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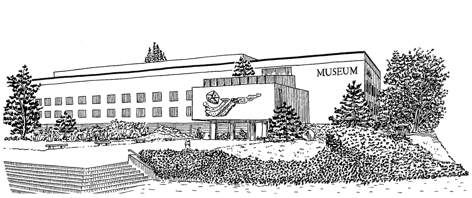

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Pliensbachian ammonoids from the Talkeetna Mountains (Peninsular Terrane) of Southern Alaska

Andrew H. CARUTHERS[1] & Paul L. SMITH[1]

Abstract
In this study we describe Late Pliensbachian ammonites from two stratigraphic sections of the Talkeetna Formation exposed in southern Alaska. Ammonites indicate the Kunae Zone in the Camp Creek section and Carlottense Zone in the Hicks Creek section. An interbedded ash within the Camp Creek section provides a ^{206}Pb/^{238}U TIMS age date of 184.12 ± 0.17 Ma from the uppermost Kunae Zone, very close to the base of the overlying Carlottense Zone which is currently calibrated at 184.1 + 1.2/-1.6 Ma). Ammonoid taxa described in this study represent the Tethyan, Boreal, and East Pacific Realms and include: *Amaltheus* sp., *Arieticeras* aff. *domarense* (MENEGHINI), *Fanninoceras (Fanninoceras) carlottense* MCLEARN, *Fanninoceras (Fanninoceras) fannini* MCLEARN, *Fanninoceras (Charlotticeras)* cf. *maudense* SMITH & TIPPER, *Leptaleoceras*? sp., *Lioceratoides (Lioceratoides)* cf. *involutum* SMITH & TIPPER, and *Lytoceras* sp., of which *Fanninoceras (Charlotticeras)* cf. *maudense*, *Leptaleoceras*? sp., and *Lioceratoides (Lioceratoides)* cf. *involutum* are new to Alaska.

Keywords
Early Jurassic, Pliensbachian, Ammonoids, Peninsular terrane, Alaska.

I. INTRODUCTION

The Peninsular terrane of southern Alaska (Fig. 1) is considered one of the largest outboard tectonostratigraphic terranes in western North America (CONEY *et al*., 1980; WILSON *et al*., 1985; WANG *et al*., 1988). It comprises much of the modern-day Alaskan Peninsula extending ~1200 km throughout the Talkeetna Mountains and is bordered by the Chugach terrane to the southeast and the Wrangell terrane to the east (CSEJTEY *et al*., 1978; JONES & SILBERLING, 1979; CSEJTEY & ST. AUBIN, 1981; WILSON *et al*., 1985). Sequences deposited on the Peninsular terrane are thought to have initially accumulated in the paleo Pacific Ocean far from the North American margin (WILSON *et al*., 1985; WANG *et al*., 1988; PLAFKER *et al*., 1989, 1994; CLIFT *et al*., 2005a, b; BLODGETT & STRALLA, 2006; RIOUX *et al.,* 2007). Deposition began in a shallow-water, tropical, backarc environment during Permian-Triassic time (WANG *et al.,* 1988; BLODGETT & STRALLA, 2006) and shifted toward an intraoceanic volcanic island arc-type environment throughout the Early Jurassic and into the early Middle Jurassic (BARKER & GRANTZ, 1982). Island arc related magmas have recently been dated using U-Pb zircon and whole-rock isotope analysis indicating that magmatism occurred primarily between 202.1 and 181.4 Ma (CLIFT *et al*., 2005a, b; RIOUX *et al*., 2007). By Middle-Late Jurassic time, it is thought that the depositional environment had shifted toward a forearc including deep-water fan-delta deposition, shelf sedimentation, post-depositional uplift, and strike-slip displacement (TROP *et al*., 2005).

Current tectonic models postulate that the Peninsular terrane was amalgamated with Wrangellia and the Alexander terrane, forming the Wrangellia composite terrane, which then accreted to the western margin of North America (WANG *et al*., 1988; PLAFKER *et al*., 1989; RIDGEWAY *et al*., 2002; TROP *et al*., 2005). However, the timing of amalgamation versus the timing of accretion is a complex issue that is still unclear. Originally it was thought that the composite terrane was assembled by Triassic time (WANG *et al*., 1988; PLAFKER *et al*., 1989) and accreted to the continental margin of western North America between the Late Jurassic and Late Cretaceous (CSEJTEY *et al*., 1982; JONES *et al*., 1982; PAVLIS, 1982; MCCLELLAND *et al*., 1992; COLE *et al*., 1999; RIDGWAY *et al*., 2002; TROP *et al*., 2002). Other studies have indicated that collision of the composite terrane with western North America may have occurred as early as Middle Jurassic-Early Cretaceous time (MCCLELLAND & GEHRELS, 1990; MCCLELLAND *et al*., 1992; VAN DER HEYDEN, 1992; KAPP & GEHRELS, 1998; GEHRELS, 2001). However, recent work concludes that Late Jurassic deformation and synorogenic sedimentation could reflect either the initial collision of Wrangellia and the Peninsular terranes or their collision with western North America (TROP *et al*., 2005).

In this study we describe Early Jurassic ammonoid faunas from two sections in the Talkeetna Mountains of southern Alaska (Fig. 1) and provide a U-Pb age date from an ash

[1] *Department of Earth and Ocean Sciences, University of British Columbia, 6339 Stores Road, Vancouver British Columbia V6T 1Z4, Canada. E-mail addresses: acaruthers@eos.ubc.ca, psmith@eos.ubc.ca*

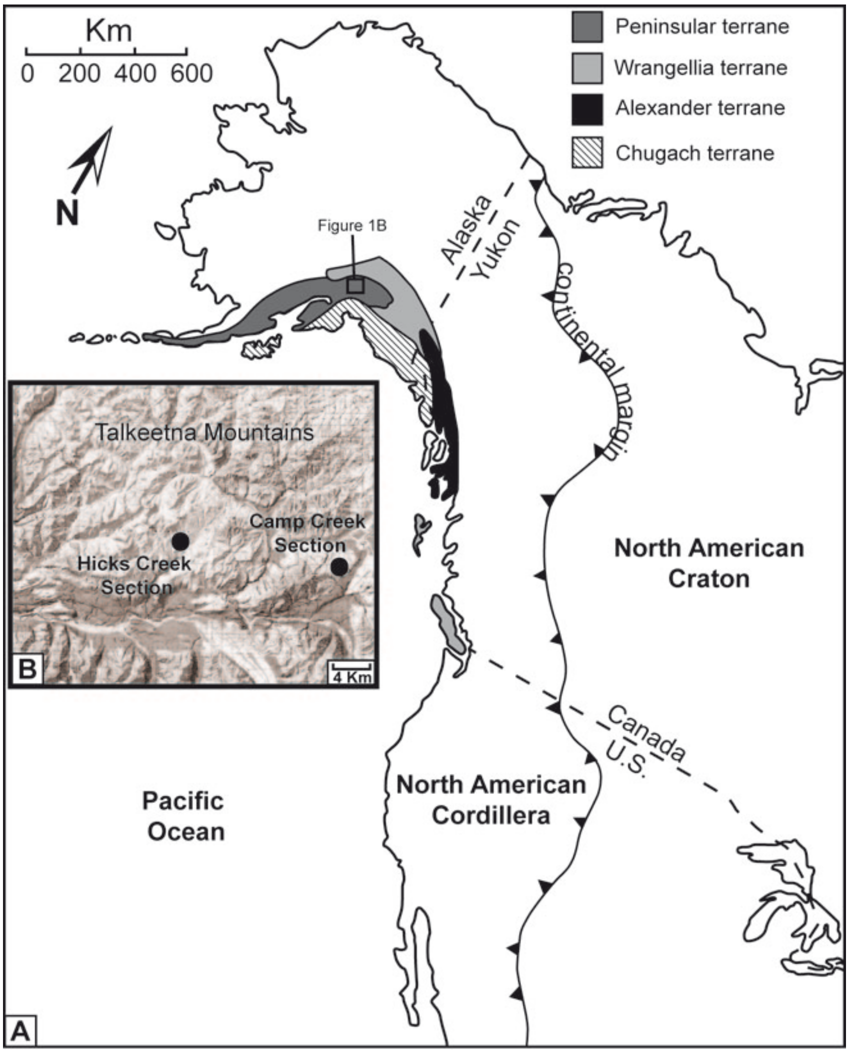


Fig. 1: A) Map of western North America showing the study area (black box) and approximate terrane boundaries specific to this study (terrane boundaries after CONEY *et al*., 1980; TROP *et al*., 2005). B) Topography of the southern Talkeetna Mountains indicating location of the Camp Creek (N61º50'13.92; W147º25'50.88) and Hicks Creek (N61º52'23.52; W147º51'46.08) sections (black dots).

bed within one of the sections. Results from this study further our understanding of the Peninsular terrane by providing paleontological and geochronological data for a key interval of the Early Jurassic when ammonoid endemism was marked. The ammonoid fauna described herein incorporates both new and previously collected (IMLAY, 1981) material from the Talkeetna Mountains. We update taxonomy, integrate new ammonoid occurrences into measured stratigraphic sections for the first time, and provide higher resolution age constraint on the marine sedimentation that produced the Talkeetna Formation.

Pliensbachian ammonite zonal scheme

The Early Jurassic fossiliferous marine sedimentary and interbedded volcaniclastic sequences in the western North American Cordillera are extremely useful for calibrating biochronologic and geochronologic time scales. Previous studies have established an ammonite-based zonal scheme for Pliensbachian and Toarcian successions in western North America that is calibrated with dates from interbedded zircon-bearing ash beds (SMITH *et al*., 1988; JAKOBS *et al*., 1994; JAKOBS, 1997; PÁLFY *et al*., 2000) and further correlated with the ammonite zonal schemes of NW Europe, the Mediterranean, and South America (Fig. 2). In ascending stratigraphic order, the Pliensbachian and earliest Toarcian ammonite zones include the Imlayi, Whiteavesi, Freboldi, Kunae, Carlottense and Kanense Zones. Of these, the Kunae and Carlottense Zones comprise the later part of the Pliensbachian which is thought to have lasted ~2.1 Ma (using data in PÁLFY *et al*., 2000).

In western North America the first appearance of the genus *Fanninoceras* is used to define the base of the Kunae Zone, which is characterized by the first appearance of *Fanninoceras* above *Dubariceras*

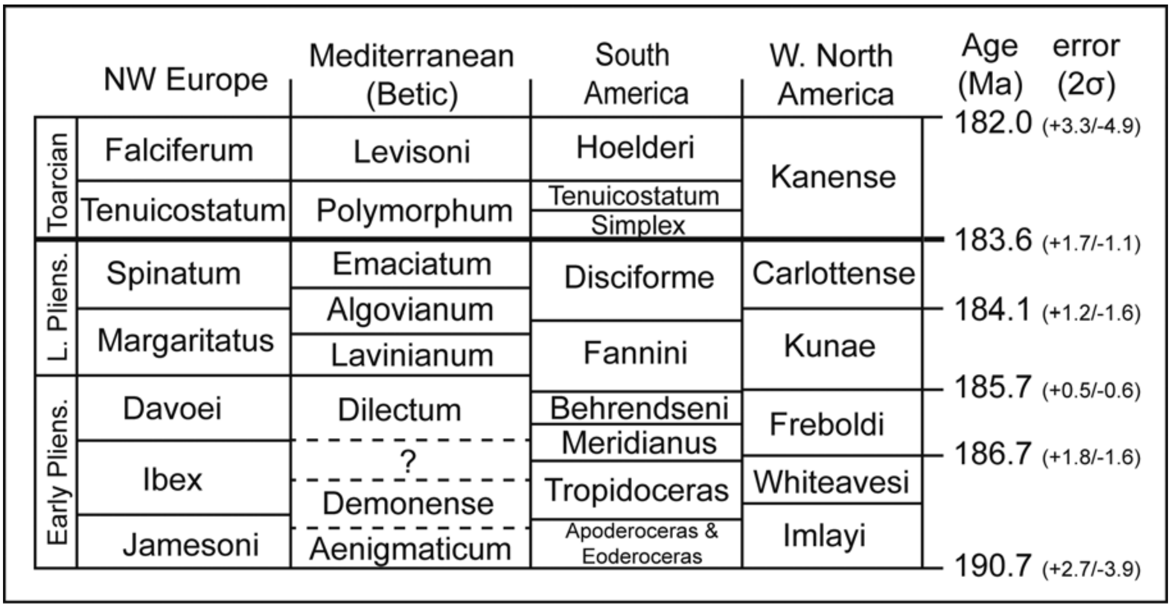


Fig. 2: Correlative ammonite zonal schemes and absolute U-Pb age data for the Pliensbachian (after SMITH *et al*., 1988) and Toarcian (after JAKOBS *et al*., 1994; JAKOBS, 1997) of NW Europe, Mediterranean, South America and western North America. Absolute age dates from data in PÁLFY *et al*. (2000). Pliens. = Pliensbachian; L. = Late.

freboldi (SMITH *et al*., 1988). The Kunae Zone is further characterized by several other ammonite species from a variety of genera including *Phylloceras*, *Cymbites*, *Fanninoceras (Fanninoceras)*, *Fanninoceras* (*Charlotticeras*), *Aveyroniceras*, *Reynesocoeloceras*, *Fieldingiceras*, *Arieticeras*, *Liparoceras*, *Leptaleoceras*, *Fontanelliceras*, *Amaltheus*, *Reynesoceras*, *Fuciniceras,* and *Protogrammoceras* (Fig. 3).

The base of the Carlottense Zone is marked primarily by the first appearance of the index species *Fanninoceras (Fanninoceras) carlottense* (SMITH *et al*., 1988) and various other characterizing species from *Lioceratoides (Lioceratoides)*, *Protogrammoceras*, *Amaltheus*, *Fieldingiceras*, *Lioceratoides* (*Pacificeras*), and *Tiltoniceras* (Fig. 3). The presence of the species *Lioceratoides* (*Pacificeras*) *propinquum* (WHITEAVES), *Protogrammoceras paltum* (BUCKMAN), and *Tiltoniceras antiquum* (WRIGHT) in the latest Pliensbachian of western North America contrasts with other parts of the world where these taxa are characteristic of the Early Toarcian (SMITH *et al*., 1988; SMITH & TIPPER, 1996). In western North America the base of the Toarcian is defined by the first appearance of *Dactylioceras kanense* MCLEARN (Fig. 3) above the last occurrences of *Amaltheus* and *Fanninoceras* species (SMITH *et al*., 1988; JAKOBS *et al*., 1994; JAKOBS, 1997).

Geologic Setting of the Peninsular terrane

There are no known crystalline basement rocks underlying the Peninsular terrane (WANG *et al*., 1988; BLODGETT & STRALLA, 2006). Previous work has shown that the oldest strata crop out at Puale Bay along the Alaska Peninsula. They consist of a small (~11 m thick) unnamed unit of volcanic agglomerate, volcaniclastic sandstone, and fossiliferous limestone that is thought to be of Middle Permian age (HANSEN, 1957; JEFFORDS, 1957; WANG *et al*., 1988; BLODGETT & STRALLA, 2006). A variety of shallow-water marine fossils have been identified from the limestone beds within this unnamed unit including species of rugose corals, spiriferid and productid brachiopods, rare bryozoans, sponge spicules, ostracods, and foraminifera (JEFFORDS, 1957). The presence of the brachiopod species *Phricodothyris guadalupensis* (SHUMARD), "*Spirifer*" *sulcifer* SHUMARD, and *Stenoscisma venustum* (GIRTY) as well as coral species *Lophophylidium* spp. and the fusulinid *Verbeekiella* sp. is indicative of Middle Permian Guadalupian age (JEFFORDS, 1957; BLODGETT & STRALLA, 2006).

Lying unconformably above the Permian unit is the Upper Triassic (Norian) Kamishak Formation (BLODGETT & STRALLA, 2006). This unit crops out throughout much of the Alaska Peninsula and comprises ~700 m of shallow marine and biogenic carbonate interbedded with volcanic rocks in its upper part (WANG *et al*., 1988; BLODGETT, 2008). Numerous shallow-water organisms have been identified from this formation including colonial scleractinian corals, spongiomorphs, brachiopods, bivalves, gastropods, nautiloids, and ammonoids (WANG *et al*., 1988; BLODGETT, 2008). The presence within the Kamishak Formation of the bivalve *Monotis subcircularis* GABB, the ammonite genera *Metasibirites* and *Rhabdoceras*, and the hydrozoan *Heterastridium* indicates a late Norian age (CAPPS, 1923; SMITH, 1926; SILBERLING *in* DETTERMAN *et al*., 1985; WANG *et al*.,

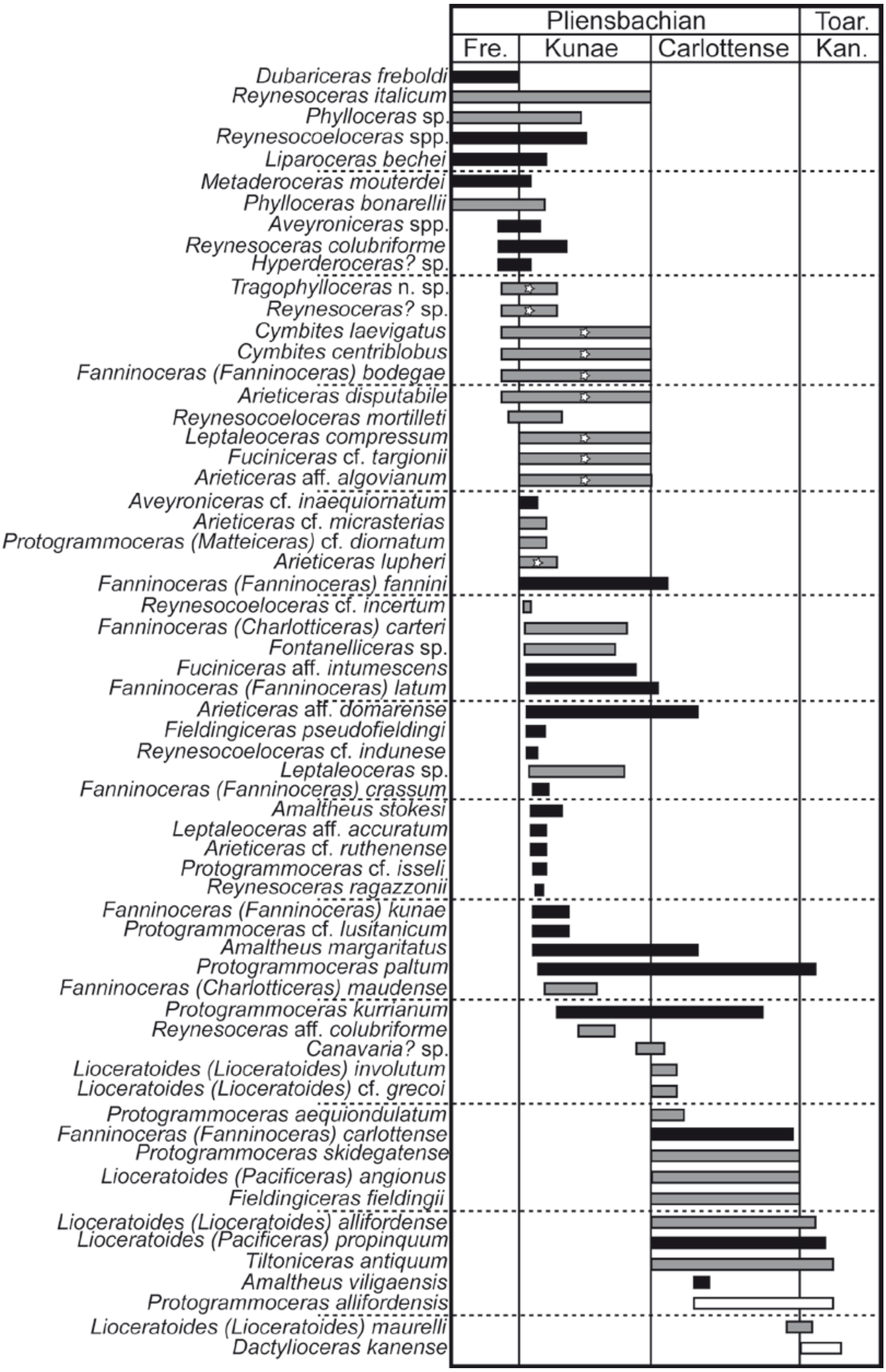


Fig. 3: Taxonomic range chart showing ammonite species ranges for the Freboldi, Kunae, and Carlottense Zones of the Pliensbachian and Kanense Zone of the Early Toarcian. Black bars denote species range applicable to original zonal scheme of SMITH *et al*. (1988), grey bars refer to species ranges in SMITH & TIPPER (1996), and white bars represent species ranges in JAKOBS *et al*. (1994) & JAKOBS (1997). Toar. = Toarcian; Fre. = Freboldi; Kan. = Kanense. White star indicates that the exact taxonomic range within the zone is uncertain.

1988; NEWTON, 1989; SILBERLING *et al*., 1997; PÁLFY *et al*., 1999; BLODGETT, 2008).

The Early Jurassic Talkeetna Formation, the subject of this study, rests conformably on the Late Triassic Kamishak Formation (NEWTON, 1989; PÁLFY *et al*., 1999). The Talkeetna Formation is a widespread unit that is exposed in many outcrops and cores throughout the Alaska Peninsula extending northeast to the Talkeetna Mountains (BARKER & GRANTZ, 1982; NOKLEBERG *et al*., 1994; SANDY & BLODGETT, 2000). It is primarily composed of volcanic (flows and pyroclastics) and volcaniclastic rocks with minor interbedded marine sedimentary sequences (sandstone, siltstone, and mudstone) that reach a thickness of ~3,000 m (BARKER & GRANTZ, 1982; NOKLEBERG *et al*., 1994; TROP *et al*., 2005). The Talkeetna Formation is generally thought to be Hettangian-Late Toarcian in age (IMLAY & DETTERMAN, 1973; IMLAY, 1981; NEWTON, 1989) with zone-level age constraints published for a Hettangian-Sinemurian sequence exposed in Puale Bay (PÁLFY *et al*., 1999). In the Talkeetna Mountains there are currently no age constraints at the zone-level. IMLAY (1981) indicates the presence of Late Sinemurian-Late Toarcian ammonites from several isolated localities but does not provide detailed stratigraphic distributions.

Stratigraphically above the Talkeetna Formation are the Middle Jurassic-Late Cretaceous Tuxedni (Bajocian-Bathonian), Chinitna (Bathonian-Callovian), Naknek (Oxfordian-Kimmeridgian), Nelchina limestone (Valanginian-Hauterivian), and Matanuska formations (Albian-Maastrichtian) representing deposition in a shallow water marine shelf, forearc environment (GRANTZ, 1960a, b; WINKLER, 1992; TROP *et al*., 2005). The lithology of these units is quite variable in that the Tuxedni and Chinitna formations are composed primarily of mudstone and fine-grained sandstone; the Naknek Formation of coarse-grained cobble conglomerate, sandstone, and mudstone; the Nelchina limestone of massively bedded limestone, and the Matanuska Formation of sandstone, conglomerate and mudstone (TROP *et al*., 2005 and references therein). The coarse-grained cobble conglomerate lithofacies of the Upper Jurassic Naknek Formation is thought to record collision of the Peninsular terrane with either adjacent Wrangellia or the North American margin (TROP *et al*., 2005 and references therein).

II. LITHOLOGIC & BIOSTRATIGRAPHIC DATA

We describe 64 Late Pliensbachian ammonoid specimens from two sections of the Talkeetna Formation in the southeastern Talkeetna Mountains, Anchorage D-3 quadrangle (Fig. 1B). Lithostratigraphy of the Camp Creek and Hicks Creek sections suggests that deposition occurred in a shallow-water marine shelf environment offshore of the Talkeetna volcanic arc. Ammonoid biostratigraphy indicates Kunae Zone age for the Camp Creek section and Carlottense Zone age for the section exposed in Hicks Creek.

Camp Creek

This section is located along an unnamed tributary of Camp Creek on the southeastern side of Gunsight Mountain in the Talkeetna Mountains (Fig. 1B). It is a ~250 m thick sequence of the Talkeetna Formation that is truncated above and below by faulting (Fig. 4). It consists predominantly of medium–coarse grained volcaniclastic sandstone with interbedded conglomerate and minor volcanic and pyroclastic rocks. Conglomerate facies include rounded and sub-rounded basalt and felsic magma clasts with rare occurrences of chert and sandstone. The basal 41 m consists of mostly siltstone with minor sandstone and conglomerate interbeds. Above 120 m, scoured and graded beds become more frequent, generally beginning with coarser-grained facies that grade into a fine sand or siltstone, suggesting deposition by turbidity currents. Low angle cross beds are recorded at ~37 and 89 m and oscillatory ripples at ~14 and 97 m. Previous work at this section suggested that the marine sedimentation that produced the Talkeetna Formation was restricted within the Sinemurian to Toarcian interval. This was based on the occurrence of the bivalves *Weyla unca* (PHILIPPI), *Ostrea* sp., and *Cardinia* sp., and several specimens of the brachiopod *Callospiriferina tumida* (VON BUCH) (IMLAY, 1981; SANDY & BLODGETT, 2000). Ammonites identified in our study indicate that deposition of the Talkeetna Formation (at this section) occurred over a much shorter time interval than previously thought. We identify 45 specimens of Late Pliensbachian ammonoids representing five genera that occur at ten localities distributed throughout the section (Fig. 4; Fig. 5). A Kunae Zone age determination is indicated by the presence of *Leptaleoceras*? sp., *Fanninoceras* (*Charlotticeras*) cf. *maudense*, and *Amaltheus* sp. from localities 6, 8, 13 & 14; these taxa are known to be restricted to this zone (SMITH & TIPPER, 1996). The presence of *Arieticeras* aff. *domarense* and *Fanninoceras* (*Fanninoceras*) *fannini* from localities 6-15 is also indicative of the Kunae Zone, however, these taxa also rarely occur in the lower Carlottense Zone (SMITH & TIPPER, 1996). Although a Kunae Zone age is determinable for this section, its stratigraphic relationship to the overlying Carlottense Zone is uncertain due to a lack of age-specific ammonites from the top of the section. A U-Pb TIMS age date has been obtained from an ash bed occurring near the top of the section at 242.2 m (CCA-1 on Fig. 4).

The age of the ash bed, derived from the youngest cluster of zircon grains (F-J), is calculated to be 184.12 ± 0.17 Ma (Fig. 6A). Based on current time scale calibrations (PÁLFY *et al*., 2000), this indicates a late Kunae Zone age (Fig. 6B) which is consistent with the ammonite fauna from the Camp Creek section. The older population of zircon grains (A-E), yielding a date of ~188 Ma, may

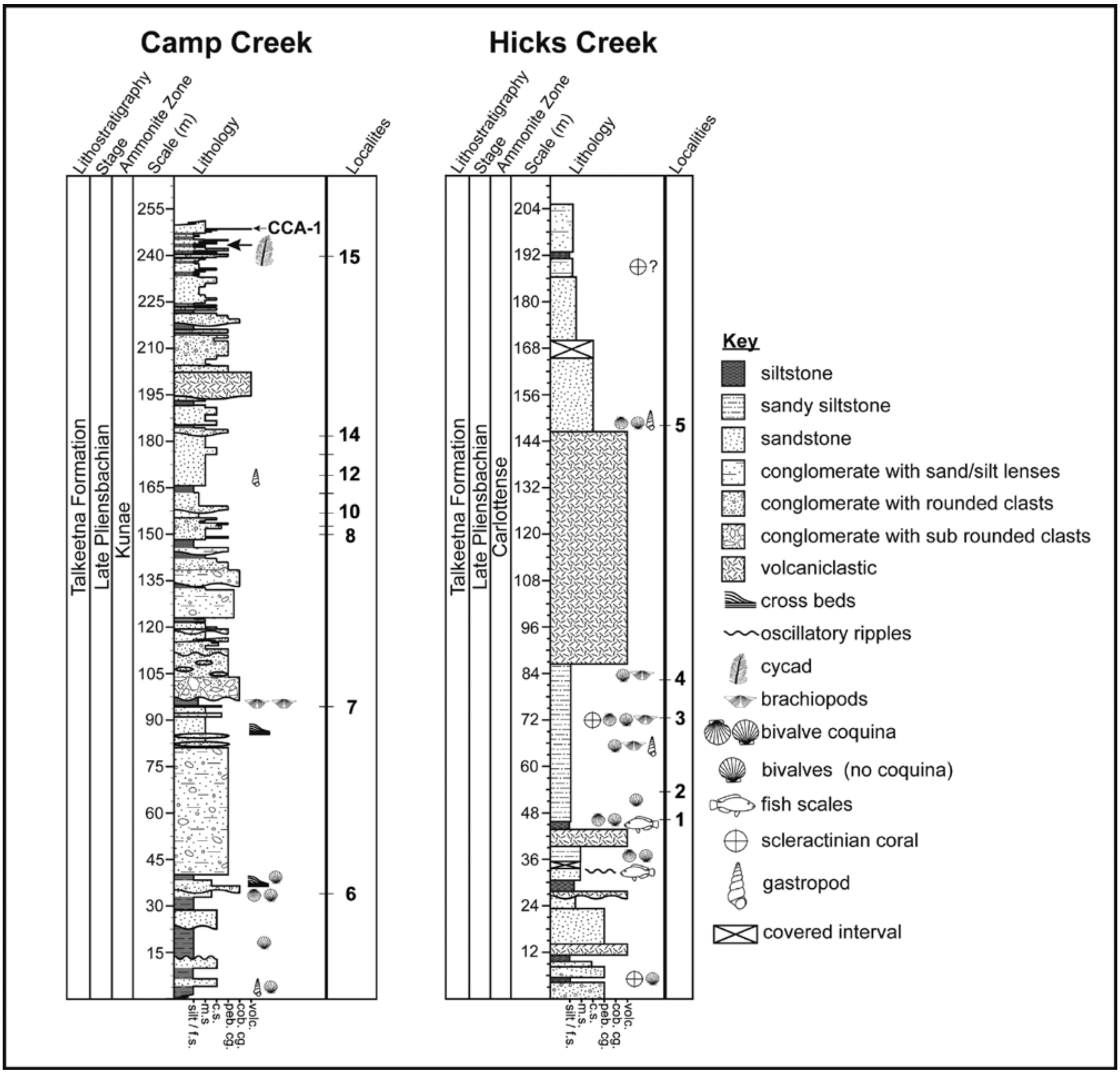


Fig. 4: Measured stratigraphic sections at Camp Creek and Hicks Creek in the southern Talkeetna Mountains of southern Alaska. f.s. = fine sand; m.s. = medium sand; c.s. = coarse sand; peb. = pebble; cg. = conglomerate; cob. = cobble; volc. = volcaniclastic; and CCA-1 = volcanic ash sample.

Taxa	Hicks Creek					Camp Creek										Specimen count	Paleogeographic Realm
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Amaltheus sp.														X		2	Boreal
Arieticeras aff. *domarense*							X	X						X	X	17	Tethyan
Fanninoceras (Fanninoceras) carlottense	X	X		X												9	East Pacific
Fanninoceras (Fanninoceras) fannini			X			X		X	X	X	X	X	X	X		28	East Pacific
Fanninoceras (Charlotticeras) cf. *maudense*								X								2	East Pacific
Lioceratoides (Lioceratoides) cf. *involutum*						X										3	Tethyan & mixed
Leptaleoceras? sp.			X													2	Tethyan & mixed
Lytoceras sp.					X											1	predominantly Tethyan
																64	

Fig. 5: Distribution of Pliensbachian ammonite taxa according to locality number at the Hicks Creek and Camp Creek sections as illustrated in Fig. 4. Specimen counts and primary paleobiogeographic affinities are also given.

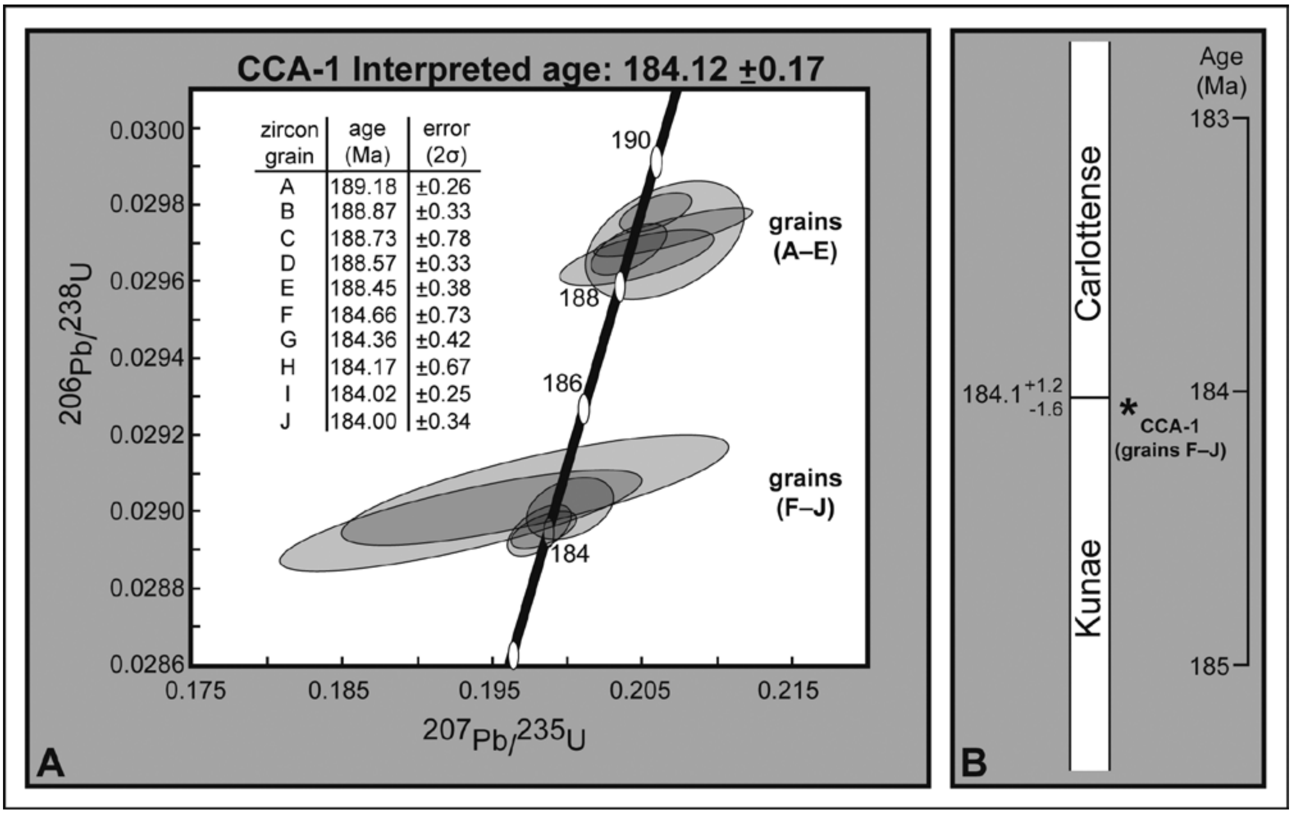


Fig. 6: A) U-Pb concordia diagram for ash sample CCA-1 in the Camp Creek section of the Talkeetna Mountains, Alaska. Diagram shows $^{206}Pb/^{238}U$ TIMS ages for ten zircon grains showing two distinct age populations, one at ~188 Ma and the other at ~184 Ma. The age of magmatism is calculated to be 184.12 ± 0.17 Ma, based on five zircon grains (F-J). The population of five zircon grains A-E at ~188 Ma consists of xenocrysts or crystals containing inherited cores. B) A comparative diagram showing the relationship of the calculated age for grains F-J of CCA-1 to the calibrated geochronologic Time Scale for the Kunae / Carlottense zonal boundary (Pálfy *et al*., 2000).

consist of either xenocrysts or crystals with inherited cores. These zircon crystals are most likely related to arc-related magmatism of the Peninsular terrane that occurred over a time span of 202.1 to 181.4 Ma (Clift *et al*., 2005a, b; Rioux *et al*., 2007).

Hicks Creek

The section cropping out along Hicks Creek in the southern Talkeetna Mountains ~10 km from the Glenn Highway (Fig. 1B) consists of ~205 m of fossiliferous marine volcaniclastic and volcanic rocks (Fig. 4). The lower 43 m consist of coarse-grained volcaniclastic sandstones, interbedded conglomerate lenses and minor siltstone. Conglomerate lenses contain rounded–sub-rounded, pebble-sized clasts of basalt and other igneous rocks. Siltstones and sandy siltstones occur from 43-87 m and are directly overlain by a thick (~60 m) unit of undifferentiated volcanic/volcaniclastic rocks. The succession is capped by ~58 m of coarse-grained sandstone and sandy siltstone. In general, the stratigraphic succession at Hicks Creek is lithologically similar to that of Camp Creek but differs by the predominance of finer grained sedimentary rocks and the absence of scoured bedding surfaces and graded bedding.

The fauna from the Hicks Creek section is taxonomically diverse and includes ammonoids, bivalves, brachiopods, gastropods, corals, plant fossils, fish scales and trace fossils. Bivalves and brachiopods are most abundant and diverse throughout the section, frequently occurring in coquinas but also as isolated individuals in siltstone intervals. The bivalves contain a mix of free-lying and encrusting forms. Other taxonomic groups such as ammonoids, gastropods and corals are rare occurring mostly in the siltstone intervals. Two intervals in the lower 48 m of the section contain abundant fish scales that occur in a thin-bedded (1 cm), light gray, volcanic ash (Fig. 4). The diverse benthic fauna from this section will be the subject of further research.

We identify 20 specimens of Late Pliensbachian ammonoids representing five genera that occur at five localities within this stratigraphic section (Fig. 4; Fig. 5). *Fanninoceras* (*Fanninoceras*) *carlottense*, and *Lioceratoides (Lioceratoides)* cf. *involutum* are identified from localities 1-4 and indicate the Carlottense Zone

(SMITH & TIPPER, 1996). *Fanninoceras* (*Fanninoceras*) *fannini*, which is recorded from locality 3, is known primarily from the Kunae Zone of western North America but it also occurs rarely in the lower Carlottense Zone (SMITH & TIPPER, 1996). Lastly, *Lytoceras* sp. is identified from locality 5. *Lytoceras* is uncommon in the Lower Jurassic of North America and the specimen from Hicks Creek is the first figured specimen from the Pliensbachian. Ammonite biostratigraphy of this section indicates that deposition of the Talkeetna Formation at Hicks Creek occurred during the Carlottense Zone of the Late Pliensbachian, a slightly younger age than that of the Camp Creek section.

III. SYSTEMATIC PALEONTOLOGY

The following ammonoid taxa are briefly described using the open nomenclature following BENGSTON (1988). Specimens described herein are curated at the University of Montana Paleontology Center (UMPC).

Class Cephalopoda CUVIER, 1797
Order Ammonoidea ZITTEL, 1884
Suborder Ammonitina HYATT, 1889
Family Oxynoticeratidae HYATT, 1875
Genus *Fanninoceras* MCLEARN, 1930
Subgenus *Fanninoceras* MCLEARN, 1930
Type species: *Fanninoceras fannini* MCLEARN, 1930.

Fanninoceras (*Fanninoceras*) *carlottense* MCLEARN, 1930
Pl. I, figs. 1-6

1884. *Sphenodiscus requienianus*? D'ORBIGNY.– WHITEAVES, p. 248, pl. 22, fig. 4.
1996. *Fanninoceras (Fanninoceras) carlottense* MCLEARN.– SMITH & TIPPER, pl. 2, figs. 3-7, text-figs. 30j, 31d (and synonymy therein).

Description: Involute, rapidly expanding form with a very narrow umbilicus, compressed whorl section and acute venter without a keel. Inner whorls have gently sinuous prorsiradiate ribs that project onto the venter and become weak and disappear as shell diameter increases.
Material: Nine specimens from localities 1, 2, & 4 in the Hicks Creek section, Talkeetna Mountains Alaska.
Discussion: *Fanninoceras carlottense* is the most involute and stratigraphically highest ranging species of *Fanninoceras* in western North America and is distinguishable by its characteristically narrow umbilicus. *Fanninoceras carlottense* has previously been reported from two isolated localities in the Talkeetna Mountains by IMLAY (1981) but it was not figured or placed within stratigraphic context.
Occurrence: Reported from the East Pacific Realm from South America (Argentina and Chile) to western North America (Nevada, Oregon, British Columbia Canada, and Alaska).
Age: *Fanninoceras carlottense* characterizes the Carlottense Zone.

Fanninoceras (*Fanninoceras*) *fannini* MCLEARN, 1930
Pl. I, figs. 7-19

1930. *Fanninoceras fannini* MCLEARN, p. 4, pl. 1, fig. 3.
1996. *Fanninoceras (Fanninoceras) fannini* MCLEARN.– SMITH & TIPPER, pl. 3, figs. 1–12; pl. 5, figs. 1, 2, text-figs. 27, 30d–e, 31a–c (and synonymy therein).

Description: An involute form with a moderately wide umbilicus for the genus. Whorls are depressed with a broadly arched venter early in ontogeny becoming more compressed with an acute venter in later whorls. Ribs are well spaced, simple-slightly sinuous, projected onto the venter in early whorls and becoming weak with growth. Outer whorls are smooth.
Material: Twenty five specimens from localities 6, and 8-14 in the Camp Creek section and three specimens from locality 3 in the Hicks Creek section, Talkeetna Mountains Alaska.
Discussion: As discussed by SMITH & TIPPER (1996) there is a strong resemblance between *F. fannini* and *F. carlottense* but *F. fannini* has a larger umbilicus.
Occurrence: *Fanninoceras fannini* is common in the East Pacific Realm from South America to southern Alaska.
Age: Primarily known from the Kunae Zone with rare occurrences in the Carlottense Zone of the Late Pliensbachian.

Subgenus *Charlotticeras* SMITH & TIPPER, 1996
Type species: *Fanninoceras (Charlotticeras) carteri* SMITH & TIPPER, 1996.

Fanninoceras (*Charlotticeras*) cf. *maudense* SMITH & TIPPER, 1996
Pl. I, figs. 20-22

1996. *Fanninoceras (Charlotticeras) maudense* SMITH & TIPPER, p. 32, pl. 6, figs. 6-11, text-figs. 30a-b.

Description: Midvolute form with a compressed whorl section, flat flanks, and incipient keel. Umbilical wall is low, sharp, and vertical. Ornamentation is well defined with coarse, sinuous, ribs that are prorsiradiate and project onto the venter to the incipient keel.
Material: Two specimens from the Camp Creek section, one from locality 8 and another from locality 13, Talkeetna Mountains Alaska.
Occurrence: Only known from British Columbia Canada (Haida Gwaii, formerly the Queen Charlotte Islands), and Alaska (Talkeetna Mountains).
Age: Kunae Zone (Late Pliensbachian).

Family Amaltheidae Hyatt, 1867
Genus *Amaltheus* de Montfort, 1808
Type species: *Amaltheus margaritatus* de Montfort, 1808.

***Amaltheus* sp.**
Pl. I, figs. 23-25

Description: An involute form with a compressed whorl section and convex flanks. The acute venter bears a low keel that consists of distinct forwardly directed chevrons. A sharp umbilical wall is slightly undercut. Sinuous primary ribs are prorsiradiate and fade toward the venter. Secondary ribs are much less defined and fade quickly toward the venter.
Material: Two poorly preserved specimens from locality 14 in the Camp Creek section, Talkeetna Mountains Alaska.
Discussion: These specimens resemble the well known Boreal Realm species *Amaltheus stokesi* (Sowerby), discussed in detail by Howarth (1958). However poor preservation precludes positive identification. Imlay (1981) also identifies *A. stokesi* from an isolated locality in the Talkeetna Mountains without stratigraphic context.
Occurrence: *Amaltheus* is distributed throughout the Boreal Realm including: Canada, Russia, northwest Europe, and Alaska. It is also known from localities with mixed Tethyan/Boreal faunas including: Canada, Alaska, Italy, Hungary, Japan, and Russia.
Age: Kunae Zone (Late Pliensbachian).

Family Hildoceratidae Hyatt, 1867
Genus *Arieticeras* Seguenza, 1885
Type species: *Ammonites algovianus* Oppel, 1862. Lectotype and paralectotype (the latter refigured from Schröder, 1927) designated and figured by Wiedenmayer (1977).

***Arieticeras* aff. *domarense* (Meneghini, 1867)**
Pl. I, figs. 26-31

aff. 1867. *Ammonites (Harpoceras) domarensis* Meneghini, p. 7.
1996. *Arieticeras* aff. *domarense* (Meneghini).– Smith & Tipper, pl. 20, fig. 4; text-fig. 37a (and synonymy therein).
2007. *Arieticeras* gr. *domarense* (Meneghini).– Mouterde *et al.,* p. 88, pl. 6, fig. 5.

Description: Evolute and slowly expanding with a wide umbilicus, compressed, subquadrate, whorl section and sharp keel. Simple to slightly flexuous rectiradiate ribs are most prominent along the flank and disappear at the shoulder.
Material: Seventeen specimens from localities 7, 8, 14 and 15 in the Camp Creek section, Talkeetna Mountains Alaska.
Occurrence: Known from the northern Mediterranean, Oregon, Nevada, British Columbia Canada (Haida Gwaii), and Alaska (Talkeetna Mountains).
Age: Kunae Zone (Late Pliensbachian).

Genus *Leptaleoceras* Buckman, 1918
Type species: *Leptaleoceras leptum* Buckman, 1918.
***Leptaleoceras*? sp.**
Pl. I, figs. 32, 33

Description: Midvolute to evolute with a compressed whorl section bearing a keel. Ribs are rectiradiate, sinuous and are densely spaced along the flank. The specimen figured on Pl. I, fig. 33, shows incipient bundling of ribs near the umbilicus.
Material: Three specimens from locality 6 in the Camp Creek section, Talkeetna Mountains Alaska.
Discussion: All the specimens are small. The densely spaced ribbing suggests an assignment of *Leptaleoceras* but the bundling of ribs on one specimen suggests that *Canavaria* may be represented.
Occurrence: Only known from British Columbia (Haida Gwaii), and Alaska (Talkeetna Mountains).
Age: Kunae Zone (Late Pliensbachian).

Genus *Lioceratoides* Spath, 1919
Type species: *Leioceras? Grecoi* Fucini, 1901, p. 91, pl. 11, figs. 4, 5, by original designation (Spath, 1919, p. 174).
***Lioceratoides* (*Lioceratoides*) cf. *involutum* Smith & Tipper, 1996**
Pl. I, figs. 34-36

cf. 1996. *Lioceratoides (Lioceratoides) involutum* Smith and Tipper, pl. 26, figs. 2-4; text-fig. 39p.

Description: A midvolute to involute, rapidly expanding form with a prominent keel, compressed whorl section with flat flanks, and an abrupt umbilical wall. Volution tends to be more midvolute on outer whorls. Ribs are densely spaced, sinuous, and occasionally bundled forming irregularities in appearance.
Material: Two specimens from locality 3 in the Hicks Creek section, Talkeetna Mountains Alaska.
Occurrence: British Columbia Canada (Haida Gwaii) and Alaska (Talkeetna Mountains).
Age: Carlottense Zone (Late Pliensbachian).

Genus *Lytoceras* Suess, 1865
Type species: *Ammonites fimbriatus* Sowerby, 1817.

***Lytoceras* sp.**
Pl. I, figs. 37-39

Description: An evolute form with a depressed subquadrate whorl section, a flattened venter, flat flanks and a well-defined umbilical wall. Prorsiradiate constrictions are well defined along the flank and become rectiradiate to gently rursiradiate across the venter. Ribbing is not present. A poorly preserved but complex suture is evident on the adapical part of the specimen.

Material: One fragment from locality 5 in the Hicks Creek section, Talkeetna Mountains Alaska.

Discussion: The prorsiradiate constrictions that become gently rursiradiate across the venter resemble *L. apertum* in GEYER (1893; pl. 8, figs. 4, 5) and *L. fimbriatum* (SOWERBY) in RAKUS & GUEX (2002; pl. 3, fig. 2), however the whorl shape is not the same. Our specimen also bears slight resemblance in whorl shape to *L. fuggeri* (GEYER, 1893; pl. 8, figs. 8 & 9) but it has a depressed sub-quadrate whorl shape rather than the more compressed whorl shape of *L. fuggeri*.

Occurrence: This constitutes the first figured specimen of *Lytoceras* from the Pliensbachian of western North America.

Age: Carlottense Zone (Late Pliensbachian).

IV. CONCLUSIONS

Early Jurassic ammonoids from the Talkeetna Mountains of southern Alaska indicate a Kunae and Carlottense Zone age for the marine sedimentary rocks of the Talkeetna Formation. A U-Pb TIMS age date from an ash bed near the top of the Camp Creek section yields a calculated $^{206}Pb/^{238}U$ age of 184.12 ± 0.17 Ma and helps constrain the age of the section to the uppermost Kunae Zone, at a time interval close to the geochronologically calibrated boundary between the Kunae and Carlottense zones, as currently understood.

Sixty-four ammonoid specimens are described from two shallow-water marine successions at Camp Creek and Hicks Creek. Taxa described in this study represent the Tethyan, Boreal, and East Pacific Realms and include: *Amaltheus* sp., *Arieticeras* aff. *domarense*, *Fanninoceras (Fanninoceras) carlottense*, *Fanninoceras (Fanninoceras) fannini*, *Fanninoceras (Charlotticeras)* cf. *maudense*, *Leptaleoceras*? sp., *Lioceratoides (Lioceratoides)* cf. *involutum*, and *Lytoceras* sp.

Plate I

All figures are natural size unless otherwise indicated. UMPC = University of Montana Paleontology Center; loc. = ammonite locality as illustrated in Fig. 4.

Figs. 1-6: *Fanninoceras (Fanninoceras) carlottense* MCLEARN.
1-2, UMPC 13356; Carlottense Zone; loc. 4, Hicks Creek section. 3, 5, UMPC 13353; Carlottense Zone; loc. 2, Hicks Creek section. 4, UMPC 13351; Carlottense Zone; loc. 1, Hicks Creek section. 6, UMPC 13352; Carlottense Zone; loc. 2, Hicks Creek section.

Figs. 7-19: *Fanninoceras* (*Fanninoceras*) *fannini* MCLEARN.
7, UMPC 13347; 8, UMPC 13360; 9-10, 13361; 17-18, UMPC 13362; Carlottense Zone; loc. 3, Hicks Creek section. 11, UMPC 13345; Kunae Zone; loc. 8, Camp Creek section. 12, UMPC 13342; Kunae Zone; loc. 8, Camp Creek section. 13-14, UMPC 13343; Kunae Zone; loc. 13, Camp Creek section. 15-16, UMPC 13340; Kunae Zone; loc. 8, Camp Creek section. 19, UMPC 13341; Kunae Zone; loc. 8, Camp Creek section (latex cast).

Figs. 20-22: *Fanninoceras* (*Charlotticeras*) cf. *maudense* SMITH & TIPPER
20-21, UMPC 13331; Kunae Zone; loc. 13, Camp Creek section (21 is X2). 22, UMPC 13332; Kunae Zone; loc. 8, Camp Creek section.

Figs. 23-25: *Amaltheus* sp.
23, UMPC 13308; Kunae Zone; loc. 14, Camp Creek section. 24-25, UMPC 13309; Kunae Zone; loc. 14, Camp Creek section (25 is X2).

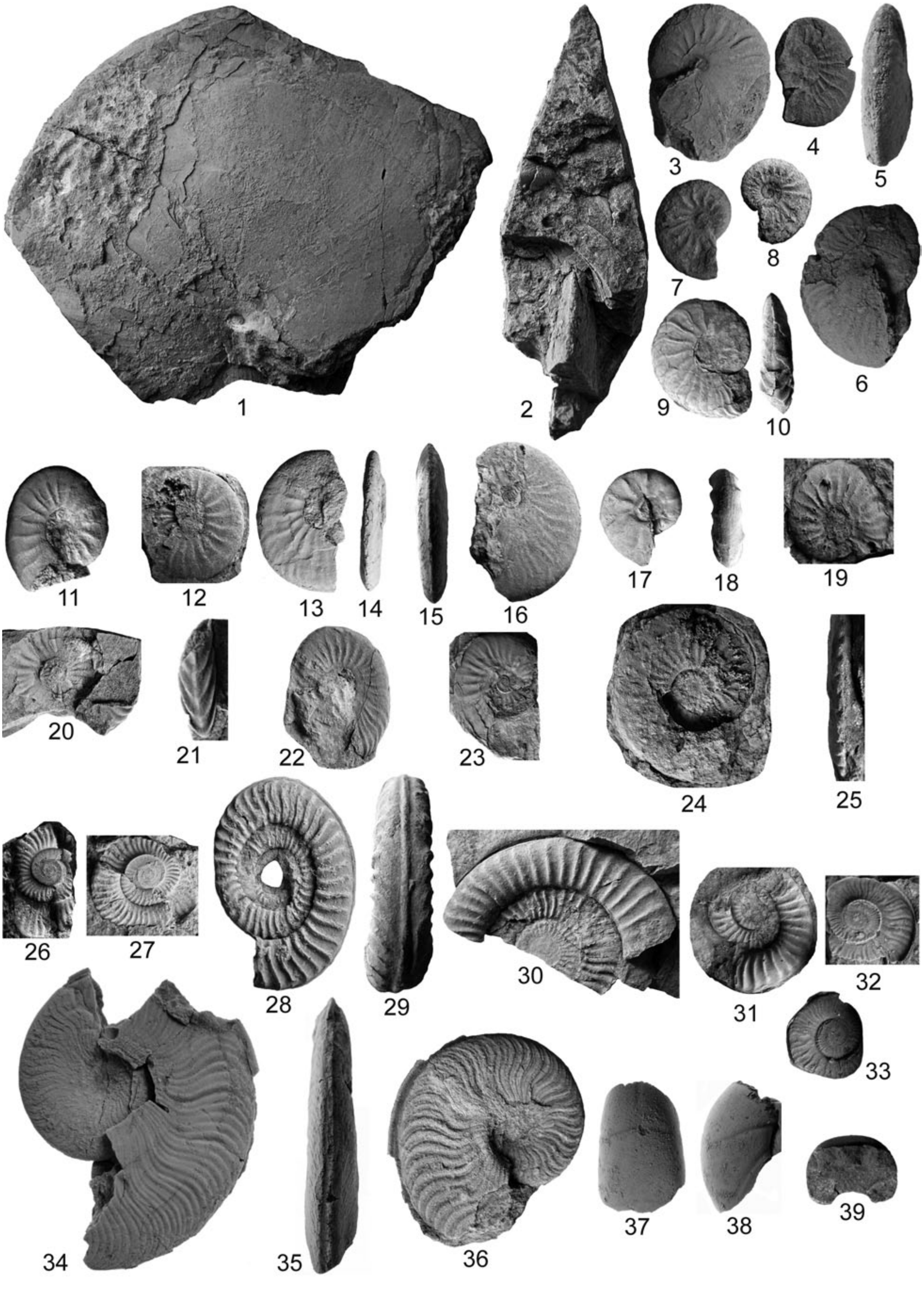
Figs. 26-31: *Arieticeras* aff. *domarense* (MENEGHINI)
26-27, UMPC 13318; Kunae Zone; loc. 7, Camp Creek section. 28-29, UMPC 13319; Kunae Zone; loc. 8, Camp Creek section. 30, UMPC 13310; Kunae Zone; loc. 15, Camp Creek section. 31, UMPC 13313; Kunae Zone; loc. 14, Camp Creek section (latex cast).

Figs. 32-33: *Leptaleoceras*? sp.
32-33, UMPC 13330; Kunae Zone; loc. 6, Camp Creek section (specimen in Fig. 33 is a cast of the specimen in Fig. 32).

Figs. 34-36: *Lioceratoides* (*Lioceratoides*) cf. *involutum* SMITH & TIPPER
34-35, UMPC 13357; Carlottense Zone; loc. 3, Hicks Creek section. 36, UMPC 13358; Carlottense Zone; loc. 3, Hicks Creek section.

Figs. 37-39: *Lytoceras* sp.
37-39, UMPC 13359; Carlottense Zone; loc. 5, Hicks Creek section.

Plate I



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