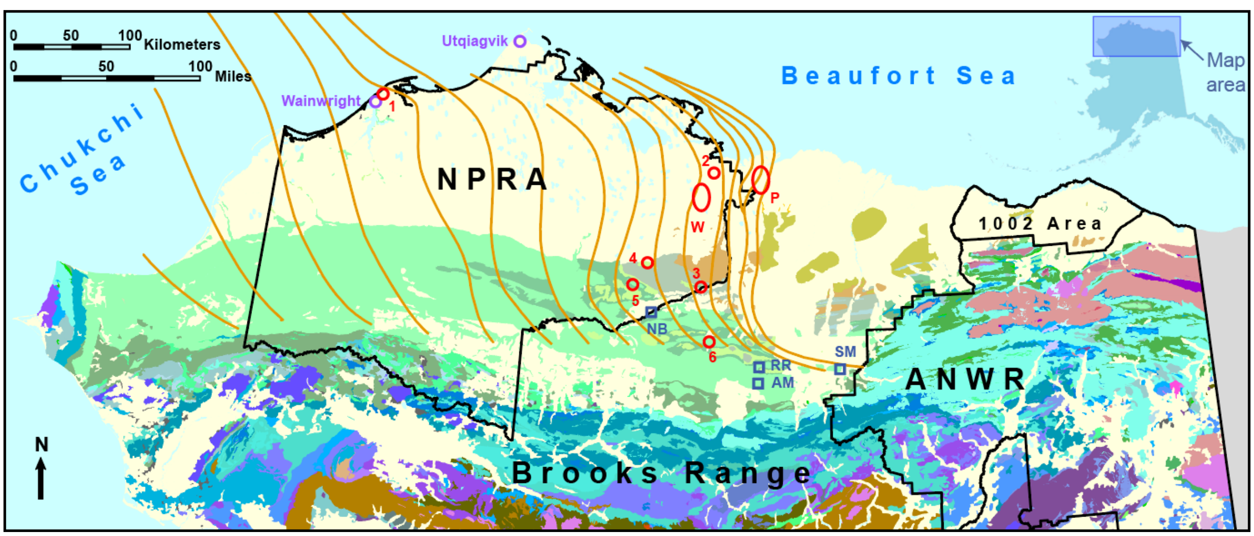

Figure 1. Simplified geologic map of northern Alaska showing the location of the Slope Mountain study area (blue square labeled SM). Red ovals show the approximate locations of oil discoveries at Willow (W) and Pikka (P). Blue squares labeled AM, RR, and NB show locations of measured sections at Arc Mountain, Rooftop Ridge, and Ninuluk Bluff, respectively. Numbered, red squares show locations of wells with Nanushuk cores. See LePain and Helmold (2021) for the key to map unit symbols. Nanushuk lowstand shelf margins are from Houseknecht (2019). Geology from Wilson and others (2015).

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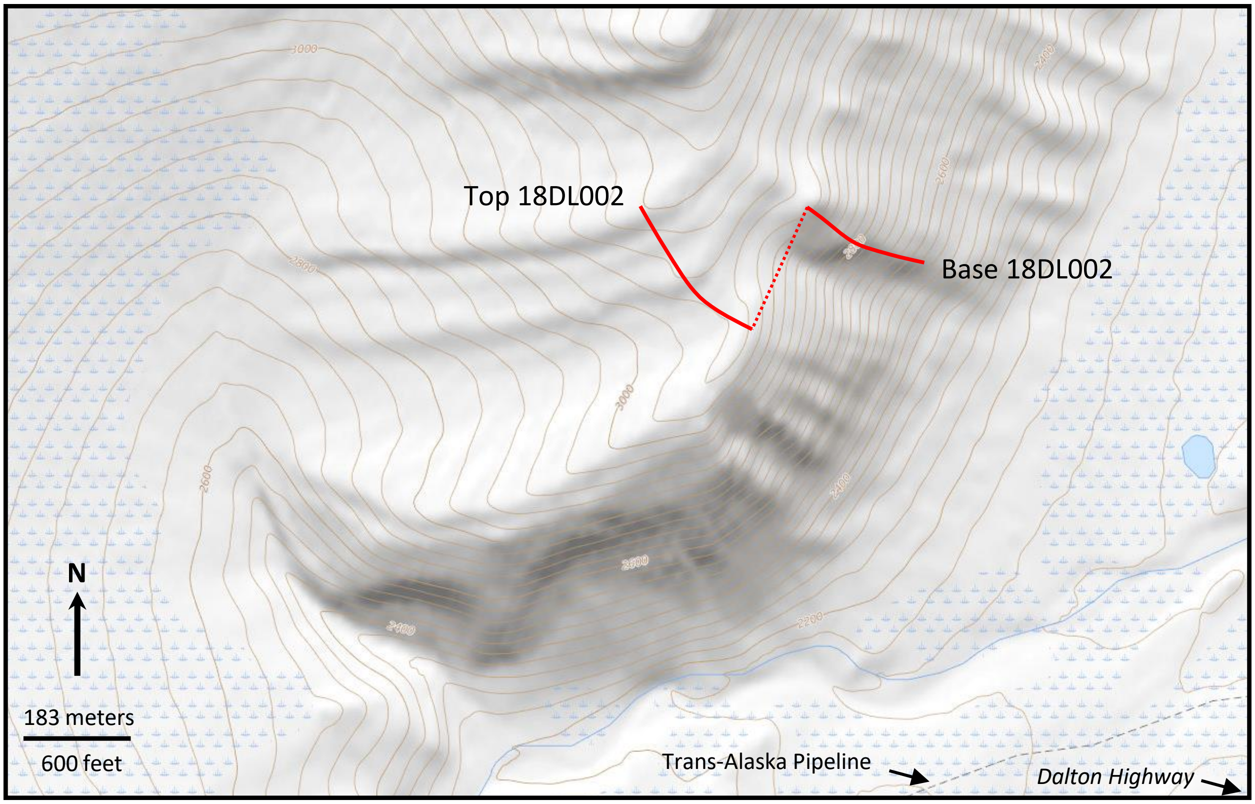


Figure 2. Shaded relief map showing the Slope Mountain study area and location of the measured section addressed in this report (red line; dotted red line shows an offset in the line of section). The section was originally measured by LePain and Kirkham in 2001 and was remeasured by LePain and Harun in 2018 to re-examine facies and collect a suite of samples for petrophysical measurements. Map from U.S. Geological Survey National Map.

Figure 4 is a modified version of the simplified Slope Mountain measured section published by LePain and others (2009) showing the stratigraphy covered in the detailed section (sheet 1). Detailed measured sections from Nanushuk outcrops along the Nanushuk River at Rooftop Ridge and Arc Mountain were recently published (LePain and others, 2021a, 2021b). Additional detailed measured sections from other important Nanushuk outcrops will be released in forthcoming reports. A companion report by Helmold and others (2021) presents a qualitative appraisal of reservoir quality in thin-sections collected from Nanushuk outcrops addressed in LePain and others (2009), including Slope Mountain. Kirkham (2005) completed a regional study of the Torok-Nanushuk transition in the southeastern part of the outcrop belt. The reader is referred to Decker (2018) and Houseknecht (2019) for discussions of the Nanushuk's petroleum potential. Willingham and Herriott (2020) published a large structure-from-motion dataset covering the southeast part of Slope Mountain, including the outcrop addressed in this report. The bedrock geology of Slope Mountain and vicinity is shown in Harris and others (2002). The amount of bioturbation is estimated using the bioturbation index (BI) of Taylor and Goldring (1993). Meterages included in this report refer to stratigraphic position above the base of the measured section on sheet 1.

SUMMARY OF STRATIGRAPHIC ORGANIZATION

The lower marine part of the Nanushuk Formation is well exposed on the southeast face of Slope Mountain, west of the Dalton Highway, near mile 301 (fig. 2; LePain and others, 2009). This face is located on the south limb of Marmot syncline, the easternmost of a series of "thumb print" synclines that

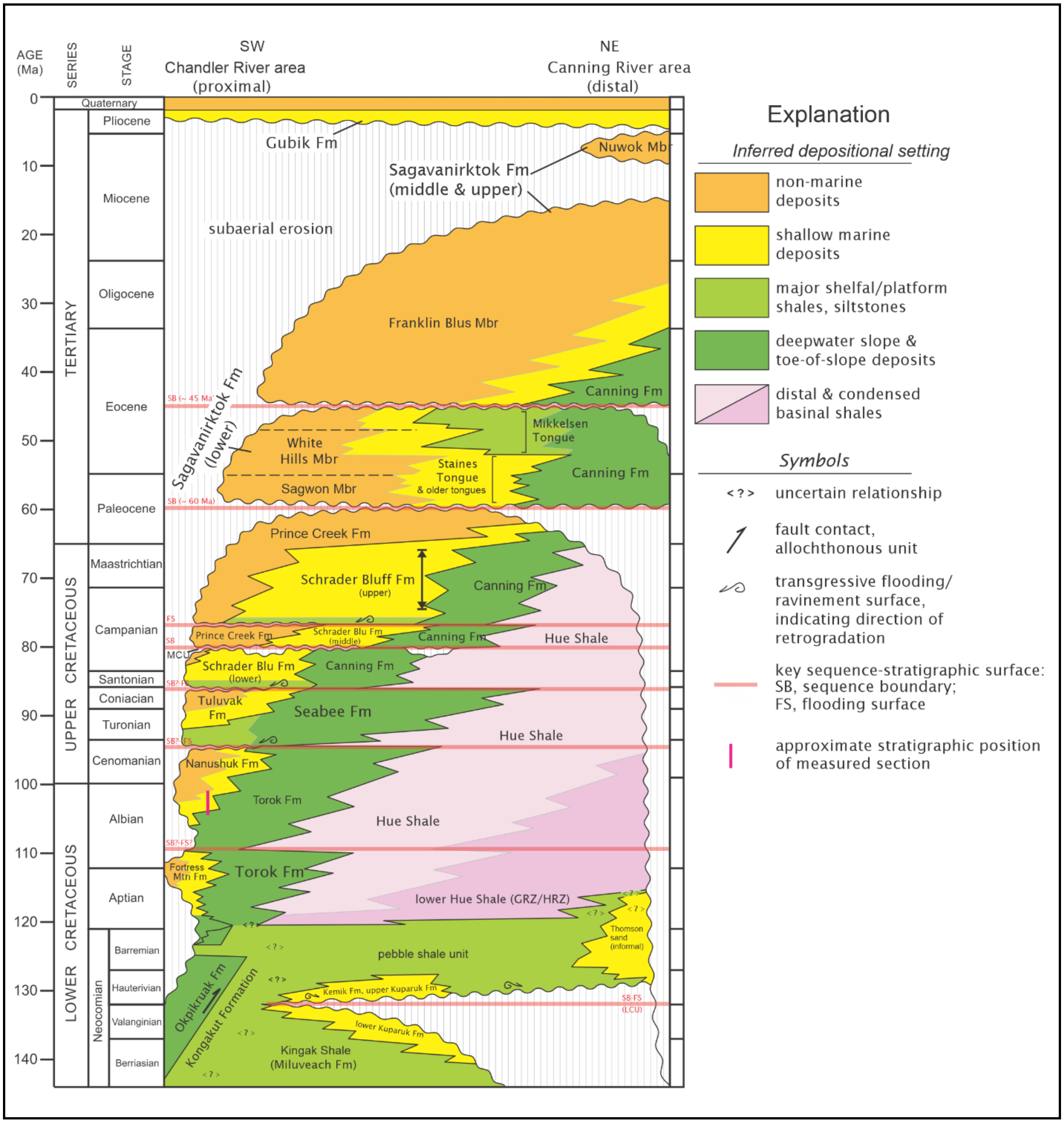


Figure 3. Simplified chronostratigraphic column and generalized sequence stratigraphy of the Brookian Sequence. The solid red line shows the approximate stratigraphic position of the detailed measured section on sheet 1. Modified from Decker and others (2009).

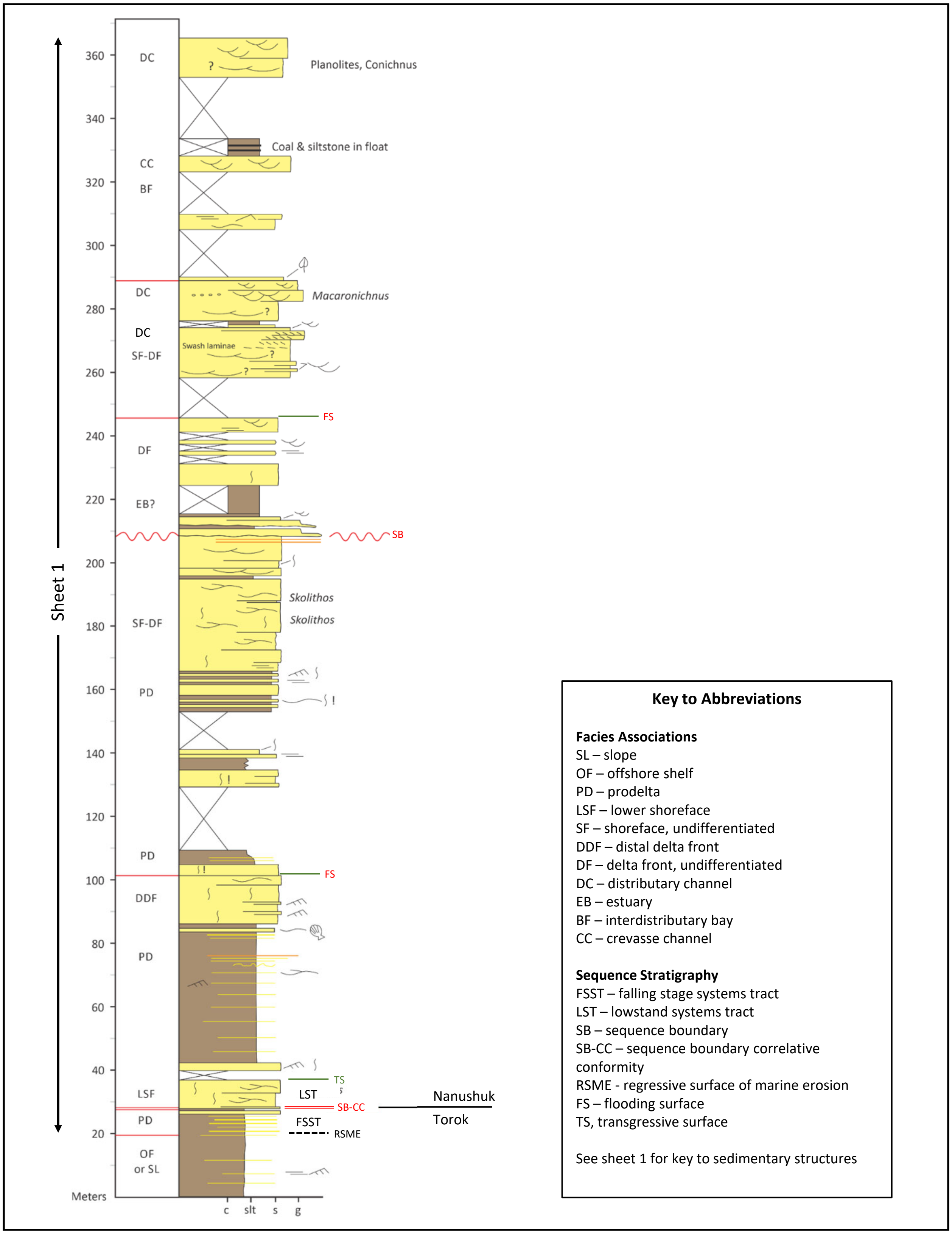


Figure 4. Simplified version of a measured section through the lower part of the Nanushuk Formation on the southeast flank of Slope Mountain (Marmot syncline), west of mile 301 of the Dalton Highway (modified from LePain and others, 2009). The detailed section on sheet 1 corresponds to the lower 336.5 m of the Nanushuk and uppermost 10 m of the Torok Formation. The simplified measured section shown in this figure includes the uppermost 28 m of the Torok Formation so meterages on this figure and sheet 1 are not the same. An additional 550 m of Nanushuk strata are present above the top of the section shown here and on sheet 1.

also represents the easternmost Nanushuk outcrop in the foothills belt (Mull and Harris, 1989; Harris and others, 2002). The Torok–Nanushuk contact is also well exposed at this location, which is one of the few locations in the eastern part of the Nanushuk's outcrop belt where the transition between the two formations can be seen. The lower marine Nanushuk grades up-section toward the west-northwest to marginal marine facies and, continuing west-northwestward, toward the axis of Marmot syncline, to a thick succession of alternating resistant fluvial channel belt deposits and recessive weathering, poorly exposed mudstone-dominated alluvial floodbasin deposits. The exposed thickness of the formation is 950–1,000 m in the study area (Keller and other, 1961; Huffman and others, 1981). The overlying Seabee Formation is not preserved so the exposed thickness may not correspond to its depositional thickness at this location.

Uppermost Torok and Basal Nanushuk (0–21.4 m)

The Torok–Nanushuk formation contact is placed at the base of the first shallow marine sandstone body, which is at least two meters thick. While the thickness cutoff is arbitrary, this criterion is easy to apply throughout most of the outcrop belt where the lower Nanushuk is exposed and is consistent with the presence of shallow marine facies and facies stacking patterns. At Slope Mountain the base of the measured section is approximately 10 m below the base of the Nanushuk (0 m on sheet 1). Figures 5A–C show the basal Nanushuk sandstone body and the uppermost 20–25 m of the Torok Formation at the southwest end of the outcrop (fuchsia colored rectangle on photograph in sheet 1). The base of the measured section on sheet 1 (0 m) corresponds to the lower dashed white line in figure 5C (labeled 0 m). Note the abrupt increase in the number and thickness of sandstone beds above this line, defining a heterolithic package between 0 m and the base of the Nanushuk at 10 m; this interval comprises the upper 10 m of the Torok Formation and consists of silty clay shale, siltstone, and numerous beds of very fine-grained sandstone ranging in thickness from 5 to 80 cm. Many of these Torok sandstone beds include partial Bouma sequences (Tabc, Tab, Tb, Tbc) and a few resemble hyperpycnites (figs. 5D–E; Mulder and others, 2003). Bioturbation in sandstone beds, where present, is limited to the upper few centimeters and consists exclusively of *Phycosiphon* or *Helminthopsis* burrows (fig. 5E); many sandstone beds appear unbioturbated. Below the heterolithic package, the exposed Torok consists of silty shale and a few thin beds of coarse siltstone and very fine-grained sandstone up to 15 cm thick (see lower 20 m of fig. 4). Sandstone beds include partial Bouma sequences (mostly thin Ta, Tab, and Tbc). The uppermost Torok at this location, including all visible strata below the base of the Nanushuk at 10 m (sheet 1 and fig. 5C), was deposited in an outer shelf to upper slope setting. The heterolithic package is interpreted as prodelta deposits that accumulated on the upper slope or outer shelf.

The basal Nanushuk sandstone body (figs. 5B–C and 6A; labeled PS1 on sheet 1, resistant package immediately above dotted fuchsia-colored line on photograph in lower left corner) is a highly bioturbated succession of amalgamated sandstone beds (figs. 6B–C). Remnants of hummocky cross-stratification (HCS) and wave-ripple cross-laminae clearly distinguish these basal Nanushuk sandstones from the uppermost Torok sandstones. Bioturbation ranges from low to intense (BI 2–5+, but mostly 4–5+) and appears to be a typical *Cruziana* ichnofacies assemblage; *Skolithos* and *Gyrochorte* are locally prominent (figs. 6D–E). A flooding surface is recognized at 19 m (figs. 5C and 6A, sheet 1) separating amalgamated sandstone beds below from highly bioturbated, very fine-grained sandstone and coarse siltstone above. The basal sandstone body records deposition in a lower shoreface or sediment starved distal delta front setting in which the rate of biogenic disruption of physical sedimentary structures exceeded the sedimentation rate, resulting in an amalgamated package that is largely intensely bioturbated. The flooding surface signals an abrupt decrease in sedimentation rate above 19 m, followed by another abrupt decrease at 21.4 m (sheet 1).

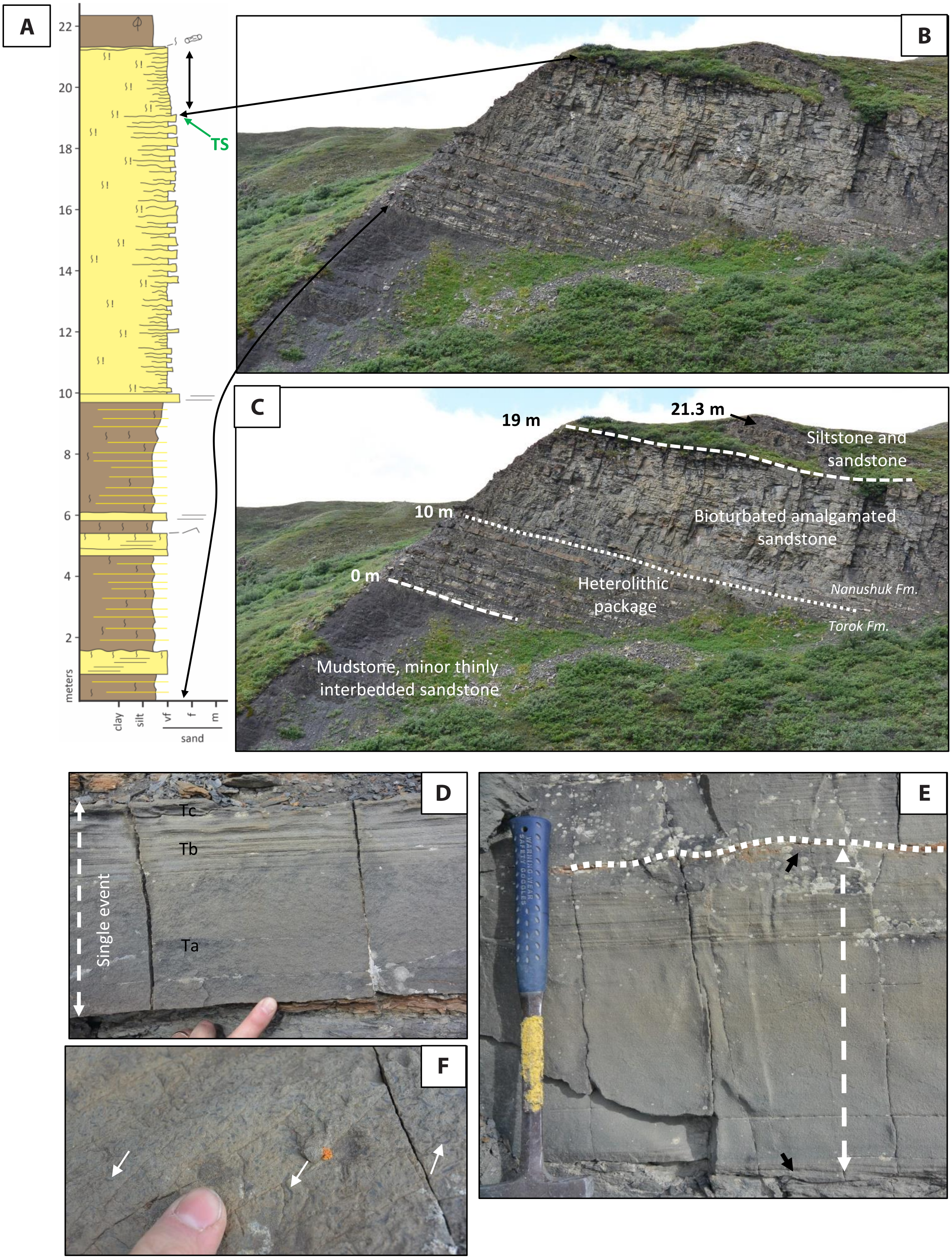


Figure 5. Caption on next page.

Figure 7 shows our sequence stratigraphic interpretation of the uppermost Torok Formation and basal sandstone body in the Nanushuk Formation. The heterolithic package is interpreted to record deposition during forced regression and, as such, represents a falling stage systems tract (see Catuneanu and others, 2011). The contact at 10 m (Torok–Nanushuk contact) is interpreted as a sequence bounding correlative conformity and the basal Nanushuk sandstone body (10 m to 19 m) as a lowstand shoreface (lowstand systems tract).

Lower Nanushuk 21.4 to 153.7 m

The interval from 21.4 m to 153.7 m includes at least six sandier-upward parasequences (labeled PS2 through PS7 on sheet 1). Each parasequence grades up-section from bioturbated silty claystone and argillaceous siltstone with thinly interbedded very fine-grained sandstone (figs. 8A and 9A) to amalgamated very fine- to fine-grained sandstone (figs. 8B–C and 9B). Successively higher parasequences record deposition in more proximal settings collectively defining a larger progradational stacking pattern (sheet 1). Sandstones include prominent horizontal laminations (figs. 8B and 9B), current ripple cross-laminations (fig. 8C), and many beds that appear structureless. Wave-ripple bedforms locally cap some sandstone beds (fig. 8D). Some thin sandstone beds interbedded in mudstones in the lower parts of parasequences resemble Bouma Ta, Tab, and Tbc beds, like those noted above in the uppermost Torok Formation. Mudstone rip-up clasts are common in sandstone beds and convolute bedding is locally prominent (figs. 8E, sheet 1). Terrestrial plant debris is common on parting surfaces in sandstones and litters the tops of many beds. Pelecypod and ammonite impressions are present locally but do not appear to be common (figs. 8G). Bioturbation ranges from absent to intense (BI 0–5) but is typically absent to moderate (BI 0–3). A single starfish impression (*Asteriacites*) was found in float at 114 m (fig. 8H). Two beds of medium-grained sandstone, separated by 10 cm of siltstone, cap a parasequence at 56.2 m (PS3) and three amalgamated beds of very coarse-grained sandstone at 65.7 m interrupt the lower siltstone-dominated part of the parasequence from 56.7 m to 88 m (fig. 8F, PS4 on sheet 1). The prevalence of unidirectional current indicators, abundance of soft-sediment deformation features in sandstones (convolute bedding and ball and pillow structures), plant debris, and highly variable bioturbation, combined with the relatively minor occurrence of wave-generated features suggests these parasequences record deposition in river-dominated delta-front settings, with each parasequence representing a single episode of delta lobe progradation in progressively more proximal locations (Bhattacharya and Walker, 1991; Bhattacharya, 2006; Ryer and Anderson, 2004).

Figure 5, previous page. Selected photographs showing details of the uppermost Torok Formation and the Torok–Nanushuk contact. **A.** Segment of measured section from 0-22 m shown on sheet 1. **B–C.** Photograph showing the lower 35 meters of exposure at the southeast end of the Slope Mountain outcrop approximately 1 km along strike from the measured section (sheet 1, see fuchsia rectangle in lower left corner of photograph). Meter annotations on the left side of the outcrop in C correspond to the measured section on sheet 1. Uninterpreted and interpreted versions are shown in B and C, respectively. Note the abrupt increase in sandstone beds at 0 m and 10 m. The interval from 10 m to 21.3 m corresponds to the basal sandstone body in the Nanushuk Formation. Below 0 m the Torok Formation consists dominantly of silty clayshale with relatively few thin, discontinuous beds up to 15 cm thick of coarse siltstone and very fine-grained sandstone. Between 0 m and 10 m sandstones beds account for approximately 50 percent of the total thickness of the interval. Individual sandstone beds thin laterally and some pinch out over the length of outcrop shown in the photograph. Sandstone beds are unbioturbated except for the upper few centimeters. **D, E.** Photographs showing details commonly observed in thicker sandstone event beds between 0 m and 10 m. Bouma Tabc, Tab, Tb, and Tbc divisions are common. The lower cross-laminated division visible in E (lower black arrow) is probably associated with an earlier flow event and is unrelated to the event responsible for the bed delineated by the dashed white vertical line. The upper cross-laminated division (upper black arrow) represents deposition during the waning stage of the density underflow event. Visible part of hammer in D is 41.5 cm long. **F.** *Phycosiphon* or *Helminthopsis* burrows in the upper few centimeters of the sandstone bed at 5.6 m (sheet 1).

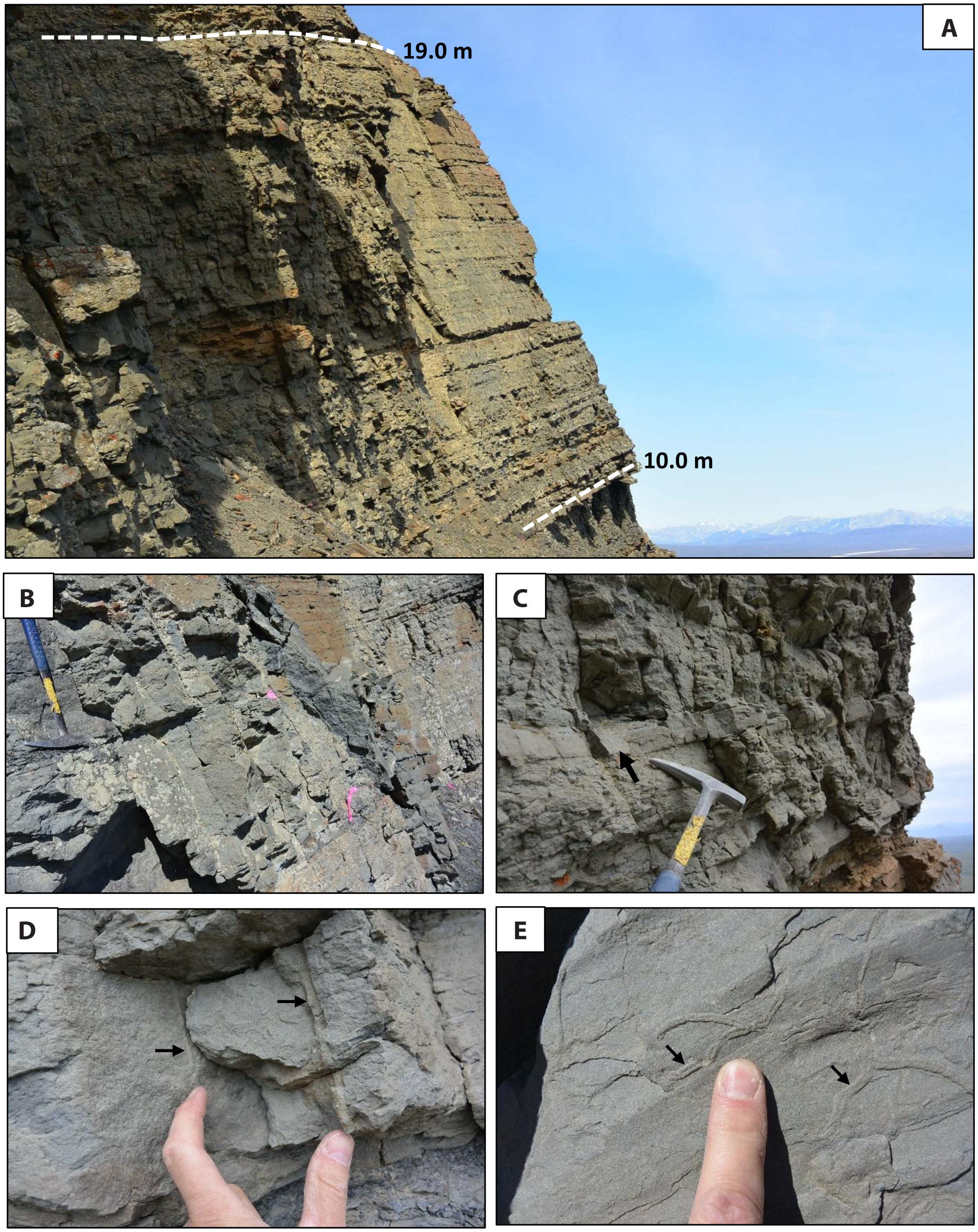
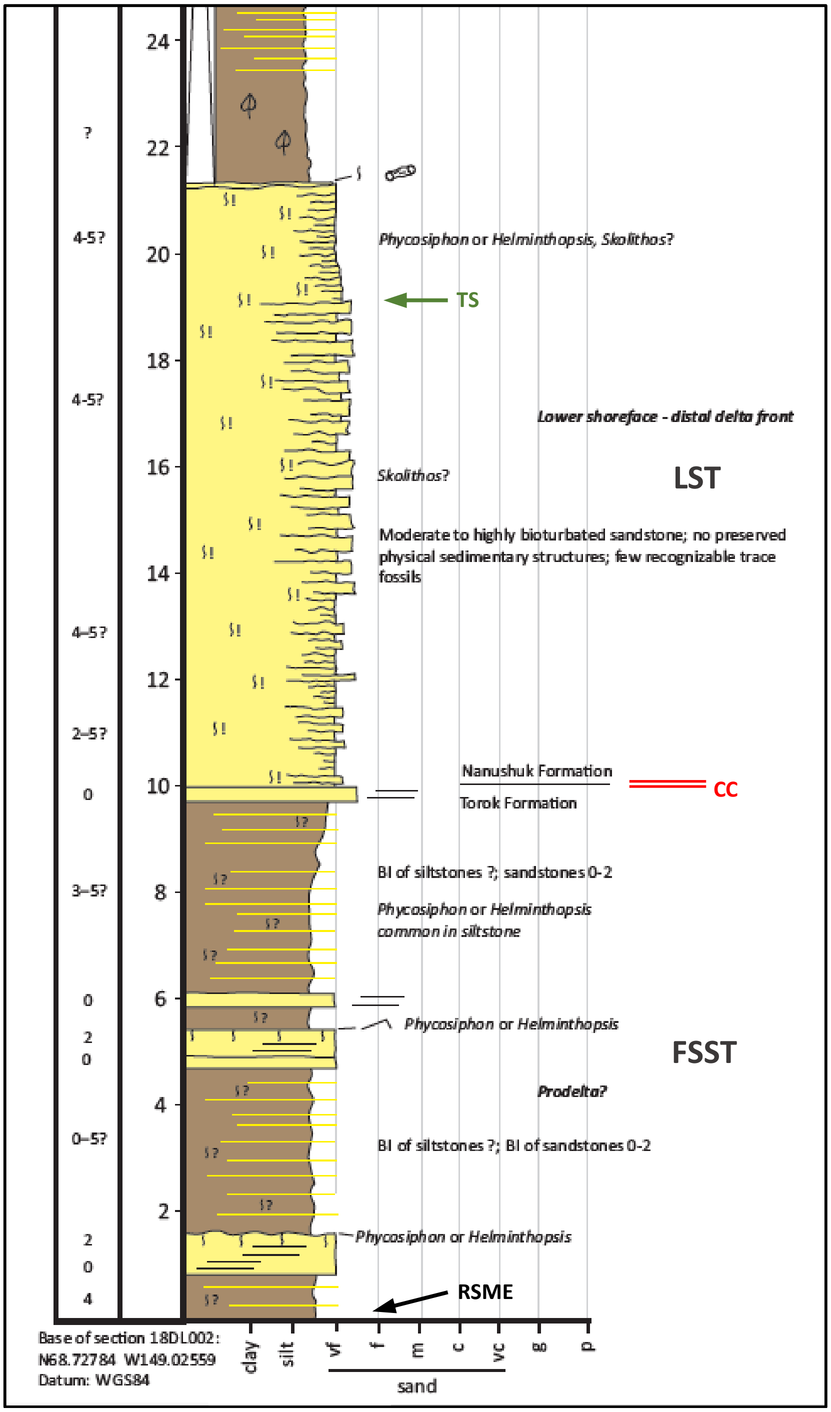
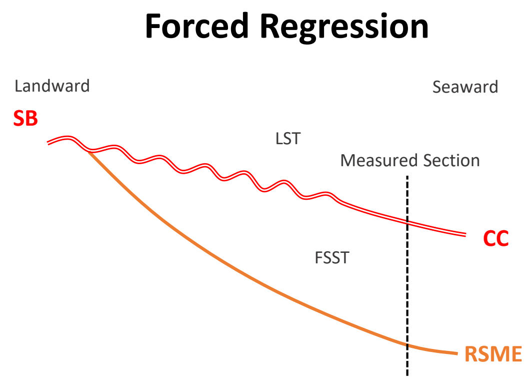


Figure 6. Selected photographs showing key characteristics of the lower part of the basal sandstone body in the Nanushuk Formation at Slope Mountain (sheet 1; fig. 5A–C). **A.** Photograph showing the basal sandstone body (10 m to 19 m on sheet 1). **B, C.** Photographs showing the bioturbated character of sandstone beds in the basal sandstone body. Most beds in this interval are moderately to intensely bioturbated (BI 4–5+) but a few beds have low to moderate bioturbation (BI 2–3, see black arrow pointing to bed above tip of hammer head in C). Visible part of hammer is 40 cm long in B and 25 cm long in C. **D.** Highly to intensely bioturbated (BI 4–5) sandstone bed that was subsequently re-burrowed by *Skolithos*. **E.** Wave ripple bedforms preserved on the upper surface of sandstone bed at 18.2 m with well-preserved *Gyrochorte* traces.





Key to Abbreviations
SB, sequence boundary
CC, correlative conformity
RSME, regressive surface of marine erosion
TS, transgressive surface
FSST, falling stage systems tract
LST, lowstand systems tract

Figure 7. Cartoon showing sequence stratigraphic interpretation of the lower 21.3 m of the measured section shown on sheet 1. The abrupt increase in the number and thickness of sandstone beds at the base of the measured section (0 m) is associated with a regressive surface of marine erosion (RSME) formed during forced regression in response to falling relative sea level. During this time the shoreline moved seaward and downward. On the shelf or upper slope, seaward of the shoreline, density underflows (dilute and concentrated) emanating from distributary channels deposited thin to thick Tabc, Tab, Tb, Tbc beds during forced regression. Those beds with thick Ta layers were likely deposited from concentrated density underflows. Following Hunt and Tucker (1992), the sequence boundary is placed at the top of the forced regressive package, which is placed at the base of the basal Nanushuk sandstone body (10 m). At the location of our measured section, we infer the sequence boundary (contact between Torok and Nanushuk Formations) to be a correlative conformity and the erosional, unconformable part of the sequence boundary to be located a short distance landward (south). Note the basal surface of forced regression, which forms the lower boundary of the falling stage systems tract (Catuneanu, 2019), is not identified on this figure, however, suggest it is co-located with the RSME at this location. The overlying basal Nanushuk sandstone body includes shallow marine facies associated with a lowstand systems tract.

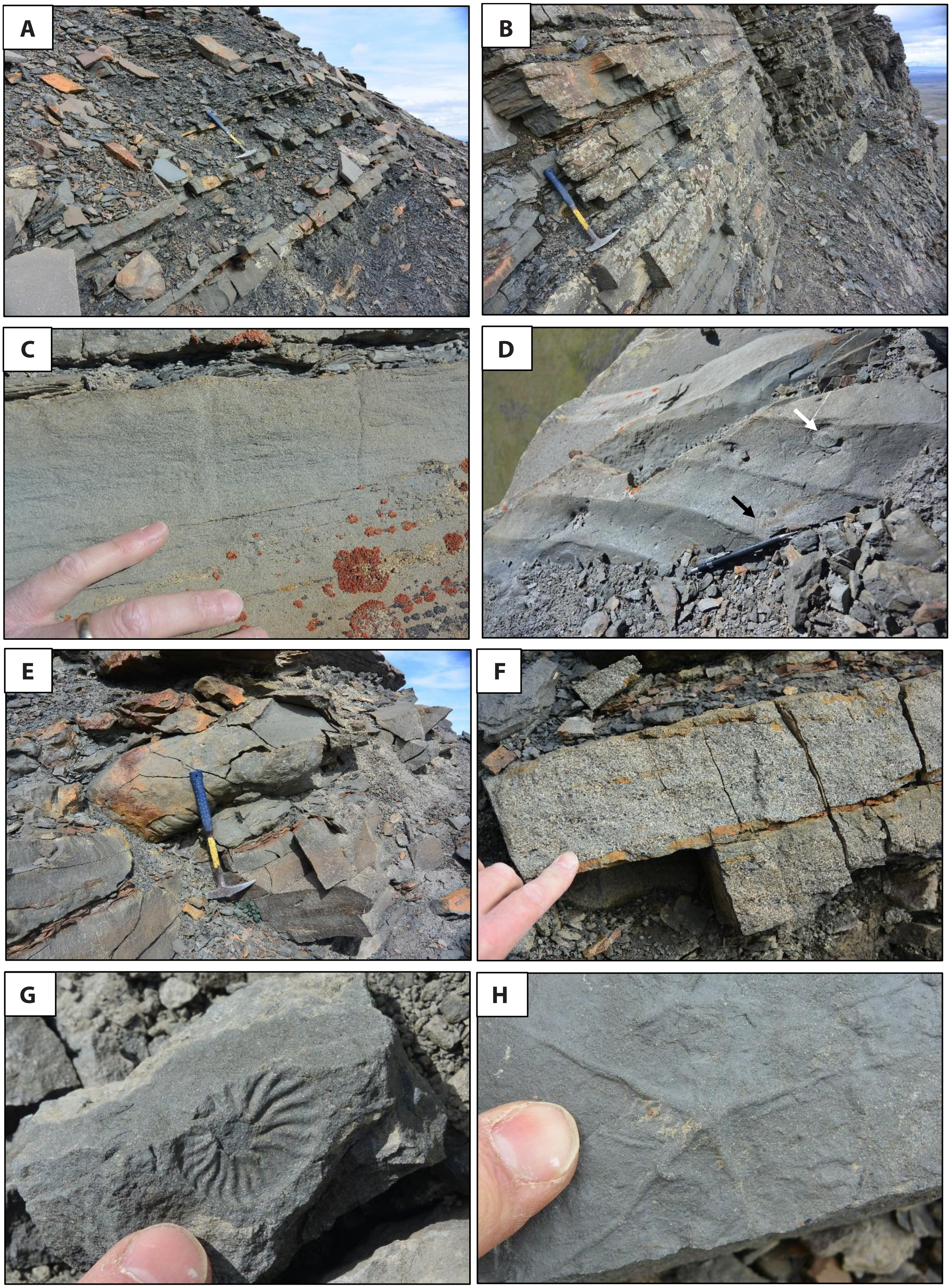


Figure 8. Caption on next page.

The abrupt grainsize increase at 56.2 m (sheet 1) is situated at the top of a gradual coarsening- and thickening-upward trend and is interpreted as an unconformity. Given our inability to trace this surface laterally for more than 10 m due to the steep slope, we cannot rule out an origin from autocyclic processes operating in the drainage basin supplying a nearby distributary channel. The bedset of very coarse-grained sandstone at 66 m likely records frontal splays associated with a nearby distributary channel.

Erosion Surface at 153.7 m

A prominent erosion surface truncates a 7.9-m-thick succession of amalgamated very fine-grained, horizontally laminated sandstone at the top of a parasequence at 153.7 m (PS7 on sheet 1 and fig. 10A). This surface displays a complex geometry that extends across the length of the outcrop (sheet 1, dotted white line on photograph in lower left corner). The surface has 15–20 m of relief locally and truncates sandstones deposited in a proximal delta-front setting (fig. 9B, sheet 1, photograph in lower left corner). Evidence of subaerial exposure has not been found where the surface is accessible, but the steep topography precludes access along most of its exposed extent.

The surface at 153.7 m is overlain by four conglomerate beds (sheet 1). The lower three beds consist of pebble conglomerate–coarse-grained sandstone couplets 20–50 cm thick. The upper conglomerate bed is separated from the lower three beds by a 40-cm-thick succession of silty clayshale and siltstone (lower part of fig. 10B and sheet 1). The upper conglomerate bed is 1.1 m thick, is very poorly sorted, includes clasts ranging in size from granules to boulders (one clast is at least 55 cm in diameter) and has a matrix of coarse- to very coarse-grained sandstone (fig. 10B). The larger clasts are sandstone that closely resemble sandstone in the underlying marine parasequence (similar texture and degree of induration). This bed is overlain by a 1.2-m-thick succession of coarse- to very coarse-grained sandstone with abundant mudstone rip-up clasts that is, in turn, overlain by a sooty appearing (organic-rich?) coarse siltstone to silty very fine-grained sandstone (fig. 11A and sheet 1). The complex topography embodied on the surface at 153.7 m is suggestive of a subaerial unconformity that was drowned during the subsequent transgression. The three conglomerate-sandstone couplets are tentatively interpreted as fluvial—but there is nothing about them that clearly indicates a fluvial setting. The upper conglomerate bed is a debris flow deposit (debrite) and the sandstone clasts in it are likely intraformational in origin. It is unknown if the debrite bed was deposited in a fluvial or marginal-marine (estuarine) setting but its source was likely one of the locally steep surfaces visible in the photograph on sheet 1 or the up–dip continuation of these surfaces.

Figure 8, previous page. Selected photographs showing key characteristics of the interval from the top of the basal sandstone body (21.3 m) to 141.4 m (sheet 1). This interval includes at least five sandier-upward parasequences (PS2-PS6 on sheet 1) and one candidate sequence bounding unconformity. **A.** Mudstone with thinly interbedded very fine-grained sandstone from 90 m to 94 m. Bioturbation in mudstones ranges from moderate to intense (BI 3–4?) and in sandstones from absent to low (BI 0-2). Hammer is 42 cm long. **B.** Thin- to medium-bedded very fine-grained sandstone from 118 m to 119 m. Some sandstone beds are amalgamated and others are separated by thin siltstones (up to 5 cm thick). Hammer is 42 cm long. **C.** Amalgamated sandstone beds at 131.4 m. Horizontal plane-parallel laminated sandstone is visible at and below the geologist's ring finger and current ripple cross-laminated sandstone is visible in the upper 7 cm of the bedset. Asymmetrical ripple bedforms cap the sandstone bedset. **D.** Wave ripple bedforms on a sandstone bed surface at the top of a parasequence at 141.1 m. The circular feature at the tip of white arrow is a large vertical burrow thought to be caused by a pelecypod. Few crawling traces are also visible on the bed surface (black arrow). Mechanical pencil below black arrow is 14 cm long. **E.** Foundered sandstone bed at 52 m. Foundered sandstone masses and convolute bedding are common in the interval between 40 m and 99 m. Hammer is 42 cm long. **F.** Amalgamated beds of coarse- to very coarse-grained sandstone with common sideritized mudstone rip-up clasts at 66 m. **G.** Ammonite impression on bed surface at 54 m. **H.** Starfish impression (*Asteriacites*) at 114 m.

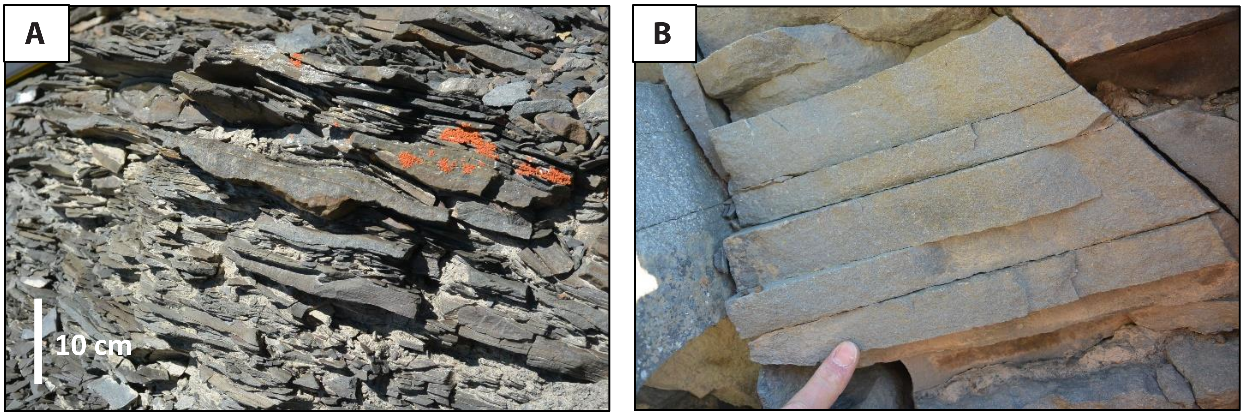


Figure 9. Selected photographs showing key characteristics of the parasequence truncated by the erosion surface (sequence bounding unconformity) at 153.7 m. **A.** Mudstone and lenticular very fine-grained sandstone at 142 m. White bar is 10 cm long. **B.** Amalgamated very fine-grained sandstone at 148 m. Horizontal plane-parallel laminations are faintly visible in some beds and others appear massive.

The sooty appearance of the lithology overlying the conglomeratic succession is likely the result of argillaceous material and finely divided terrestrial organic fragments mixed in with siliciclastic detritus and is interpreted to record deposition in an estuarine setting.

Lower Nanushuk 167 m to 235.2 m

The succession from 167 m to 235.2 m includes two stacked parasequences (PS8 and PS9 on sheet 1). The lower parasequence grades up-section from interbedded argillaceous siltstone and very fine-grained sandstone (fig. 11B), with abundant macerated plant fragments and larger wood impressions on parting surfaces, to amalgamated very fine- to fine-grained sandstone with horizontal plane-parallel laminations and common wood impressions. The higher parasequence (PS9) is similar in the succession of lithologies but the interbedded siltstone and sandstone package at its base is thinner and the lower sandy part of the parasequence consists largely of swaley cross-stratified sandstone (SCS). Interbedded siltstones and sandstones near the base of both parasequences are moderately to highly bioturbated (BI 3–4?; fig. 11C) and the amalgamated sandstones appear unbioturbated. The delta front and shoreface successions in PS8 and PS9, respectively, are abruptly overlain (truncated) by successions of medium- to very coarse-grained sandstone with large-scale trough cross-bedding in sets up to 2 m thick (PS8 and PS9 on sheet 1; figs. 11D–F, 12A). Trough cross-bedded sandstones are largely unbioturbated (BI 0) but the lower package (DC1) includes discrete intervals that are moderately to highly bioturbated with *Macaronichnus* (BI 3–4; figs. 11G–H). Wood impressions are locally common on parting surfaces and bedding planes in both trough cross-bedded sandstone packages. PS8 records deposition in proximal prodelta to delta-front settings and PS9 records deposition in a shoreface setting (sheet 1). Horizontal laminae in the amalgamated sandstones of PS8 indicate either strong (upper plane-bed conditions) unidirectional currents or long-period oscillatory-dominant currents with maximum velocities greater than the stability conditions for HCS and SCS. SCS in PS9 indicates powerful storm waves shaped this part of the nearshore environment and oscillatory flows were within the stability field of large three-dimensional hummocky bedforms. The coarse-grained trough cross-bedded packages capping both parasequences represent distributary channel-fill deposits. The occurrence of *Macaronichnus* in float from the lower trough cross-bedded sandstone package indicates deposition in a sandy marginal-marine setting characterized by normal marine salinities

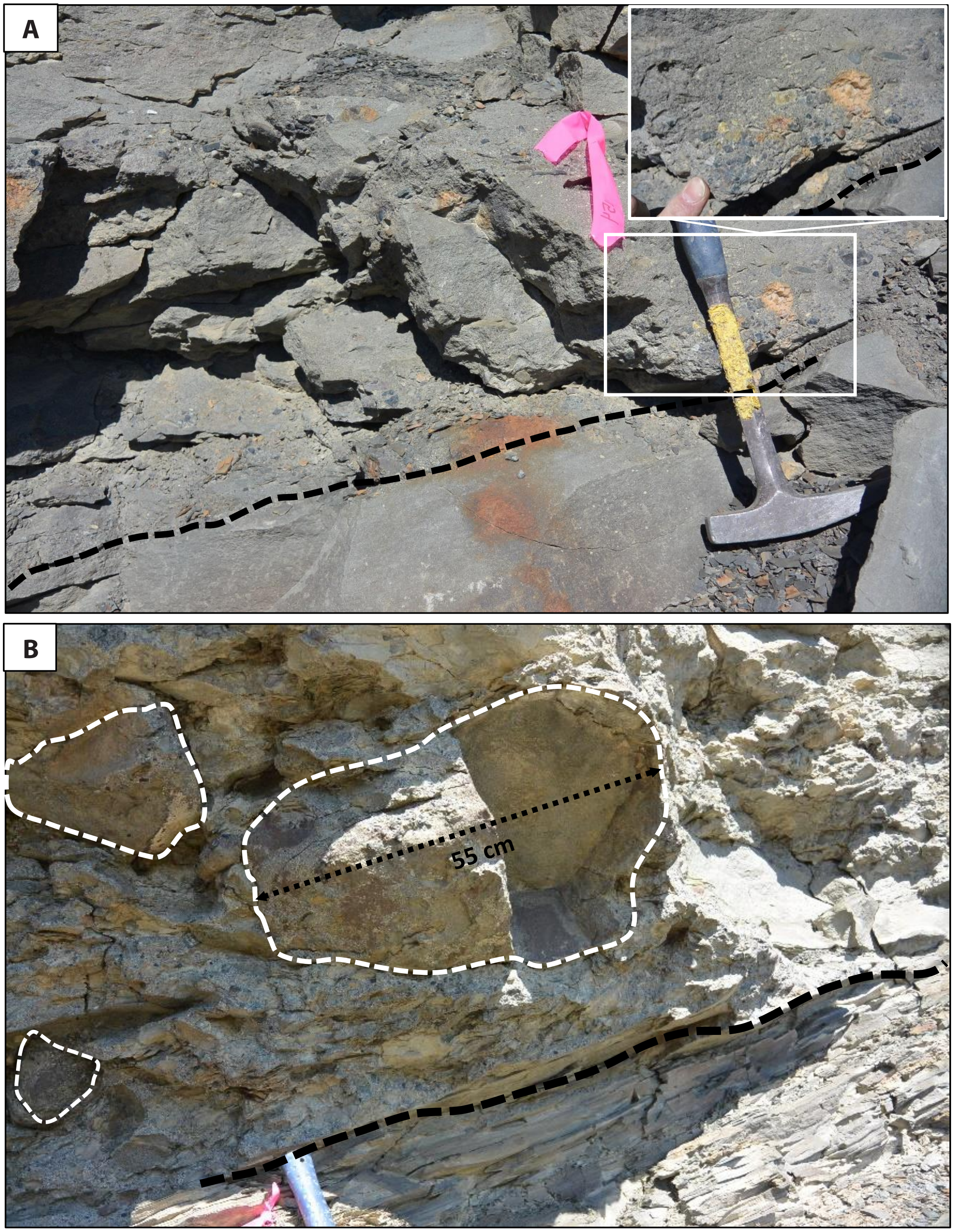


Figure 10. Photographs showing the erosion surface (unconformity) at 153.7 m and strata immediately above. **A.** The erosion surface at 153.7 m (black dashed line). The inset photograph shows a closeup view of the pebble conglomerate bed overlying the unconformity surface. Clasts include chert, vein quartz, and siderite. Visible part of hammer is 25 cm long. **B.** Unsorted cobble-boulder conglomerate bed at 155.1 m. The heavy dashed black line marks the bed contact at 155.1 m with underlying siltstones. Clast sizes range from granule to small boulders. The larger clasts are intraformational sandstones, whereas granule- and pebble-sized clasts are similar in composition as the bed immediately overlying the unconformity surface.

(Clifton and Thompson, 1978; MacEachern, J.A., 2001). This could record deposition in the seaward portion of a distributary channel during a period of low discharge when incursions of saline water would extend landward some distance from the channel mouth.

Upper Nanushuk 235.2 m to 346.5 m

The succession from 235.2 m to the top of the measured section at 346.5 m consists of poorly exposed mudstones with minor interbedded sandstones and thin coaly stringers interrupted by well-exposed medium- to coarse-grained sandstone bodies up to 19.5 m thick (fig. 12B and sheet 1). The lower mudstone interval includes thin beds of siltstone, thin coaly stringers, and a 4.5-m-thick coarsening-upward succession that culminates in amalgamated thin, discontinuous beds of coarse siltstone and very fine-grained sandstone with scattered poorly preserved plant fragments on parting surfaces (fig. 13A). The lower sandstone body (290–296.2 m) is trough cross-bedded throughout its thickness in sets up to 1.5 m thick (fig. 13B). The upper mudstone interval includes argillaceous siltstone with thin coaly stringers (fig. 13C) and few thin beds of fine-grained sandstone with discontinuous wavy laminae and small-scale trough cross-stratification (fig. 13D). The upper sandstone body (327–346.5 m) includes small- and large-scale trough cross-bedding and horizontally laminated sandstone in beds up to 2 m thick (figs. 12B and 14A–D). A bed of fine-grained sandstone 20 cm thick with abundant poorly preserved plant debris interrupts the upper sandstone body at 335.8 m (sheet 1). The top of the body is capped by medium-grained sandstone characterized by planar-tabular and planar-tangential cross-bedding in sets with opposing foreset dip directions resembling herringbone cross-stratification (fig. 14E), and trough cross-bedding in sets up to 40 cm thick that are amalgamated and laterally discontinuous. Wood impressions are common on sandstone parting surfaces and bedding planes. Both sandstone bodies represent distributary channel complexes that traversed a poorly to moderately drained lower delta plain, cross-bed geometries at the top of the upper distributary channel complex suggest a tidal influence (fig. 14E). The next major sandstone body up-section from 346.5 m is interpreted as a fluvial channel complex (fig. 14F).

Figure 11, next page. Photographs showing key features between 160 m and 214.4 m (PS8). **A.** Dark gray, sooty appearing, silty, very fine-grained sandstone at 161 m. Strata immediately up-section from the conglomeratic package above the unconformity at 153.7 m are poorly exposed along the line of section where they include mudstone and interbedded sandstone like those shown in this photograph. Elsewhere along the southeast face of Slope Mountain, strata filling paleotopographic lows on the unconformity surface are better exposed but inaccessible due to steep topography. Strata infilling topographic lows are interpreted as estuarine deposits. Visible part of hammer head in lower left corner is 11 cm long. **B.** Thin- to medium-bedded very fine-grained sandstone with thinly interbedded argillaceous siltstone from 168 m to 171 m. Bioturbation is variable but generally moderate to high (BI 3–4?), and macerated plant fragments and wood impressions on parting and bed surfaces are common. Hammer is 42 cm long. Wood staff is 1.5 m long. **C.** Robust *Palaeophycos* or *Schaubcylindrichnus* burrows in very fine-grained sandstone at 173.1 m. **D–E.** Large-scale trough cross-bedded, medium-grained sandstone at 201 m (D) and low-angle inclined laminations in medium- to very coarse-grained sandstone from 208 m to 211.5 m (E). The latter possibly records beach swash laminae. Sandstone from 197 m to 214.4 m represents the fill of a distributary channel. Black bar in E is 1 m long. **F.** Interbedded medium-grained trough cross-bedded sandstone, low-angle inclined laminated sandstone, and horizontal plane-parallel laminated sandstone from 210 m to 215 m. This succession is a continuation of the succession shown in E and likely records interfingering of beach swash laminae and distributary channel deposits. **G–H.** Medium-grained sandstone in float at 200 m (G) and 209 m (H) with *Macaronichus* burrows throughout. The pieces of sandstone are most likely from the distributary channel-fill extending up to 214.4 m and indicate normal marine salinity levels at the locations they were deposited. Visible part of hammer tip in G is 3 cm long.

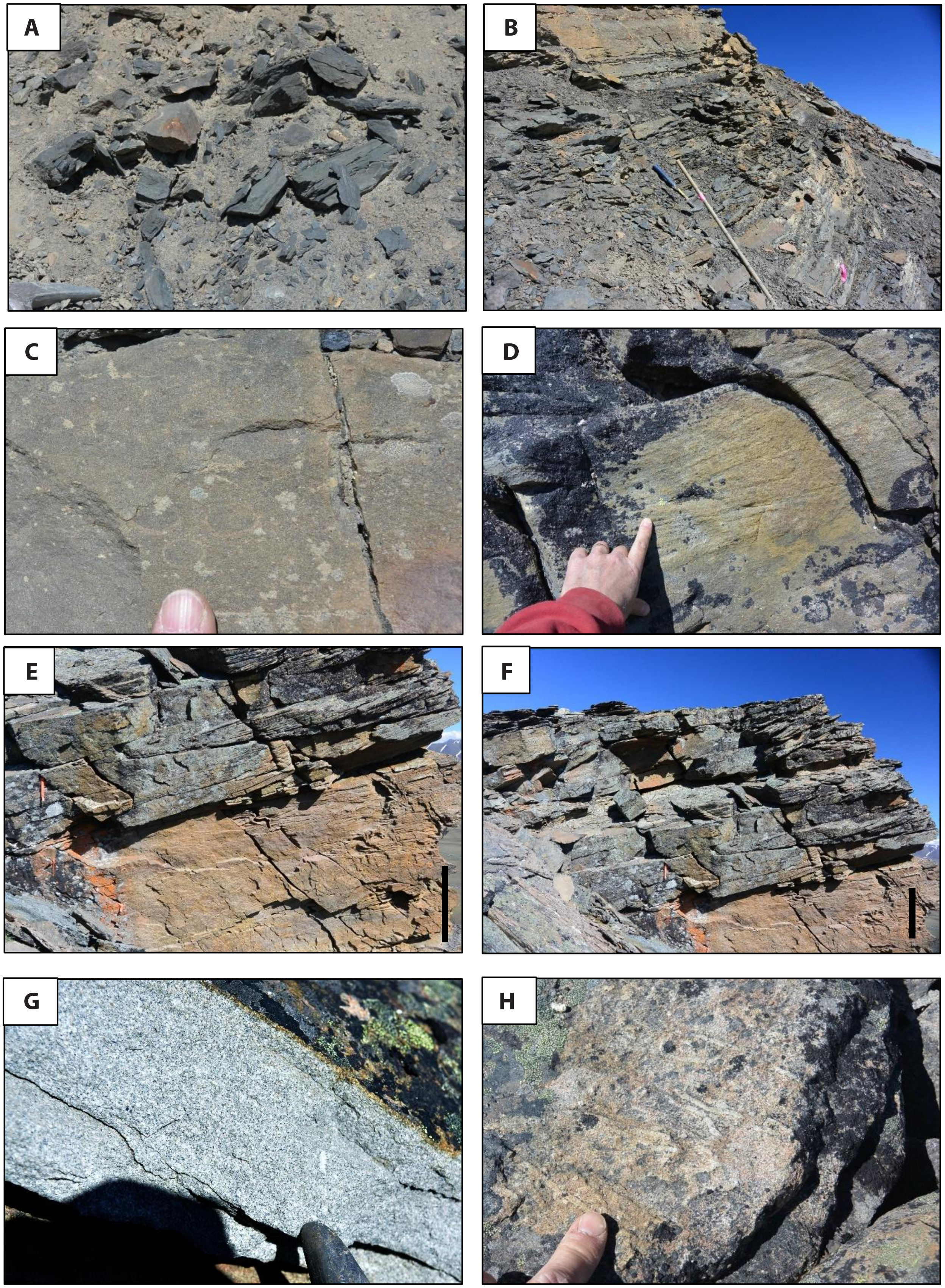
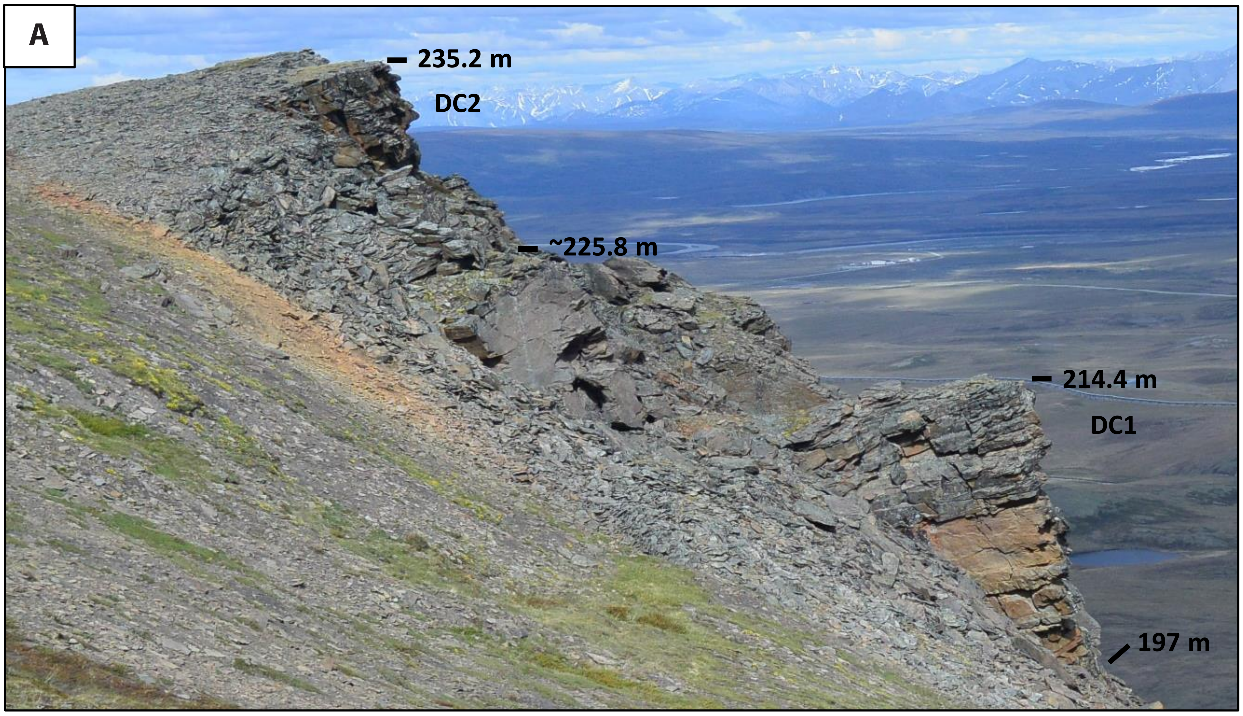


Figure 11. Caption on previous page.



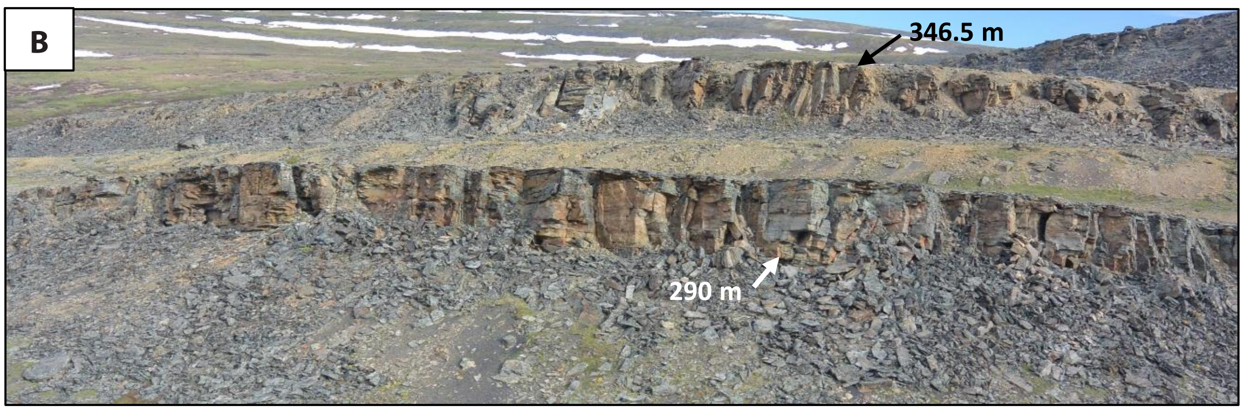
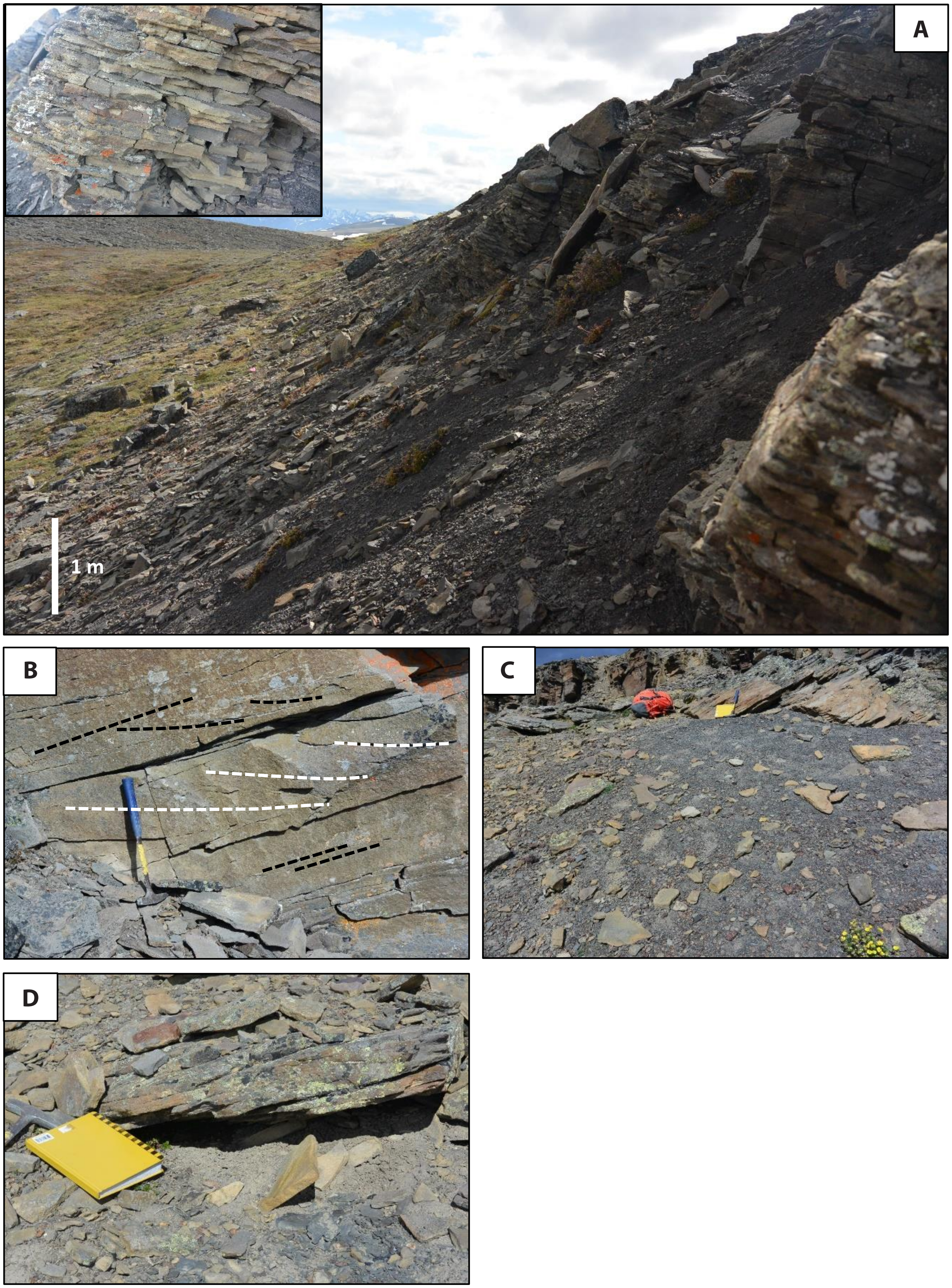


Figure 12. Photographs showing the outcrop character of the upper 150 m of the measured section. **A.** View toward the northeast showing the medium-grained, trough cross-bedded sandstone packages that truncate the marine parasequences at 197 m and 225.8 m. These packages are interpreted as the fill of two distributary channels. The channel-fills extend for several hundred meters along local strike. **B.** View toward the west-northwest showing the two distributary channel complexes between 290 m and the top of the measured section at 346.5 m (sheet 1). The rubble-strewn and tundra-covered areas between the two channel complexes, and below the lower one, conceal mudstone-dominated lower delta plain deposits (bayfill or poorly drained floodplain deposits).

Figure 13, next page. Photographs showing key features from approximately 265 m to 312 m. **A.** Minor coarsening-upward succession from approximately 265 m to 270.1 m. Amalgamated, discontinuous beds of very fine-grained sandstone cap the succession (see inset photo in upper left corner of image). This succession is interpreted to record progradation of a small crevasse delta across a poorly drained flood basin on the lower delta plain. White bar is approximately 1 m long. **B.** Medium-grained trough cross-bedded sandstone at 291 m. This sandstone is part of the fill of a distributary channel from 290 m to 296.2 m. Hammer is 42 cm long. **C.** Poorly exposed mudstone from approximately 311 m to 312 m. Small pieces of coal are scattered around the field of view. These deposits record deposition in a poorly drained flood basin in a lower delta plain setting. The orange backpack is approximately 30 cm high and 70 cm long and the yellow notebook is 22 cm long. **D.** Thin bed of very fine- to fine-grained sandstone at 301.4 m. Thin beds like this are interpreted as splay sandstone sheets. Notebook is 22 cm long.



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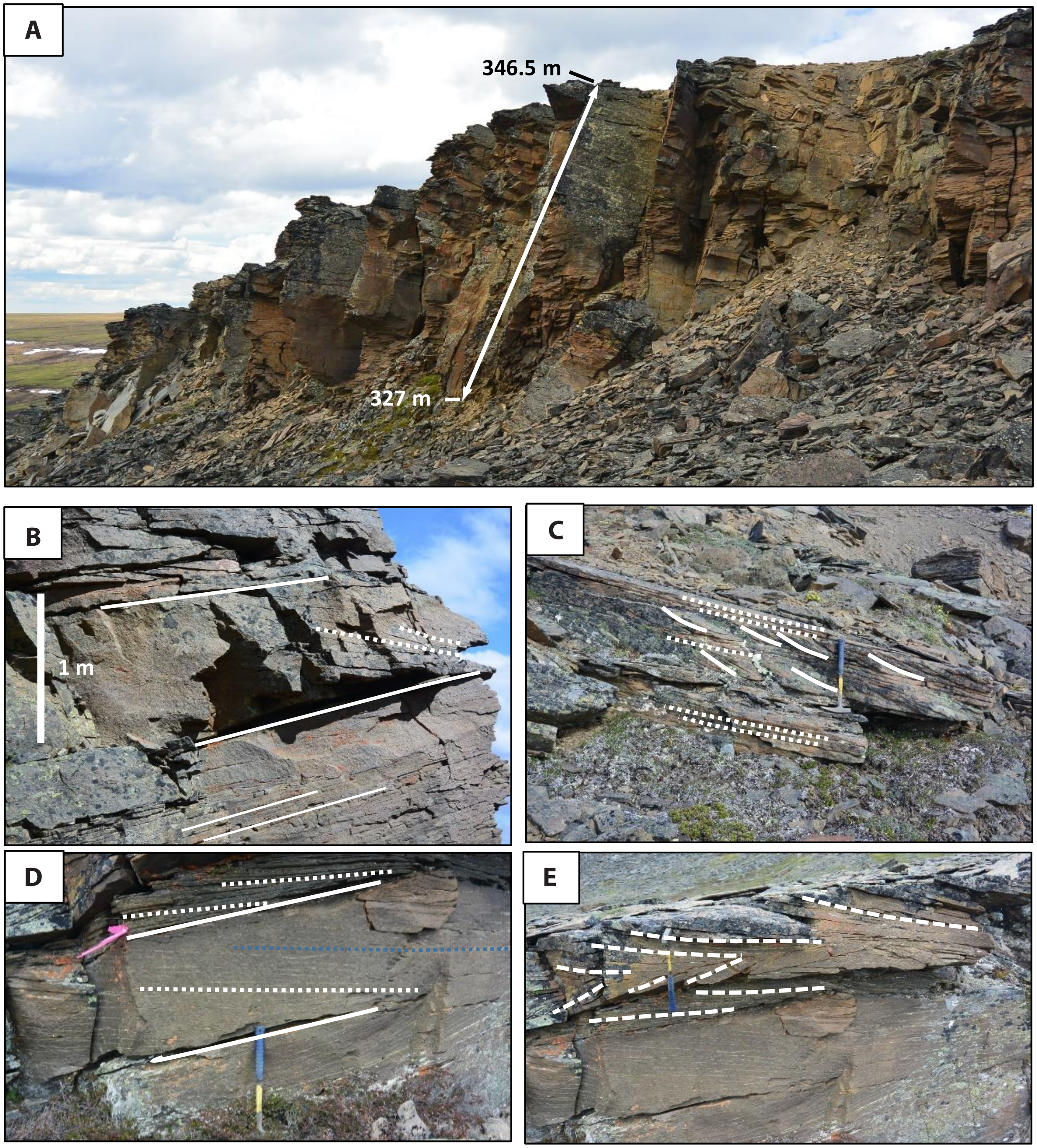

Figure 14. Selected photographs showing key features in the sandstone body from 327 m to 346.5 m. **A.** View toward the southwest showing amalgamated beds of medium- to very coarse-grained sandstone. This sandstone body represents the fill of a distributary channel complex. **B–D.** Large-scale trough cross-bedded sandstone at 335 m, 337.6 m and 344.4 m, respectively. These large-scale trough cross-bed sets record migration of large-scale three-dimensional dune bedform along the base of a distributary channel. Hammer in each photograph is 42 cm long. **E.** Low-angle foresets in medium-grained sandstone at 346 m. Opposing foreset dip directions suggest herringbone cross-stratification resulting from tides (ebb and flood).

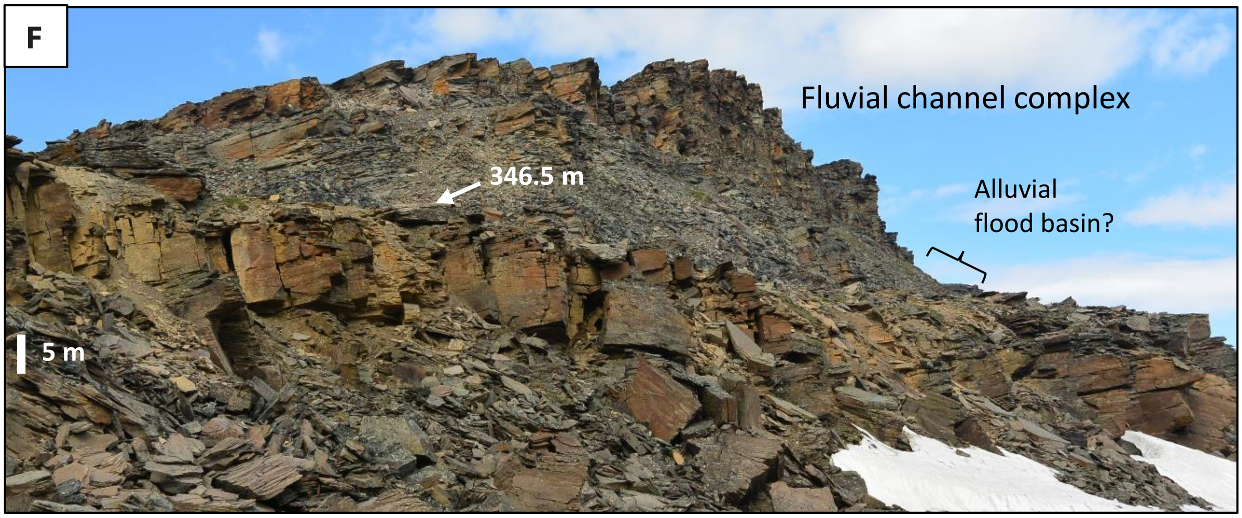

Figure 14, continued. Selected photographs showing key features in the sandstone body from 327 m to 346.5 m. **F.** View to the northwest showing the top of the measured section (346.5 m) and the next higher sandstone body (at skyline). The higher sandstone is interpreted as a fluvial channel complex. Scale bar in lower left corner is approximate and applicable only to the sandstone body in the foreground.

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