

THE CHIGNIK FORMATION, ANIAKCHAK NATIONAL MONUMENT & PRESERVE, ALASKA: A LATE CRETACEOUS (CAMPANIAN-MAASTRICHTIAN) ESTUARY-FILL



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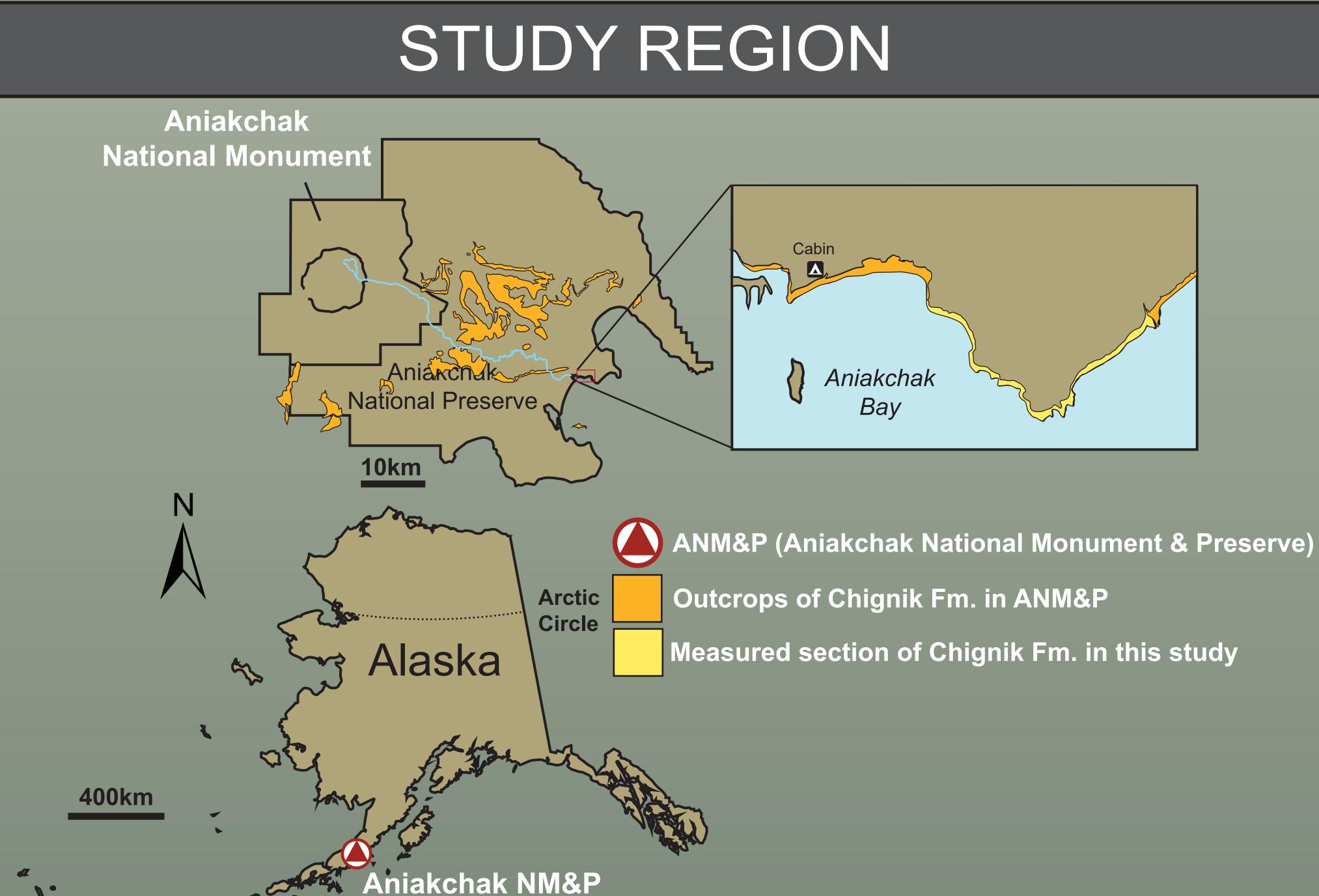
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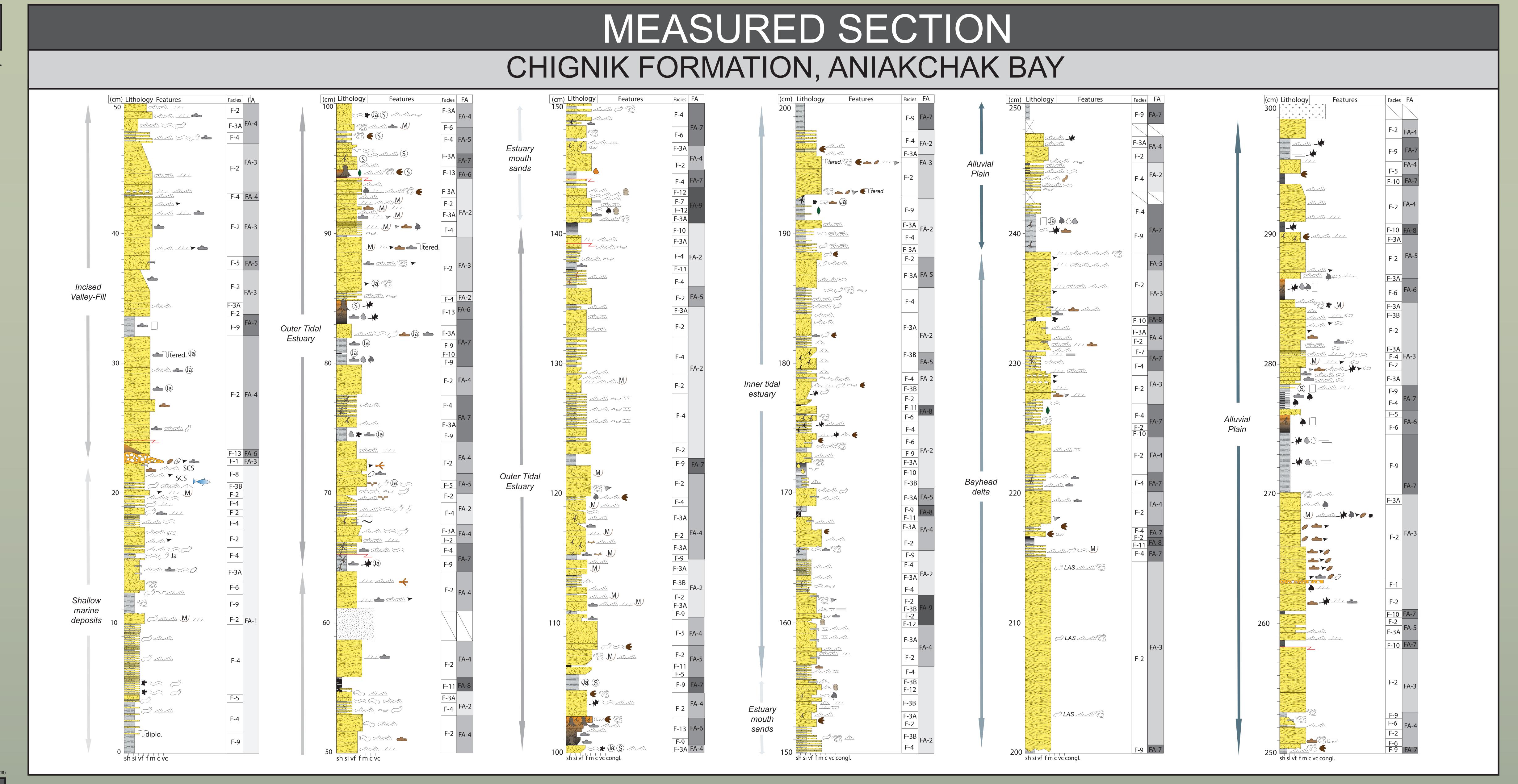
ABSTRACT

The Chignik Fm. is a cyclic succession of sedimentary rocks deposited at a relatively high latitude under Late Cretaceous greenhouse conditions. A ~300 m succession exposed along the coast of Aniakchak Bay represents shallow marine to near shore marine environments in the lower part and continental alluvial/coastal plain environments in the upper part. Nine facies associations represent shallow marine deposits, tidal flats, large and small fluvial channels, crevasse splays, backswamps, tidal marshes, floodplains, paleosols, and storm deposits. The basal shallow marine part of the section consists of offshore shales and siltstones with thin sandstones interbeds that coarsen upward into bioturbated cross-bedded sandstones. Interbedded sandstones and siltstones, double mud drapes and flaser, wavy, and lenticular bedding represent tidal flats. Layers of broken bivalve shells in non-preferred orientations are interpreted to represent wave/storm action at the coastal margin. Tidal channels are characterized by burrowed, cross-bedded and ripple cross-laminated fining upward sandstones. Fluvial deposits are represented by fining-upward, cross-bedded and ripple cross-laminated sandstones with erosional lower contacts. Mudstones rich in organic matter and thin coal beds represent floodplains, backswamps, and tidal marsh deposits. Blocky mudstones with siderite nodules, root traces, disseminated organic matter, plant fragments, and bioturbation are interpreted as paleosols. In places standing tree trunks are present at the top of paleosols. The entire section contains a rich fossil floral and faunal record. Currently over 100 dinosaur track sites have been documented including hadrosaurids, ankylosaurs, non-avian theropods, and avian theropods. A large multi-story fluvial channel (~30 m) overlying shallow marine deposits is interpreted as an incised valley. The valley fill is overlain by coastal/tidal flat deposits that transition upward into continental fluvial depositional environments. The entire section is interpreted as a transgressive-regressive succession, consistent with a tide-dominated estuary fill. The modern Aniakchak River entering Aniakchak Bay provides an excellent modern analogue.

OBJECTIVES

- This project focuses on a 300-meter measured section of the Chignik Fm. exposed in Aniakchak National Monument & Preserve, AK.
- This section contains one of the most densely concentrated dinosaur track sites in any high-latitude location, thus it provides unique terrestrial paleoecological insights into ancient Arctic/sub-Arctic greenhouse environments.*
- The Chignik Fm. is partially coeval with the Late Cretaceous Prince Creek Fm. (North Slope, AK) and the Cantwell Fm. (Denali National Park, AK), which are both well-studied dinosaur track sites in Alaska.
- This section provides an excellent opportunity to study the detailed sedimentology of another Late Cretaceous high-latitude dinosaur track-bearing site.



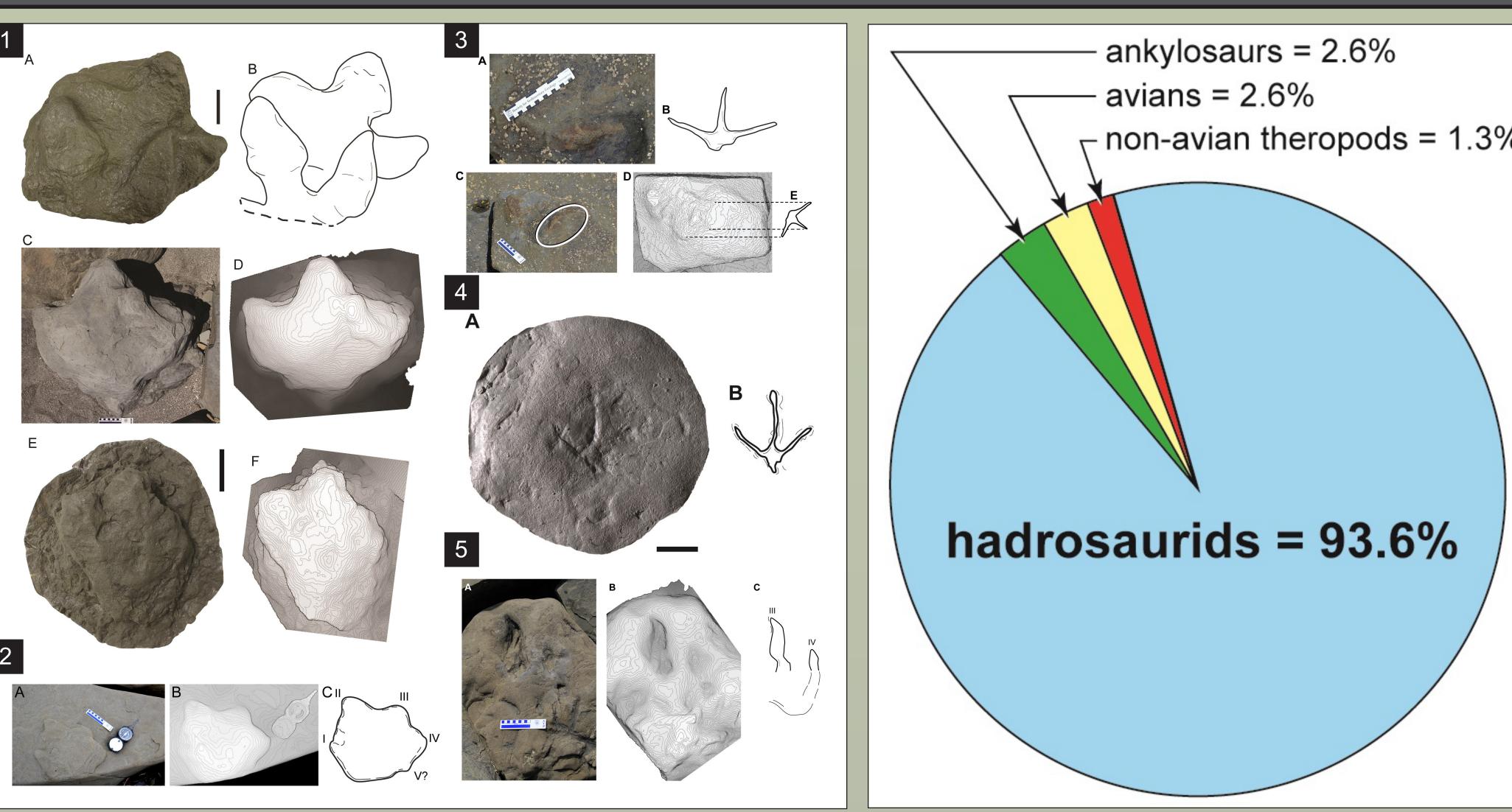


LEGEND FACIES AND FACIES ASSOCIATIONS SEDIMENTARY STRUCTURES **FACIES ASSOCIATIONS** FA-1: Shallow marine offshore transymmetrical ripple lamination convolute bedding sition to upper shoreface A-2 FA-2: Tidal flat deposits = planar lamination tabular beds and channel lag deposits) Symmetrical wave ripples LAS lateral accretion surfaces nudstone interbeds liscontinous interbeds of sand-1) Interbedded sandstone and stone and mudstone mudstone overlying dark colored coaly shale FA-6 FA-6: Paleosols paleosol with orange weathering dark organic rich siltstone Interbedded sandstones and FA-7 FA-7: Floodplain deposits BIOLOGICAL FEATURES bivalve-bearing sandstone H) Drone image of large meanderupright tree trunk woodcoalified wood ing fluvial channel in outcrop FA-9 FA-9: Beach and/or storm deposits wood impression FA-6: Paleosol orange weathered coaly roots plant fragments LITHOLOGIC ACCESSORIES Asymmetrical ripple cross-lamileaves organic matter coalified organic matter disseminated Organic matter siderite nodules .) Orange weathering on fossilized irregular bedding/dinoturbation dinosaur ichno-fossil bird ichno-fossil ----- sharp marine bivalve shells mud lined vertical burrows > shale clasts Stered. Teredolites

Th. Thalassinoides

volcanic pebbles

REPRESENTATIVE DINOSAUR ICHNOLOGY



(Left) Photo plates of ichnofossils from the Chignik Formation: (1) multiple tracks are attributed to hadrosaurs, (2) ankylosaur track, (3) multiple birds tracks, (4) small bird track, (5) non-avian theropod tracks. (Right) Pie graph quantifying distribution of dinosaur tracks identified from the Chignik Fm. along Aniakchak Bay (Fiorillo et al., 2019).

CONCLUSIONS

Depositional Environment

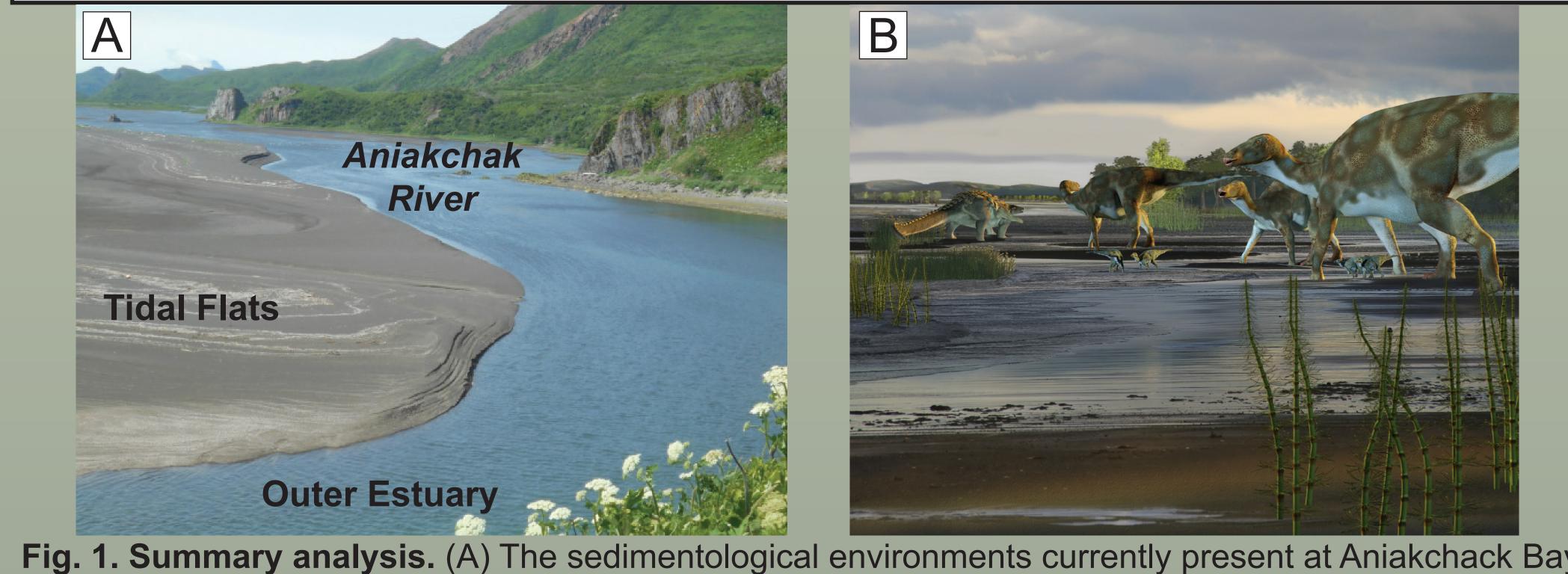


Fig. 1. Summary analysis. (A) The sedimentological environments currently present at Aniakchack Bay provide an excellent modern analogue for those presevered within the Chignik Fm. exposed along Aniakchak Bay; (B) Artist rendering of the depositional environments represented by the Chignik Fm. at Aniakchak Bay. Representative paleo-flora and fauna are also shown.*

➤Nine facies associations were identified from the Chignik Fm. at Aniakchak Bay and are interpreted to represent the following depositional environments: Shallow marine offshore transition to upper shoreface, tidal flats, thick meandering channels and channel lags, small fluvial channels and point bars, crevasse splay and delta splays, paleosols, floodplains, backswamps, beach and/or storm deposits.

➤This detailed facies analysis indicates that the Chignik Fm. at Aniakchak Bay comprises a Late Cretaceous tide-dominated estuary-fill.

➤Abundant dinosaur ichnofossils in the section at Aniakchak Bay suggest that this estuarine environment was capable of supporting a diverse assemblage of dinosaurs.

ACKNOWLEDGMENTS & REFERENCES

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Fiorillo AR, Kobayashi Y, McCarthy PJ, Tanaka T, Tykoski RS, Lee Y-N, et al. (2019) Dinosaur ichnology and sedimentology of the Chignik Formation (Upper Cretaceous), Aniakchak National Monument, southwestern Alaska; Further insights on habitat preferences of high-latitude hadrosaurs. PLoS ONE 14(10): e0223471