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AN INVENTORY OF BELEMNITES DOCUMENTED IN SIX US NATIONAL PARKS IN ALASKA

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Abstract—Belemnites (order Belemnitida) are an extinct group of coleoid cephalopods, known from the Jurassic and Cretaceous periods. We compiled detailed information on 252 occurrences of belemnites in six National Park Service (NPS) areas in Alaska. This information was based on published literature and maps, unpublished U.S. Geological Survey internal fossil reports ("Examination and Report on Referred Fossils" or E&Rs), the U.S. Geological Survey Mesozoic locality register, the Alaska Paleontological Database, the NPS Paleontology Archives and our own records of belemnites found in museum collections. Few specimens have been identified and many consist of fragments. However, even these suboptimal specimens provide evidence that belemnites are present in given formations and provide direction for future research. Two especially interesting avenues for research concern the time range of belemnites in Alaska. Belemnites are known to have originated in what is now Europe in the Early Jurassic Hettangian and to have a well-documented world-wide distribution in the Early Jurassic Toarcian. Some researchers (Iba et al. 2011) suggest that belemnites were absent from the North Pacific after the Early Cretaceous. We found several claims of belemnites prior to the Toarcian and in the Late Cretaceous. However, there were potential limitations in the data. These findings indicate a strong need for further collecting and detailed study of the specimens to assure that the Sinemurian-age belemnites are truly belemnites rather than aulacocerids, a morphologically similar taxon with earlier origins. Reassessment of the age of the strata in which possible Early Jurassic and Late Cretaceous belemnites are found is crucial. Further studies could shed light on the evolution and migration patterns of belemnites, and on the motion of terranes that make up Alaska.

INTRODUCTION

Belemnites (order Belemnitida) are extinct members of the phylum Mollusca, class Cephalopoda, subclass Coleoidea, that existed during the Jurassic and Cretaceous periods. Their closest living relatives are squids and cuttlefish. Belemnites had an internal posterior calcite structure, the rostrum or "guard", which is of variable shape, but is commonly cylindrical to conical. The rostrum is often the only part of the organism that remains in the rock record and consists of radially oriented longitudinal calcite crystals. The living organism occupied the anterior-most of a series of chambers in the phragmocone, a conical structure that fits into a socket (the alveolus) in the rostrum (Fig. 1). Portions of the phragmocone are often found as fossils but are not helpful for identification. The classification of belemnites is based on morphologic characteristics of the rostrum, including shape, measurements of diameters and length, and presence or absence of grooves and/or lines on the rostral surface. Examination of internal structures is also necessary in many cases and requires careful preparation of longitudinal and cross sections of the rostrum. Very often, only fragments of rostra are found and collected. These are generally not helpful in establishing a diagnosis but do indicate that belemnites are present in a given formation and indicate directions for future work.

It is generally accepted that the first "true" belemnites appeared in the Hettangian (Lower Jurassic) of what is now Europe (Doyle 1987). There is fragmentary evidence that belemnites may have been found outside of Europe by the Sinemurian, possibly in the Antarctic, Baluchistan, Canada, Tibet, Algeria, and East Greenland (Doyle 1987). However, a later review points out that the evidence for belemnites having expanded beyond Europe prior to the Toarcian is weak (Doyle 1994). Doyle et al. (1997) state that true belemnites in the Hettangian-Pliensbachian were restricted to Europe and that they developed global distribution only in the Toarcian. In the North Pacific, belemnites appear to have become extinct in the latest Albian and to have been absent throughout the Late Cretaceous (Iba et al. 2011). In the context of the time range of belemnites in the North Pacific, it should be noted that comprehensive systematic study of Alaskan belemnites using modern preparation techniques and taxonomic schemes has never been conducted. It must also be noted that the Aulacocerida, coleoids that can be confused with belemnites in the case of poorly preserved specimens of either, had a world-wide distribution prior to the Toarcian (Doyle 1994), having appeared in the Lower Carboniferous and persisting into the Lower Jurassic (Doyle et al. 1994).

As of 2020, there is no volume on taxonomy of coleoids in the Treatise on Invertebrate Paleontology. This can make identification and taxonomic assignment of belemnite specimens problematic. In the early to mid 20th century many specimens were assigned to the genus *Belemnites*, which is no longer used and is not informative for identification or taxonomic purposes. Belemnite occurrences in Alaska national parks are documented in a series of National Park Service (NPS) inventory reports (see "methods" below). These inventory reports provide detailed park historical background, geologic descriptions, and notations on known belemnite occurrences.

The purpose of this report is to compile detailed information on occurrences of belemnites in national parks and preserves in Alaska and to suggest avenues for future research based on this information. In addition, we summarize some new data gathered during an ongoing project to locate and describe identifiable belemnites from Alaska.

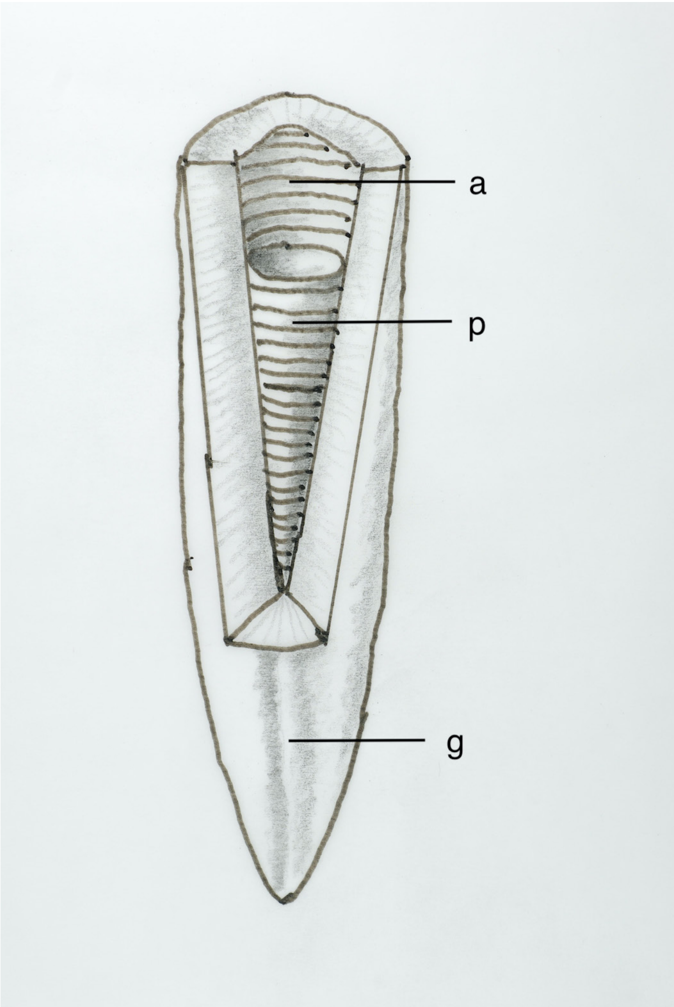

FIGURE 1. Diagram of belemnite rostrum with anterior end cut away to show alveolus and phragmocone. Abbreviations: a, alveolus, cavity in which phragmocone is seated; p, phragmocone; g, groove. Diagram by D. Schraer.

METHODS

The National Park Service began compiling data on paleontological resources within the parks in 1985 (Santucci et al. 2018). This work resulted in the creation of the NPS Paleontology Archives and Library which includes paleontological information obtained in NPS research, results of literature searches, and interviews with people knowledgeable about local geology. Summaries of this information have been published in three types of reports: a series of paleontological resource summaries compiled for the 32 NPS Inventory & Monitoring (I&M) networks; an ongoing series of park-specific paleontological resource inventories; and a second ongoing series of thematic inventories, such as this document. The archives are continually updated with new and previously unavailable or overlooked information. For example, there has been a major push to integrate U.S. Geological Survey internal fossil reports ("Examination and Report on Referred Fossils" or E&Rs) into the archives.

We reviewed network reports for the national parks within the Alaska region. These include Kenworthy & Santucci 2003 (Southwest Alaska network), Santucci & Kenworthy 2008 (Southeast Alaska network), Elder et al. 2009 (Arctic network), and Santucci et al. 2011 (Central Alaska network). We used the search terms "belem", "cyl", "acrot", and "pachy". These terms were chosen to cast a wide search for terms commonly used for unspecified belemnites, as well as genera *Belemnites*, *Cylindroteuthis*, *Acroteuthis*, and *Pachyteuthis*; these genera were commonly used in attempts to identify belemnites in Alaska. Through these searches we found that belemnites had been documented in parks in the Southwest and Central Alaska networks, but not in parks in the Arctic and Southeast Alaska networks. A total of six parks and preserves had records of belemnites. These are Aniakchak National Monument and Preserve (ANIA), Denali National Park and Preserve (DENA), Katmai National Park and Preserve (KATM), Lake Clark National Park and Preserve (LACL), Wrangell-Saint Elias National Park and Preserve (WRST), and Yukon-Charley Rivers National Preserve (YUCH) (Fig. 2).

Based on the findings in the network reports, we searched pertinent literature and the Alaska Paleontological Database, an online database of Alaska fossils, originally funded by the Minerals Data and Information Rescue in Alaska (MDIRA) project. Search terms in the database field "taxon" included *Belemnites*, *Cylindroteuthis*, *Pachyteuthis*, and *Acroteuthis*. We used the search term "Belemnitida" in the "group" field. We used associated USGS Mesozoic locality numbers, geographic descriptions, pertinent literature, and USGS maps to determine which belemnites were collected from lands that are now in national parks, monuments and preserves.

Beginning in 2015, C. & D. Schraer visited museums in the US in which Alaskan belemnites may be found. These include the National Park Service Regional Curatorial Center in Anchorage, the University of Alaska Museum of the North (UAMN) in Fairbanks, the University of California Museum of Paleontology (UCMP) in Berkeley, the California Academy of Sciences (CAS) in San Francisco, the US National Museum (Smithsonian) in Washington, D.C. (USNM), the USGS repository at the Federal Center in Colorado, and the University of Montana Paleontology Center in Missoula (UMPC). Belemnite specimens from what are now Alaska national parklands were found in San Francisco (CAS), Berkeley (UCMP), Fairbanks (UAMN), and Washington, D.C. (USNM).

Data were compiled for each belemnite occurrence from multiple sources including published literature, the Alaska Paleontological Database, the USGS Mesozoic locality registry at USNM, the National Park Service I&M Network Reports, reports by John Reeside, assistant USGS geologist in the early 20th century, and notes found with specimens in museum collections. In order to provide accurate counts, specimens with records in multiple sources were only counted once.

ANIAKCHAK NATIONAL MONUMENT AND PRESERVE (ANIA)

Aniakchak National Monument and Preserve (ANIA) was established on December 1, 1978 and on December 2, 1980 the boundaries were expanded to include Aniakchak National Preserve. ANIA currently reported park acreage is 601,294 acres (V. Santucci, email communication, 22 February 2020). This unit preserves the Aniakchak Caldera, which is a 30-square-mile dry caldera that is still active, having last erupted in 1931. This is one of the greatest examples of a dry caldera known in the world and has given rise to lava flows, cinder cones, and explosive pits. ANIA includes Surprise Lake, which is in the caldera, and the Aniakchak River, which flows from the lake via a breach in the caldera rim (National Park Service 2016; Kenworthy & Santucci 2003). USGS quadrangles that include portions of ANIA include Bristol Bay, Ugashik, Chignik, and Sutwik Island.

In addition to the volcanic features, ANIA contains Mesozoic sedimentary strata of the Upper Jurassic Naknek Formation, the Lower Cretaceous Staniukovich Formation and the Upper Cretaceous Hoodoo Formation and Chignik Formation (Detterman et al. 1981 & 1996).

A search of the Alaska Paleontological Database reveals four

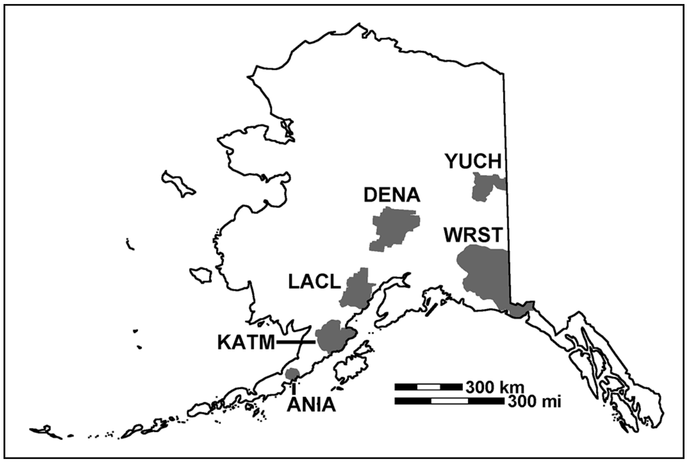

FIGURE 2. Map showing Alaska national parks and preserves in which belemnites have been found. ANIA, Aniakchak National Monument and Preserve; DENA, Denali National Park and Preserve; KATM, Katmai National Park and Preserve; LACL, Lake Clark National Park and Preserve; WRST, Wrangell-Saint Elias National Park and Preserve; YUCH, Yukon-Charley Rivers National Preserve.

records of belemnites within the boundaries of ANIA, all in the Sutwik Island quadrangle. These specimens were collected from USGS Mesozoic localities M6606 ("Belemnite indeterminate") (D.L. Jones & J.W. Miller, written communication (E&R) to R.L. Detterman, 19 July, 1977), M6910 ("Belemnite fragment") (D.L. Jones & J.W. Miller, written communication (E&R) to R.L. Detterman, 27 April, 1978), M6925 ("*Cylindroteuthis* sp.") (D.L. Jones & J.W. Miller, written communication (E&R) to R.L. Detterman, 27 April, 1978), and M6967 ("*Cylindroteuthis* sp.") (D.L. Jones & J.W. Miller, written communication (E&R) to R.L. Detterman, 4 December, 1978). All except M6967 were stated to be from upper Oxfordian strata of the Naknek Formation. The E&R noting the *Cylindroteuthis* at M6967 states that the collections were from the Upper Cretaceous Hoodoo and Chignik Formations, but the conclusion by R. Detterman in the E&R was that the *Cylindroteuthis* sp. and the accompanying *Phylloceras* sp. and *Buchia concentrica* were of Late Oxfordian age. Plotting the locality data indicates that it was likely to have been found in a small exposure of Naknek Formation just north of Cape Ayutka (Detterman 1981). Although Detterman et al. (1996, p. 26) mention that concretions in the Lower Cretaceous Staniukovich Formation commonly contain belemnites, the reference pertains to a location outside of ANIA. Another Staniukovich locality with a belemnite record (USGS locality M7088) is north of Amber Bay, outside of ANIA but close to the boundary.

No descriptions or figures of the specimens diagnosed as *Cylindroteuthis* were provided. It is our observation that in past decades, long slender belemnite specimens were often stated to be *Cylindroteuthis*, but as noted in our summary of the findings in Dzyuba et al. (2019) in Lake Clark National Park, surface appearance is often not adequate to support this diagnosis. However, a Late Oxfordian age is consistent with this diagnosis.

In summary, reports from ANIA provide evidence of belemnites in the Upper Jurassic. It would be very interesting to find enough additional long thin specimens that some could be sectioned in order to look at the internal structure. It would also be interesting to know whether the Naknek Formation contains additional taxa. Since Upper Cretaceous formations are near the Naknek Formation on Cape Ayutka, it could be informative to explore these younger strata for any evidence of belemnites because they are thought to have disappeared from the North Pacific after the Early Cretaceous (Iba et al. 2011). Exploration of the Staniukovich Formation within ANIA could possibly yield Early Cretaceous specimens not previously described.

DENALI NATIONAL PARK AND PRESERVE (DENA)

Denali National Park and Preserve (DENA) is located in Interior Alaska in the Alaska Range and contains Denali, the highest mountain in North America. The park includes 6,075,030 acres and the preserve includes 1,334,118 acres (V. Santucci, email communication, 22 February 2020). DENA encompasses the large glaciers of the Alaska Range and a diverse fauna (Santucci et al. 2011). The park was established as Mt. McKinley National Park on February 26, 1917. In December of 1978 a separate designation created Denali National Monument and on December 2, 1980, both the park and monument were incorporated into and established as Denali National Park and Preserve (National Park Service 2016; Kenworthy & Santucci 2003). Only one road penetrates the park and huge areas of the park remain remote and very difficult to explore. The geologic history of DENA has seen limited reconnaissance fieldwork and many units have not been formally named (Santucci et al. 2011). USGS quadrangles that include portions of DENA include Mt. McKinley, Talkeetna, Kantishna River, and Healy.

Belemnite specimens have been identified at 11 localities within the boundaries of DENA and three potentially pertinent locations near the boundaries of the park. None of the specimens have been identified or figured and no identifying features are described. All but one specimen were noted to be fragments.

The Alaska Paleontological Database and Moxham et al. (1959) note that a belemnite was found at Field Number location 47ACb79 on a ridge between Bain and Windy Creeks about four and a half miles north of Cantwell. The age is noted to be Mesozoic and there is no identification beyond the term "Belemnites" (R. Imlay, written communication (E&R) to E.H. Cobb, 13 November 1951). We do not know whether Imlay used this term as a genus or as a description.

On the east side of the park, in the Chulitna River area, Blodgett and Clautice (2000) note three belemnite collection localities within DENA boundaries. These three locations (Field Numbers 97BT230, 97BT229 and 97BT227) are all from the drainage of an unnamed tributary of the West Fork of the Chulitna River, northeast of VABM JOYCE. There is no information about the formation, the age is listed only as Early Cretaceous, and the specimens are noted to be "belemnite guards". Also, in the east end of DENA, near the Buckskin Glacier, belemnites were found at two Hauterivian-Barremian sites (Field Numbers 76Ans56E and 76Ans55E).

Two specimens identified as "Belemnoidea" in the UAMN Arctos database were collected by the late Denali NPS geologist Phil Brease. One is noted to have been collected in the Chulitna District and the other has no provenance.

The Alaska Paleontological Database contains records of belemnites found at three localities in the Shellabarger Pass vicinity, located within DENA, on the western park boundary (USGS Mesozoic localities 30907, 30909, and 31268). The belemnite fragments found at localities 30907 (field no. 75AR38A) and 30909 (field no. 75AR38C) are from unnamed beds stated by R. Imlay to be Early Jurassic in age (R. Imlay, written communications (E&Rs) to Bruce Reed, 3 October 1975). The specimens from 31268 (field no. 76ADt147A), consisting of seven fragments, were found and photographed at the USNM by V. Santucci. The fragments are not of a quality that they can be identified. There are no specimens mentioned in the E&R for this sample other than "Belemnite fragments" and no age is given by Imlay (R. Imlay, written communication (E&R) to Bruce Reed, 9 November 1976).

Regarding locality 30908 (sample no. & field no. 75AR39, just outside the western park boundary) Imlay states in the E&R, ". . . the presence of *Coroniceras* at locality 75AR39 shows that the beds at that place are definitely lower Sinemurian." (R. Imlay, written communication (E&R) to Bruce Reed, 3 October 1975).

The E&Rs by R. Imlay for the localities 30907, 30908 and 30909 contain much of the same material and discuss several localities and sample numbers in each E&R. All three discuss field no. 75AR38C and refer to possible mixing with field no. 75AR38B, which does not have a record in the Alaska Paleontological Database. No identification of belemnites to genera or species was provided.

Outside of DENA but close to the eastern boundary in the Chulitna River area, are two localities (USGS Mesozoic localities 31261 & 31265) where belemnites were collected (Alaska Paleontological Database; Blodgett and Clautice 2000; Jones et al. 1980). These two sites are dated as Sinemurian (R. Imlay, written communication (E&Rs) to Bela Csejtey, Jr., and Norman J. Silberling, 10 November 1976).

As noted in the introduction to this paper, Sinemurian belemnites in Alaska would be quite unexpected. Any possible migration routes from Europe in the Sinemurian would be speculative. This is an interesting question and deserves further evaluation. Collecting of identifiable specimens is needed. Such collecting should carefully document the basis for age determination. Evidence that specimens are belemnites (as opposed to members of the Aulacocerida) would be crucial.

In summary, belemnite reports for Denali National Park and Preserve provide direction for future studies. The question of the presence of Sinemurian belemnites is especially significant. Further study of belemnites could clarify the relationship of terranes at the east and west ends of the park.

KATMAI NATIONAL PARK AND PRESERVE (KATM)

Katmai National Monument (KATM), located on the Alaska Peninsula, was designated as a monument in 1918 because of the violent eruption of Novarupta Volcano which formed the ash-filled "Valley of Ten Thousand Smokes", a result of the countless fumaroles that resulted from the ash fall. Katmai National Park and Preserve was established December 2, 1980, after the unit had undergone numerous boundary changes (National Park Service 2016; Kenworthy & Santucci 2003). The National Park encompasses 3,674,368 acres; the preserve includes 418,698 acres (V. Santucci, email communication, 22 February 2020). The following USGS quadrangles include land within Katmai National Park and Preserve: Iliamna, Seldovia (all water, within the Park because boundary is off-shore), Naknek, Mt. Katmai, Afognak, and Karluk.

Belemnites have been documented in what is now the park and preserve since the mid-19th century Russian-American era. Grewingk (1850, p. 26 in 2003 English translation of same) discusses fossils, including *Belemnites paxillosus*?, collected two miles from the sea on Katmai Bay near "Katmaiskoe village", presumably from Jurassic strata. The specimen was figured and described in German, by Pompeckj (1900), Plate VII, figure 4 A-F, legend p. 282), who equated it to *Belemnitella*. Pompeckj (1900, p. 274) states that the belemnite was a Cretaceous form. Stanton and Martin (1905, p. 409) discuss the same specimen. Their interpretation of the report of Pompeckj (1900) is that Upper Cretaceous deposits were present. However, Stanton & Martin (1905, p. 409) remarked that this lacked confirmation.

Jurassic and Cretaceous formations from which belemnites have been reported in more recent sources include the Middle Jurassic (Callovian) Shelikof Formation, the Upper Jurassic Naknek Formation, the Lower Cretaceous (Hauterivian-Barremian) Herendeen Formation, and possibly the Upper Cretaceous Kaguyak Formation. In our search of the Alaska Paleontological Database, museum collections, and various publications (Elder & Miller 1993; Miller et al. 1995; Jones & Detterman 1966; Jones & Miller 1976; Detterman & Reed 1980; Blodgett et al. 2016; Pompeckj 1900; and Grewingk 2003 translation), we found 111 belemnite records, either individual specimens or groups of rostra and/or fragments collected together. The following discussion presents information on belemnite finds in KATM from oldest to youngest.

The geologically earliest evidence of belemnites from Katmai National Park and Preserve in this inventory (USGS Mesozoic locality 29271) was found in the USNM. The specimens consisted of two unidentifiable fragments from the Callovian Shelikof Formation, Kashvik Bay. Although the description by Ralph Imlay for that locality notes only the Callovian ammonite *Cadoceras* (*Stenocadoceras*) *multicostatum* Imlay (Imlay & Detterman 1973, p. 25), the belemnite specimens were found in the USNM collections and records with the specimens included the locality number (C. & D. Schraer, personal observation). The entry in the USNM Mesozoic locality registry verifies the formation and age.

The Late Jurassic Naknek Formation was the source of 66 records of belemnites. The Naknek Formation is the most widespread formation within the park and consists of five members as recognized by Detterman et al. (1996). In ascending order these members are the Chisik Conglomerate, the Northeast Creek Sandstone, the Snug Harbor Siltstone, the Indecision Creek Sandstone, and the Katolinat Conglomerate. Our searches found 25 belemnite records in the Naknek Formation without comment as to specific member. Among these, 12 were stated to be *Cylindroteuthis* sp. and one was stated to be *Pachyteuthis* sp. in the E&Rs. We found 18 records in the Snug Harbor Siltstone Member, of which 14 were stated to be *Cylindroteuthis* sp., and 21 records in the Indecision Creek Sandstone Member, 20 of which were stated to be *Cylindroteuthis* sp. None of these specimens were figured or formally described. We found two records in the "Upper Sandstone Member" of the Naknek Formation, but we are uncertain as to which member this was. One of these was stated to be a *Pachyteuthis* sp., but again without figures or description (Detterman & Reed 1980, p. B39, Table 2).

Belemnite records from the Early Cretaceous include 33 records from the Herendeen Formation (Early Cretaceous, Hauterivian-Barremian), 19 of which were stated to be *Acroteuthis*. Among these, three were figured and published. Two of the three figured *Acroteuthis* specimens were diagnosed as *Acroteuthis* sp. A (Jones & Detterman 1966, p. D54, fig. 3, g-i, USNM 153998 and p. 56, fig. 4, c-d, USNM 154000) and one was diagnosed as *Acroteuthis* sp. B (Jones & Detterman 1966, p. D56, fig. 4, c-d, USNM 154000). In addition to the above-mentioned *Acroteuthis* specimens, three occurrences noted both *Acroteuthis* sp. and *Cylindroteuthis* sp. and were stated in the reports in the Alaska Paleontological Database (based on Miller et al. 1995) to be "reworked in Cretaceous" (Mesozoic localities M6754, M6755, M6802). The Pedmar Formation (Early Cretaceous, Albian) was noted to have four records of belemnites (USGS Mesozoic localities M7859, M8416, M8412, M8469). All stated in the reports in the Alaska Paleontological Database (based on Miller et al. 1995) to be "*Acroteuthis* sp. reworked".

In addition to the Pompeckj (1900) specimen, the Kaguyak Formation is the possible source of four Late Cretaceous belemnite occurrences, USGS Mesozoic localities M6838, M5678, 25855, and 25856. This is notable because belemnites are thought to have been absent from the North Pacific after the Early Cretaceous (Iba et al. 2011). However, the data for each locality is equivocal. The report in the Alaska Paleontological Database (based on Miller et al. 1995) for locality M6838 lists *Acroteuthis* sp. and *Cylindroteuthis* sp. but notes "(reworked)" for the *Acroteuthis* and "(reworked from Cretaceous)" for the *Cylindroteuthis*. For M5678, the only source of information indicating the Kaguyak Formation was a transcribed card with the specimen (a rostrum in two pieces) in the UCMP (C. &

D. Schraer, personal observation). No record for this locality is found in the Alaska Paleontological Database. The E&Rs for localities 25855 (field No. CEK 742) and 25856 (field No. CEK 744) contain a long discussion by Ralph Imlay in which he states that "This is not the first instance of reworked belemnites occurring in Upper Cretaceous beds in Alaska." (R. Imlay, written communications (E&Rs) to C.E. Kirschner, 4 November 1955). Imlay concludes the reports by saying that the *Acroteuthis* specimens at both localities were "derived from Neocomian beds" and that the *Cylindroteuthis* at locality 25856 was "derived from Neocomian or Late Jurassic beds".

Robert B. Blodgett (personal communication) observed a longitudinal section of a belemnite in Campanian-Maastrichtian age Kaguyak Formation strata (Fig. 3) on the west side of Dakavak Bay (Mt. Katmai A-3 1:63,360 scale quadrangle) in KATM. He visited the locality (approx. coordinates 58°00.749' N, 154°44.742' W) which is situated at or just above the high tideline. The site visit was conducted on June 15, 2012 with geologists from the Apache Corporation. No attempt was made to collect the specimen as the permit from the NPS did not allow collection of fossils. This single large specimen does not appear to be reworked, but in light of reworking of other Kaguyak Formation belemnite specimens noted by Imlay it is imperative that this locality be relocated, and the specimen collected for further study. Photos of inoceramid bivalves observed by Blodgett nearby were sent to Will Elder (NPS, Golden Gate National Recreation Area) who identified them as members of *Inoceramus* (*Endocostea*) group, probably *I*. (*E*.) *shikotanensis* Nagao and Matsumoto, known from the early Maastrichtian of Japan (W. Elder, written communication, July 10, 2016).

It must be emphasized that systematic paleontological work on belemnites has never been conducted in Alaska. Belemnite rostra in many cases are quite durable which may further complicate investigations into the question of reworking. Further collecting of belemnites and other invertebrates in KATM could provide significant information on the possible existence of belemnites in the North Pacific during the Late Cretaceous.

In addition to the above-mentioned occurrences, two localities produced belemnites with no information on the formation. USGS Mesozoic locality 25832 was found to be associated with two field numbers. CEK-834 had belemnite phragmocones, but the formation was not stated. This is very likely from the Naknek Formation as the other field number, CEK-776 was associated with the Naknek Formation, unspecified member, and produced a *Cylindroteuthis* specimen. The other USGS Mesozoic locality, 32698, produced a belemnite specimen that is in the collections of the California Academy of Sciences (C. & D. Schraer, personal observation).

In summary, KATM has a wealth of localities at which belemnites have been found. While many specimens are fragments, more have been identified at the genus level than in other parks. However, supporting figures and descriptions would be needed to verify diagnoses using modern criteria. The data indicate the need for further research to address the question of the presence of belemnites in the North Pacific in the Late Cretaceous.

LAKE CLARK NATIONAL PARK AND PRESERVE (LACL)

Lake Clark National Park and Preserve (LACL), located in the Chigmit Mountains on the Alaska Peninsula, was first designated as Lake Clark National Monument in 1978. It was established as a national park in 1980 by the Alaska National Interest Lands Conservation Act. The national park includes 2,619,713 acres; the national preserve encompasses 1,410,293 acres (V. Santucci, email communication, 22 February 2020). The park and preserve have great geologic diversity, including two active volcanoes, and a wealth of fossiliferous Jurassic sedimentary strata representing one of the most complete sequences of fossiliferous Jurassic strata in the United States (National Park Service 2016; Kenworthy & Santucci 2003; Detterman & Hartsock 1966, p. 1). The following USGS quadrangles include land within LACL: Iliamna, Kenai, Lake Clark, Lime Hills, Seldovia, and Tyonek.

FIGURE 3. Longitudinal section of belemnite rostrum, in place, Campanian-Maastrichtian age Kaguyak Formation, west side of Dakavak Bay, Mt. Katmai A-3 1:63,360 scale quadrangle, in KATM. Photo by Robert B. Blodgett.

The Jurassic sequence of marine deposits includes (oldest to youngest) the Talkeetna Formation (Lower Jurassic), the Tuxedni Group, containing six formations, (Middle Jurassic), the Chinitna Formation (Upper Jurassic) and the Naknek Formation (Upper Jurassic) (Detterman & Hartsock 1966; Wilson et al. 2012). Belemnites have been documented in what is now Lake Clark National Park since at least the early 20th century. The belemnites found in the above-mentioned formations range in age from the Early to the Late Jurassic. In our search of the Alaska Paleontological Database, museum collections, Detterman & Hartsock (1966); Blodgett et al. (2015); and

Dzyuba et al. (2019), we found 60 belemnite occurrences, either individual specimens or groups of fragments collected together. The following discussion presents information on belemnite finds in LACL, described from oldest to youngest.

The Lower Jurassic Talkeetna Formation is exposed in many areas of LACL in the Cook Inlet Region (Wilson et al. 2012). One mention of "belemnite fragments" found in the vicinity of Horn Mountain, in a discussion of the Talkeetna Formation Horn Mountain Tuff, documents the earliest belemnites known in LACL (Detterman & Hartsock 1966, pp. 19 & 20). The age is somewhat uncertain but based on comparison to this unit in the Talkeetna Mountains, the age is probably late Pliensbachian to Toarcian (Detterman & Hartsock 1966, p. 20). This is notable because mentions of belemnites in the Talkeetna Formation are rare. The Alaska Paleontological Database contains only two records from the Talkeetna Formation, both from the Talkeetna Mountains. One is of "probable" Pliensbachian age (USGS Mesozoic locality 6697, R. Imlay, written document (E&R) 23 May 1961); the other is of probable late Toarcian age (USGS Mesozoic locality 25317, R. Imlay, written communication (E&R) to A. Grantz, 1 December 1954). This suggests that the belemnite find in the Talkeetna Formation in LACL bears further investigation, given the rarity of belemnite records in this formation and other Early Jurassic strata in Alaska. This is also of interest as belemnites are thought to have existed only in what is now Europe prior to the Toarcian (Doyle et al. 1997).

The Middle Jurassic Tuxedni Group is well represented in LACL. The formations in the group, from oldest to youngest, are the Red Glacier Formation, the Gaikema Sandstone, the Fitz Creek Siltstone, the Cynthia Falls Sandstone, the Twist Creek Siltstone (all Bajocian), and the Bowser Formation (Bajocian and lower Bathonian) (Detterman & Hartsock 1966; Wilson et al. 2012).

The Red Glacier Formation, Fitz Creek Siltstone, and Cynthia Falls Sandstone are well exposed in LACL along the shoreline of Tuxedni Bay, at or near Fossil Point, and inland from the shoreline. We found 18 belemnite occurrences in the Red Glacier formation, 11 in the Fitz Creek Siltstone, and 10 in the Tuxedni Group with uncertain formation. The Bowser Formation is exposed in LACL along Tuxedni Channel and at various localities from the channel to the north shore of Chinitna Bay (Detterman & Hartsock 1966; Wilson et al. 2012). Our review found 10 belemnite occurrences in the Bowser Formation. We did not find any occurrences of belemnites in the Gaikema sandstone, the Cynthia Falls Sandstone, or the Twist Creek Siltstone, except for one box of fragments in the USNM that was either from the Fitz Creek or the Cynthia Falls (Tuxedni Group, uncertain formation).

The Middle Jurassic (Callovian) Chinitna Formation is divided into the Tonnie Siltstone Member (older) and the Paveloff Siltstone Member (younger). It is exposed in the park along Tuxedni Channel and near the north shore of Chinitna Bay (Wilson et al. 2012). Our survey found seven belemnite occurrences, two in the unspecified Chinitna, two in the Tonnie Siltstone Member and three in the Paveloff Siltstone Member.

The Upper Jurassic Naknek Formation is widely exposed in the park between Tuxedni Channel and Chinitna Bay (Wilson et al. 2012). Our survey found three belemnite occurrences in LACL, all from the north shore of Chinitna Bay.

Only eight belemnite specimens of the 60 occurrences referred to above have been identified, figured and published (Dzyuba et al. 2019). The others have been described as fragments, "Belemnites" without clarity as to whether this term is used as a genus or as a descriptor, "*Belemnites* sp." or "*Belemnites* indet." The genus "*Belemnites*" was commonly used in the 19th and 20th centuries for a wide range of forms in the general group "belemnites". Seven fragments from the Tuxedni Group are figured in Blodgett et al. (2015), pp. E-53, 55, 56, and 57, but these were not of adequate quality for definite diagnosis. However, recent work has found that the Red Glacier formation and the Fitz Creek Siltstone have yielded some very significant belemnite finds, including the recent recognition of two new taxa in the family Megateuthididae (Blodgett et al. 2015; Dzyuba et al. 2019).

In the following discussion, it is important to note that the families Cylindroteuthididae and Megateuthididae can be distinguished by careful preparation of the internal rostral calcite structures that show early ontogeny. Two belemnite specimens from the Red Glacier Formation (lower Bajocian) were provisionally identified as *Cylindroteuthis* (LACL 9398) and *Pachyteuthis* (LACL 9401) (both members of the Cylindroteuthididae) based on external characteristics prior to preparation (Blodgett et al. 2015 p. E-54, E-57 and E-58). However, the dimensions of LACL 9401 were consistent with the genus *Simobelus* (Cylindroteuthididae) which was not known in the geologic record as early as the early Bajocian. Detailed preparation of the region at the posterior end of the alveolus revealed that LACL 9401 (Dzyuba et al. 2019 p. 918, fig. 5) and LACL 9398 (Dzyuba et al. 2019 p. 921, fig.6) were members of the family Megateuthididae.

At the time of the above-mentioned research, we were in the process of measuring and documenting specimens in the UAMN and USNM that had been collected in past decades from the Red Glacier and Fitz Creek Formations in the Fossil Point area. Overall, this research has resulted in the description of two holotypes found in Lake Clark National Park, near Fossil Point, *Pseudosimobelus tuxedniensis* gen. et sp. nov. (LACL 9401), (Dzyuba et al. 2019 p. 918, fig. 5) and *Eocylindroteuthis gracilenta* sp. nov. (UAMES 34853), a new species of a genus not previously known outside of Europe (Dzyuba et al. 2019, p. 921, fig.6). Other specimens of note from the Fossil Point area included additional specimens of *E. gracilenta* (LACL 9398, UAMES 34874, Dzyuba et al. 2019, p. 921, fig. 6), some possible representatives of the genus *Eocylindroteuthis* (UAMES 34854, USNM 641840 and 641841) (Dzyuba et al. 2019, p. 923, fig. 8), and the first record of *Brevibelus gingensis* (LACL 8182), from outside Europe (Dzyuba et al. 2019, p. 918, fig. 5). We conclude that *Pseudosimobelus* gen. nov. represents a transitional form between the families Megateuthididae and Cylindroteuthididae, or that it may be ancestral to the Cylindroteuthididae, and that the presence of *Brevibelus* and *Eocylindroteuthis* (and *Hibolithes* sp. juv. from the Talkeetna Mountains, not in LACL) provide evidence for Tethyan belemnites having migrated between the western Tethys and the eastern Pacific via the Hispanic Corridor (Dzyuba et al. 2019).

In summary, Lake Clark National Park and Preserve has been the source of two holotypes of Bajocian belemnites. To the best of our knowledge, Callovian belemnites have not been systematically studied in Alaska. Since the Callovian Chinitna Formation is exposed in LACL, this could be the subject of interesting studies that would help provide a picture of the evolution and migration of belemnites through the Middle Jurassic. Future work could also focus on attempts to find more specimens of *Pseudosimobelus tuxedniensis* and *Eocylindroteuthis gracilenta* near Fossil Point, in order to further characterize these taxa.

WRANGELL-SAINT ELIAS NATIONAL PARK AND PRESERVE (WRST)

Wrangell-St. Elias National Park and Preserve (WRST), located in the southeastern corner of Alaska, was established in 1980 by the Alaska National Interest Lands Conservation Act. Previously, the unit had been proclaimed the Wrangell-St. Elias National Monument in 1978 and was designated as a World Heritage Site in 1979. This national park is the largest unit of the National Park System. The highest point in the park is Mount St.

Elias (18,008 feet), the second highest mountain in the United States. North America's largest assemblage of glaciers and the greatest collection of peaks above 16,000 feet are contained in the park and preserve (National Park Service 2016; Santucci et al. 2011). The National Park contains 8,323,147 acres while the preserve contains 4,852,652 acres (V. Santucci, email communication, 22 February 2020). U.S. Geological Survey quadrangles that cover portions of WRST include Gulkana, Nabesna, Valdez, McCarthy, Cordova, Bering Glacier, Mount St. Elias, and Yakutat.

A search of pertinent references (MacKevett 1969, 1971; MacKevett et al. 1978; Santucci et al. 2011; Martin 1926; the Alaska Paleontological Database), reports by John Reeside, and our findings in museums UCMP and USNM document occurrences of belemnites at 65 localities within WRST. Very few of the specimens have any taxonomic assignment and most are noted to be fragments. One group of fossils found in the Alaska Paleontological Database (field number 67 Awk 103) is noted to be Triassic and describes "indeterminate cylindrical or conical objects (possibly coleoids, i.e. "belemnites")" (N.J. Silberling, written communication (E&R) to E.M. MacKevett, Jr., and J.G. Smith, 29 March 1968). Geographic information is limited to the McCarthy B-4 quadrangle, in WRST. The Triassic age indicates that these specimens are not belemnites. The Alaska Paleontological Database provided E&Rs for four belemnite records in the Nabesna quadrangle that had insufficient detail to be certain that they were in the park. Since the park covers much of the Nabesna quadrangle, we believe it is likely that these localities are within WRST and include them in this dataset. We conclude that 64 localities within WRST have produced specimens that should be considered to be belemnites based on available information.

Much of the collecting in this region occurred in the early 20th century before formal names had been applied to formations (Martin 1926). Therefore, many of the localities with belemnite occurrences do not have information on formation and/or age. A formation was specified for 20 of the localities, some of which were noted to be questionable. The ages of the formations were taken from Santucci et al. (2011). They include the McCarthy Formation (two localities, Early Jurassic, possibly Sinemurian or Pliensbachian), the Lubbe Creek Formation (one locality, Pliensbachian or Toarcian), the Nizina Mountain Formation (nine localities, Middle Jurassic, Bathonian-Callovian), the Root Glacier Formation (one locality, Late Jurassic, Late Oxfordian or Kimmeridgian), and the Kennicott Formation (seven localities, Early Cretaceous). For 44 localities, a formation was not stated. Among the 44 with no formation stated, 25 had information on age, and 19 had no information on age. Ages, where stated, were indicated with varying degrees of precision and ranged from Early Jurassic to Late Cretaceous.

Only six specimens had clearly stated genera. Three specimens were identified as *Acroteuthis* (J.W. Miller, written communication (E&R) to G. Plafker, 31 October 1984). All were from USGS Mesozoic locality M7993, field number 84 Apr39, Hauterivian-Barremian. These three specimens are in the UCMP; they are three large fragments, poorly preserved, found in the Valdez D-2 quadrangle, with no data on formation (C. & D. Schraer, personal observation). Three specimens were stated to be of the genus *Cylindroteuthis*. One was described as "*Cylindroteuthis* sp." (MacKevett 1969 & 1971), USGS Mesozoic locality 28680, McCarthy C-5 quadrangle, found in the Root Glacier Formation, late Oxfordian and Kimmeridgian. The other two were from USGS Mesozoic locality 11376, Kennicott Formation, Lower Cretaceous, in the McCarthy quadrangle. They were stated to be "*Belemnites* undetermined" (R. Imlay, written communication (E&R) to D.L. Jones and E.M. MacKevett, Jr., 9 November 1961). These specimens are in the USNM; a handwritten note by J. Jeletzky, an expert belemnitologist of the mid-20th century, said "?*Cylindroteuthis* sp. ind.". The two specimens are together in the USNM; they are fragments of two separate belemnites (C. & D. Schraer, personal observation).

In addition to these six specimens, four USGS Mesozoic localities (9949, 9954, 9955, 9957) produced specimens described as "*Belemnites* (*Belemnopsis*)" by Reeside and/or Martin (1926); three were from the Kennicott Formation, while one did not have a formation stated. It is not clear whether these were presumed to be of the genus *Belemnites* or *Belemnopsis*.

Associated fossils indicate that the fossil-containing upper part of the McCarthy Formation (USGS Mesozoic localities 28687 and 28688) is of Hettangian to Pliensbachian age and the Lubbe Creek Formation (USGS Mesozoic locality 28530) is of Pliensbachian to Toarcian age (Santucci et al. 2011). Thus, the belemnite specimens in the McCarthy and Lubbe Creek Formations appear to be older than what would be classically expected for belemnites outside of Europe (Doyle 1987, 1994, 1997). Further field work could potentially elucidate whether these formations are correctly dated, and whether or not they bear true belemnites versus members of the Aulacocerida.

In summary, Wrangell-Saint Elias National Park and Preserve appears to be a rich source of belemnites. However, of all the Alaskan NPS units with belemnite records, the provenance and age data for those in WRST is the least precise and complete. While only 20 of 64 localities had information on the formation, and most specimens were fragmentary, some interesting possibilities for future studies emerge. The specimens that appear to be belemnites from the Early Jurassic deserve further study. It would not be extremely surprising to verify that belemnites of Toarcian age are present, but if true belemnites (as opposed to aulacocerids) were present earlier, that would be a significant finding. Similarly, belemnites of a verified Late Cretaceous age could provide information on the history of terrane motion and/or call into question the concept that they were absent from the North Pacific after the Early Cretaceous (Iba et al. 2011). It appears that belemnites were present from the Middle Jurassic through the Early Cretaceous. Specimens with adequate preservation for identification could contribute significant information on the evolution and migration of this group within the context of terrane history of WRST.

YUKON-CHARLEY RIVERS NATIONAL PRESERVE (YUCH)

Yukon-Charley Rivers National Monument (YUCH) was established December 1, 1978 and was designated a national preserve on December 2, 1980. It is located along the Canadian border and protects 128 miles of the Yukon River as well as the entire Charley River Basin. These river systems were of great importance in the 1898 gold rush. Cabins and other historic relics of this period of Alaskan history are present in the preserve (National Park Service 2016; Santucci et al. 2011). The preserve includes 2,526,512 acres (V. Santucci, email communication, 22 February 2020). USGS topographic quadrangles that cover the Preserve include Circle, Charley River, Big Delta, and Eagle.

Despite the long history of geological investigations and field mapping in the present area of the Yukon-Charley Rivers National Preserve (primarily Mertie, 1930, 1937; Brabb, 1969; Brabb and Churkin, 1969; Dover and Miyaoka, 1988; Miyaoka, 1990), only three collections of belemnites have been noted, all from Lower Cretaceous strata. None of these specimens have ever been illustrated or formally described. The earliest reports were from two field collections gathered by J.B. Mertie, Jr. in 1925 from USGS Mesozoic locality 13428 (field locality 25AMt207) and USGS Mesozoic locality 13429 (field locality 25AMt227). Both localities were reported in Mertie (1930 and 1937) as being from the Lower Cretaceous Kandik Formation, a stratigraphic unit established by Mertie (1930). This unit was subsequently raised in rank to that of a group by Brabb (1969), with three successive Lower Cretaceous formations recognized within it, from bottom to top consisting of the basal Keenan Quartzite (Valanginian age), Biederman Argillite (also of Valanginian age), and the uppermost Kathul Graywacke. USGS Mesozoic locality 13428 yielded *Belemnites*? sp., identified by Stanton, shown as locality 78 of Miyaoka (1990), in exposures now placed in the Biederman Argillite on the south side of the Yukon River in the Charley River B-3 quadrangle. USGS Mesozoic locality 13429 contained a *Belemnites* sp. identified by T.W. Stanton (along with an *Inoceramus* sp.) and is situated in an exposure now assigned to the Keenan Quartzite in the Charley River B-5 quadrangle. It was shown as locality 28 on the map of Dover and Miyaoka (1988). In addition, several species of the bivalve *Buchia* were reported, including *Buchia* cf. *B. crassicollis* of Valanginian age. This occurrence was also noted in Brabb (1969, p. I19). This belemnite specimen is in the UCMP; it is a poorly preserved cylindrical fragment that does not show identifying features (C.& D. Schraer, personal observation).

A third locality near but outside of the YUCH boundary (USGS Mesozoic locality M2059) was reported by Brabb (1969, p. I15-I16) to contain a belemnite and the bivalve *Buchia* "*sublaevis*" identified by D.L. Jones. This locality in the Keenen Quartzite was collected by geologists of Mobil Oil Company in 1962 and is situated in the Charley River B-2 quadrangle (lat. 65°29.7 N., long. 141°34' W). Unfortunately, the locality is not plotted on the map of Miyaoka (1990). However, the above coordinates show that it is north of the YUCH boundary between the Step Mountains and the Kandik River. This specimen, which consists of a sediment plug from the alveolus, a mold, and a rubber cast, is in the UCMP (C. & D. Schraer, personal observation).

In summary, two belemnite specimens have been found within the boundaries of Yukon-Charley Rivers National Preserve, and one has been found near the preserve. None have been identified or figured; the two that we observed are fragmentary and not identifiable. Further field work would be necessary to provide identifiable specimens.

DISCUSSION

The national parks in Alaska are very rich in belemnite finds. In the six parks with belemnites mentioned in network reports (ANIA, DENA, KATM, LACL, WRST, and YUCH), we documented 252 belemnite occurrences in national parks, monuments, and preserves, and five others near park boundaries that offer pertinent information. It is likely that there are even more occurrences of belemnites because of the fact that a number of records and specimens in museums were not associated with adequate geographic data to determine whether or not they were from a national park. Relatively few specimens had been identified taxonomically, and other than those from LACL figured in Dzyuba (2019), and those from KATM figured in Jones & Detterman (1966) and Pompeckj (1900), none have been figured, described or identified using current methods and taxonomic schemes. Many specimens are either described as fragments or "scraps" or were observed by us to consist of unidentifiable fragments. However, in our museum visits we noted a number of specimens that are potentially identifiable and could form the basis of future taxonomic work.

Even suboptimal specimens show a geographic distribution for belemnites. This is especially significant for those purported to be of Sinemurian and Late Cretaceous age. Future work to determine specific ages for Early Jurassic and Late Cretaceous belemnites would require high-quality specimens and associated fossils that would provide unequivocal dating. In the case of those of Early Jurassic age, it would be important to find specimens that are definitely belemnites and not aulacocerids. It would be informative to reexamine the shore of Tuxedni Bay in the vicinity of Fossil Point in LACL to find additional specimens of *Pseudosimobelus tuxedniensis* and *Eocylindroteuthis gracilenta*. There is only one specimen of the former and few specimens of the latter.

There are many claims of *Cylindroteuthis* (family Cylindroteuthididae, subfamily Cylindroteuthidinae), *Pachyteuthis* and *Acroteuthis* (both in family Cylindroteuthididae, subfamily Pachyteuthidinae) in E&Rs from past decades. Based on known time ranges of these three genera, these claims are plausible. The Cylindroteuthidinae ranged from the Bajocian into the Hauterivian, while the Pachyteuthidinae ranged from the Bajocian into the Barremian (Dzyuba 2011, unnumbered figure, p. 106). However, the genera of belemnites found in the six national parks discussed herein, other than those described in Dzyuba et al. (2019), have not been verified.

Field work in many of the Alaska parks in which belemnites have been found would be expensive and involve difficult access and logistics, but building a more robust dataset on belemnites in the parks of Alaska could shed light on Mesozoic marine migration routes and history of terrane motion.

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