MICROPALEO CONSULTANTS, INC.

# PHILLIPS ALASKA (ARCO)

# BRONTOSAURUS NO. 1/1A

**API #50-163-20004**

**SEC. 18, T18N/R20W UM**

**NORTH SLOPE, ALASKA**

**Prepared by:**

**Michael B. Mickey - Foraminifera**

**Hideyo Haga - Palynomorphs**

## BIOSTRATIGRAPHY REPORT

**Job No. 22-113** **January, 2003**

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Late Triassic
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Probable Early Triassic
TE

Discussion. Sadlerochit Group. Ivishak Sandstone.

6477-6510'

Possible Late Permian
PL?

Discussion. Possible Echooka Fm.

6510-6551'

Indeterminate Age

Discussion. Greenish-gray phyllite? or shale. Either basement phyllite? or Kayak Shale.

6551-6660'T.D.

Indeterminate Age

Discussion. Dark gray to black argillite.

# FORAMINIFERA REPORT

**Interpreted by**

**Michael B. Mickey**

# FORAMINIFERA SUMMARY

60-180'

| | | |
|---|---|---|
| Age. | Probable Early Cretaceous<br>Probable Albian | |
| Zone. | Probable F-9 | |
| Environment. | Probable Nonmarine<br>(Probable Alluvial Plain) | |

180-3860'

| | | |
|---|---|---|
| Age. | Early Cretaceous<br>Albian | |
| Zones. | F-9 to F-10 | |
| Environment. | 180-1350': | Marginal Marine to Middle Neritic<br>(Transitional to Middle Shelf) |
| | 1350-3860': | Middle Neritic to Upper Bathyal<br>(Middle Shelf to Upper Slope) |

3860-3950'

| | |
|---|---|
| Age. | Early Cretaceous<br>Aptian |
| Zone. | F-11 |
| Environment. | Middle to Lower Bathyal - Distal<br>(Middle to Lower Slope - Starved Basin) |

3950-4250'

| | |
|---|---|
| Age. | Early Cretaceous<br>Barremian |
| Zone. | F-12 |
| Environment. | Bathyal<br>(Slope) |

4250-4400'

| | |
|---|---|
| Age. | Early Cretaceous<br>Hauterivian |
| Zone. | F-13a |
| Environment. | Middle to Outer Neritic<br>(Middle to Outer Shelf) |

4400-4820'

| | |
|---|---|
| Age. | Early Cretaceous<br>Valanginian |
| Zone. | F-13b |
| Environment. | Outer Neritic to Upper Bathyal - Some Basal Distal<br>(Outer Shelf to Upper Slope - Some Basal Starved Basin) |

4820-5030'

| | |
|---|---|
| Age. | Late Jurassic<br>Probable Kimmeridgian |
| Zone. | Probable F-16a |
| Environment. | Outer Neritic to Bathyal<br>(Outer Shelf to Slope) |

5030-5270'

| | |
|---|---|
| Age. | Late Jurassic<br>Oxfordian |
| Zone. | F-16b |
| Environment. | Bathyal<br>(Slope) |

5270-5390'

| | |
|---|---|
| Age. | Middle Jurassic<br>Aalenian |
| Zone. | F-17 |
| Environment. | Bathyal<br>(Slope) |

5390-5930'

| | |
|---|---|
| Age. | Early Jurassic<br>Toarcian |
| Zone. | F-18a |
| Environment. | Bathyal<br>(Slope) |

5930-6050'

| | |
|---|---|
| Age. | Early Jurassic<br>Pliensbachian |
| Zone. | F-18b |
| Environment. | Bathyal<br>(Slope) |

6050-6410'

| | |
|---|---|
| Age. | Late Triassic<br>Norian |
| Zone. | F-19b |
| Environment. | Marginal Marine to Middle Neritic<br>(Transitional to Middle Shelf) |

6410-6470'

| | |
|---|---|
| Age. | Late Triassic<br>Possible Carnian |
| Zone. | F-19c? |
| Environment. | Marginal Marine to Inner Neritic<br>(Transitional to Inner Shelf) |

6470-6530'

| | |
|---|---|
| Age. | Probable Late Permian to Early Triassic |
| Zones. | Probable F-20a to F-20b |
| Environment. | Probable Nonmarine<br>(Probable Alluvial Plain) |
| Discussion. | Sadlerochit Group. Ivishak Fm. and Echooka Fm. mixed. |

6530-6590'

| | |
|---|---|
| Age. | Indeterminate |
| Environment. | Indeterminate |
| Discussion. | Greenish-gray phyllite? or shale. Either basement phyllite? or Kayak Shale. |

6590-6630'

Age. Indeterminate

Environment. Indeterminate

Discussion. Dark gray to black argillite.

# INTRODUCTION

## Scope

Data from 164 Foraminifera samples from the Phillips Alaska (ARCO) Brontosaurus No. 1/1A well were incorporated into this report. These consisted entirely of ditch samples covering the interval 60 to 6630 feet. This work was done as part of M.C.I. Job Number 22-113.

## Procedures

Standard techniques were used to process the material. All samples were boiled in Quaternary-O and washed over 20 and 200 mesh screens. Frequency symbols correspond to the following numerical values: very rare (1), rare (2 - 4), frequent (5 -25), common (26 - 100), abundant (101 - 999) and prolific (1000+). The picked foram slides and residues are reposited at the State of Alaska Geological Materials Center in Eagle River, Alaska.

Certain factors such as shelf widths, basin configuration and overall basin depths associated with Arctic Mesozoic basins are not completely understood at present. The paleoenvironments presented in this report reflect relative basinal position only and should not be tied to specific water depths. Generally, neritic corresponds to shelf or deltaic environments, while bathyal corresponds to slope or prodelta environments and bathyal (starved basin) corresponds to distal (far from the source) deposition. As an example, prodelta deposits could represent deposition as shallow as middle neritic or as deep as bathyal (slope) depending on the delta type and shelf width. With a narrow shelf, a river-dominated deltaic system could build across the shelf and the prodelta deposits would be in a bathyal (slope) depth. A tide-dominated deltaic system associated with a wide shelf could result in middle neritic prodelta deposition.

## Format

A listing of the age, environment, fauna and occasional lithology comments for each biostratigraphic interval follows. A generalized summary of the well is presented in the Conclusions section at the end of the Foraminifera Report. A Foraminifera Distribution Chart (Figure F-1) and a High Resolution Biostratigraphy Plot (Figure B-1) containing foram diversity/abundance plots, a cumulative faunal plot and paleoenvironmental plot(s) are in pockets at the back of this report.

# RESULTS

60-180'

Age. Probable Early Cretaceous
Probable Albian

Zone. Probable F-9

Environment. Probable Nonmarine
(Probable Alluvial Plain)

Fauna. Barren of Foraminifera. Rare pyritized radiolaria, and rare to frequent pyrite and coal.

180-3860'

Age. Early Cretaceous
Albian

Zones. F-9 to F-10

Environment. 180-1350': Marginal Marine to Middle Neritic
(Transitional to Middle Shelf)
1350-3860': Middle Neritic to Upper Bathyal
(Middle Shelf to Upper Slope)

Fauna. *Trochammina mcmurrayensis, Verneuilinoides borealis, Haplophragmoides excavatus, H. topagorukensis, Bathysiphon vitta, Lenticulina muensteri, Thuramminoides* sp., *Miliammina manitobensis, Gavelinella stictata, Glomospirella arctica, Lituotuba gallupi, Ditrupa cornu,* megaspores, *Inoceramus* prisms, coal, pyrite, rare to frequent paper shale, and tar below 3436 feet.

3860-3950'

| | |
|---|---|
| Age. | Early Cretaceous<br>Aptian |
| Zone. | F-11 |
| Environment. | Middle to Lower Bathyal - Distal<br>(Middle to Lower Slope - Starved Basin) |
| Fauna. | Barren of Foraminifera. Pyritized radiolaria, fish debris and common to abundant paper shale. |

3950-4250'

| | |
|---|---|
| Age. | Early Cretaceous<br>Barremian |
| Zone. | F-12 |
| Environment. | Bathyal<br>(Slope) |
| Fauna. | *Haplophragmoides coronis*, arenaceous spp. (large, coarse), *Trochamminoides* sp. (small, thin), *Cenosphaera* spp. (pyritized), *Lithocampe* sp. (pyritized), fish debris, paper shale, pyrite and frequent to common rounded frosted quartz floating sand grains. |

4250-4400'

Age. Early Cretaceous
Hauterivian

Zone. F-13a

Environment. Middle to Outer Neritic
(Middle to Outer Shelf)

Fauna. *Haplophragmoides duoflatis, H. coronis, Thuramminoides* sp., *T. septagonalis*, arenaceous spp. (large, coarse), *Gaudryina tappanae, G. tailleuri, Lenticulina muensteri, Ammobaculites reophacoides,* pyrite and frequent to common rounded frosted quartz floating sand grains.

4400-4820'

Age. Early Cretaceous
Valanginian

Zone. F-13b

Environment. Outer Neritic to Upper Bathyal - Some Basal Distal
(Outer Shelf to Upper Slope - Some Basal Starved Basin)

Fauna. *Ammodiscus mackenziensis, Ammobaculites reophacoides, A. erectus, Haplophragmoides coronis, H. goodenoughensis, H. inflatigrandis, H. duoflatis, Lenticulina muensteri*, arenaceous spp. (large, coarse), *Gaudryina leffingwelli, G. milleri, G. tailleuri, Globulina prisca, Trochammina* sp. (small, high spired), *T. kumaensis, T. kosyrevae, T. squamata, T. rostovzevi, Glomospira subarctica, Glomospirella arctica*, pyrite, pyrite sticks, rare to frequent rounded frosted quartz floating sand grains and rare to frequent basal glauconite.

4820-5030'

Age. Late Jurassic
Probable Kimmeridgian

Zone. Probable F-16a

Environment. Outer Neritic to Bathyal
(Outer Shelf to Slope)

Fauna. *Gaudryina milleri, G. leffingwelli, Frondicularia lustrata, Ammodiscus asperus, Trochammina kumaensis,* arenaceous spp. (large, coarse), *Dentalina* sp., *Ammobaculites vetusta, A. alaskensis, Lenticulina audax, Haplophragmoides canui, H.* spp., *Astacolus strombecki, Rectoglandulina humilis, Saracenaria topagorukensis, Recurvoides turbinatus, Globulina topagorukensis,* frequent pyrite and pyrite sticks.

5030-5270'

Age. Late Jurassic
Oxfordian

Zone. F-16b

Environment. Bathyal
(Slope)

Fauna. *Ammodiscus asperus*, arenaceous spp. (large, coarse), *Ammobaculites alaskensis, Haplophragmoides canui, H.* spp., *Trochamminoides* sp. (small, thin), *Marginulinopsis carievalensis, Lenticulina audax, Gaudryina leffingwelli, G. milleri, Bathysiphon anomalocoelia*, rounded frosted quartz floating sand grains, pyrite, pyrite sticks, and rare to frequent glauconite between 5120 and 5210 feet.

5270-5390'

Age. Middle Jurassic
Aalenian

Zone. F-17

Environment. Bathyal
(Slope)

Fauna. *Ammobaculites alaskensis, A. vetusta*, arenaceous spp. (large, coarse), *Haplophragmoides* spp., *H. canui, Lenticulina audax, Globulina topagorukensis, Gaudryina leffingwelli, G. milleri*, pyrite, pyrite sticks and frequent basal tar.

5390-5930'

Age. Early Jurassic
Toarcian

Zone. F-18a

Environment. Bathyal
(Slope)

Fauna. *Ammobaculites alaskensis, A. barrowensis, A.* sp. (small, bell-shaped chambers), *Haplophragmoides* spp., *Ammodiscus siliceus, Trochammina topagorukensis, Reophax densa, Gaudryina dyscrita, Glomospira pattoni, Dentalina tenuistriata*, pyrite, and rare glauconite between 5510 and 5810 feet.

5930-6050'

| | |
|---|---|
| Age. | Early Jurassic<br>Pliensbachian |
| Zone. | F-18b |
| Environment. | Bathyal<br>(Slope) |
| Fauna. | Very rare fauna consisting of single specimens of: *Haplophragmoides* sp., *Nodosaria radiata, Spongodiscus* sp. (pyritized) and rare pyrite. |

6050-6410'

| | |
|---|---|
| Age. | Late Triassic<br>Norian |
| Zone. | F-19b |
| Environment. | Marginal Marine to Middle Neritic<br>(Transitional to Middle Shelf) |
| Fauna. | *Nodosaria larina, N. radiata, N. shublikensis, Astacolus connudatus, Frondicularia acmaea,* echinoid spines, *Monotis/Halobia* fragments, ostracods (medium-large, smooth), pyrite, and rare glauconite in the top of the interval. |

6410-6470'

| | |
|---|---|
| Age. | Late Triassic<br>Possible Carnian |
| Zone. | F-19c? |
| Environment. | Marginal Marine to Inner Neritic<br>(Transitional to Inner Shelf) |
| Fauna. | *Astacolus connudatus, Trochammina helicta*, echinoid spines and frequent *Monotis/Halobia* shell fragments. |

6470-6530'

| | |
|---|---|
| Age. | Probable Late Permian to Early Triassic |
| Zones. | Probable F-20a to F-20b |
| Environment. | Probable Nonmarine<br>(Probable Alluvial Plain) |
| Fauna. | Barren of Foraminifera. Frequent white triplitic chert. |
| Discussion. | Sadlerochit Group. Ivishak Fm. and Echooka Fm. mixed. |

6530-6590'

| | |
|---|---|
| Age. | Indeterminate |
| Environment. | Indeterminate |
| Fauna. | Barren of Foraminifera. |
| Discussion. | Greenish-gray phyllite? or shale. Either basement phyllite? or Kayak Shale. |

6590-6630'

| | |
|---|---|
| Age. | Indeterminate |
| Environment. | Indeterminate |
| Fauna. | Barren of indigenous Foraminifera. |
| Discussion. | Dark gray to black argillite. |

# CONCLUSIONS

The Phillips Alaska (ARCO) Brontosaurus No. 1/1A well penetrated the following biostratigraphic sequence based on foraminiferal analysis:

- 4340+ feet (60-4400') of Hauterivian to probable Albian age (Early Brookian & Beaufortian - Rift Sequence) generally upward shallowing base of slope bottomsets, slope foresets and inner to outer shelf topsets with a basal middle to outer shelf transgressive sandstone.

- 1650 feet (4400-6050') of Pliensbachian to Valanginian age (Beaufortian - Incipient Rift Sequence) outer shelf to slope sedimentation.

- 480 feet (6050-6530') of undifferentiated Early Triassic to Late Triassic (Norian) age (Late Ellesmerian) nonmarine, marginal marine and inner to middle shelf deposition.

- 60 feet (6530-6590') of indeterminate age greenish-gray basement phyllite? or Kayak shale equivalent.

- 40+ feet (6590-6630') of indeterminate age (Franklinian) dark gray to black basement argillite.

# PALYNOLOGY REPORT

**Interpreted by:**

**Hideyo Haga**

# PALYNOLOGY SUMMARY

120-300'

| | |
|---|---|
| Age. | Early Cretaceous<br>Probable Middle - Late Albian |
| Zone. | Probable P-M17 |
| Environment. | Marginal Marine |

300-3890'

| | |
|---|---|
| Age. | Early Cretaceous<br>Aptian - Early Albian |
| Zone. | P-M18 |
| Environment. | Marginal Marine |

3890-4280'

| | |
|---|---|
| Age. | Early Cretaceous<br>Barremian - Aptian |
| Zone. | P-M18a |
| Environment. | Marine |

4280-4460'

| | |
|---|---|
| Age. | Early Cretaceous<br>Hauterivian |
| Zone. | P-M19 |
| Environment. | Marine |

4460-4760'

| | |
|---|---|
| Age. | Early Cretaceous<br>Valanginian |
| Zone. | P-M20 |
| Environment. | Marine |

4760-4940'

| | |
|---|---|
| Age. | Late Jurassic<br>Kimmeridgian |
| Zone. | P-M21 |
| Environment. | Marine |

4940-5240'

| | |
|---|---|
| Age. | Late Jurassic<br>Oxfordian |
| Zone. | P-M22 |
| Environment. | Marine |

5240-6200'

| | |
|---|---|
| Age. | Early - Middle Jurassic<br>Undifferentiated |
| Zones. | P-M24? to P-M23 |
| Environment. | Marine |

6200-6320'

| | |
|---|---|
| Age. | Late Triassic<br>Norian |
| Zone. | P-M26 |
| Environment. | Marine |

6320-6560'

| | |
|---|---|
| Age. | Permian? - Triassic<br>Undifferentiated |
| Zones. | P-T18? to P-T15 |
| Environment. | Nonmarine - Marginal? Marine |

6560-6660'T.D.

| | |
|---|---|
| Age. | Indeterminate |
| Environment. | Indeterminate |
| Remarks. | Highly altered black organics. In argillitic facies. |

# INTRODUCTION

## Purpose and Scope

Micropaleo Consultants, Inc. (MCI) conducted palynological analyses on a total of 90 samples from the Phillips Alaska (ARCO) Brontosaurus No. 1/1A well. This total consisted of ten-foot or 30-foot ditch cutting composites with gaps between samples. The sample gaps varied in footage, but the most common gaps were 50 feet. The sample coverage extended from 120 feet to the total depth of 6,660 feet.

The analyses were made from palynological preparations available at the State of Alaska Department of Natural Resources, Geologic Materials Center in Eagle River, Alaska.

## Procedures

As each sample was examined, an estimate of abundance was recorded for each taxon. These data were entered into a desktop PC, which produced the basic elements for a palynomorph species distribution chart (Figure P-1).

Based on the palynomorph assemblages observed, an age and generalized environment of deposition are interpreted for the palynostratigraphic subdivisions. The environments, as interpreted from the palynological preparations, are simply categorized as nonmarine, marginal marine or marine. These categories are based on the absence or presence and diversity of microplankton cysts.

# RESULTS

The species distribution chart (Figure P-1) is located in the pocket. This chart provides the palynostratigraphic subdivisions and the occurrences and estimated frequencies of observed taxa. Additionally, curves displaying the diversity and abundance of the spore-pollen, and microplankton cyst assemblages in each sample are included. These curves comprise a quick reference showing intervals where an influx of marine or nonmarine assemblages may be significant.

120-300'

Age. Early Cretaceous
Probable Middle to Late Albian

Zone. Probable P-M17

Environment. Marginal Marine

Palynomorphs. The uppermost interval recovered a general Early Cretaceous spore-pollen assemblage that includes the spores *Foveosporites*, *Kuylisporites lunaris* and *Gleicheniidites senonicus*. Numerous reworked spores of Carboniferous and Triassic age were also recorded

The dinocyst assemblage includes the species *Cyclonephelium distinctum*, *Oligosphaeridium complex, Ovoidinium verrucosum, Palaeoperidinium cretaceum* and *Pseudoceratium retusum.*

Discussion. The tentative age assignment is based on the presence of only one specimen of the age restrictive dinocyst form *Ovoidinium verrucosum*.

300-3890'

Age. Early Cretaceous
Aptian to Early Albian

Zone. P-M18

Environment. Marginal Marine

Palynomorphs. The palynomorph diversity increases compared to the above interval. Absent, however, are any age restrictive Middle - Late Albian species.

The spore-pollen assemblage includes *Aequitriradites spinulosus*, *Classopollis classoides*, *Podocarpidites*, *Rogalskaisporites cicatricosus* and Taxodiaceae. The reworked Carboniferous and Triassic forms persist.

The dinocyst assemblage increases in diversity and includes the forms *Gardodinium*, *Hystrichodinium pulchrum*, *Imbatodinium jaegeri* (long apical) and *Spiniferites*.

Reworked Late Triassic, Jurassic and Neocomian species were recorded in most of the samples.

3890-4280'

Age. Early Cretaceous
Barremian to Aptian

Zone. P-M18a

Environment. Marine

Palynomorphs. The Barremian - Aptian interval is marked by an increase in abundance of dinocysts, particularly *Cyclonephelium distinctum, Oligosphaeridium complex* and *Palaeoperidinium cretaceum*. Also recorded in this interval are *Cribroperidinium edwardsi*, *Fromea amphora*, *Gardodinium trabeculosum*, *Micrhystridium* sp. A and *Senoniasphaera microreticulata*.

4280-4460'

Age. Early Cretaceous
Hauterivian

Zone. P-M19

Environment. Marine

Palynomorphs. The Hauterivian section is characterized by an increase in dinocyst diversity. The assemblage includes *Florentinia cooksoniae, Imbatodinium micropodum, Lunatadinium dissolutum*, *Muderongia* sp. N, *Muderongia* cf. *M. simplex, Odontochitina* sp. 1 and *Pseudoceratium nudum*.

4460-4760'

Age. Early Cretaceous
Valanginian

Zone. P-M20

Environment. Marine

Palynomorphs. The beginning of consistent occurrences of the pollen *Classopollis classoides* marks the Valanginian section. The numbers of reworked Paleozoic spore species also increase in this interval.

Most of the dinocysts recorded above continue in the samples of this section. The age significant species for this interval are *Gochteodinia villosa*, *Sirmiodinium grossi* and *Tubotuberella apatela*.

4760-4940'

Age. Late Jurassic
Kimmeridgian

Zone. P-M21

Environment. Marine

Palynomorphs. The Kimmeridgian interval is identified by the appearance of the dinocysts *Gonyaulacysta jurassica* and *Pareodinia osmingtonensis*.

4940-5240'

Age. Late Jurassic
Oxfordian

Zone. P-M22

Environment. Marine

Palynomorphs. The Oxfordian section marks a distinct change in the dinocyst assemblage. The change includes the appearance of *Acanthaulax senta, Chytroeisphaeridia pericompsa, Endoscrinium galeritum, Gonyaulacysta cladophora, Nannoceratopsis pellucida* and *Pareodinia prolongata*.

5240-6200'

Age. Early to Middle Jurassic
Undifferentiated

Zones. P-M24? to P-M23

Environment. Marine

Palynomorphs. The dinocyst recoveries decrease somewhat. The indigenous species include *Micrhystridium*, *Nannoceratopsis gracilis*, *N. senex* and *Phallocysta subconica*. The algal form *Pterospermopsis* is also recorded.

A few samples within the interval contained significant quantities of "Loss Circulation Material" (LCM).

Discussion. The occurrence of *Phallocysta subconica* at 5840 feet suggests that Toarcian age strata are present by that depth.

The dinocyst assemblage essentially drops out by 6020 feet and indicates that the P-M24 zonule may be present below.

6200-6320'

Age. Late Triassic
Norian

Zone. P-M26

Environment. Marine

Palynomorphs. The Norian interval is marked by appearance of the dinocysts *Noricysta* sp. and *Suessia swabiana*.

6320-6560'

Age. Permian? to Triassic
Undifferentiated

Zones. P-T18? to P-T15

Environment. Nonmarine to Marginal? Marine

Palynomorphs. This interval is assigned a broad age range. The spore-pollen assemblage consisted mainly of indeterminate verrucate spores; however, ?*Ricciisporites tuberculatus* and *Taeniaesporites* were also present.

The marine component consisted of *Veryhachium*. Rare *Suessia* was also recorded but are interpreted to be sloughed from up-hole.

Discussion. Large amounts of LCM were recovered in the upper two samples of the interval.

6560-6660'T.D.

Age. Indeterminate

Zone. Indeterminate

Environment. Indeterminate

Palynomorphs Barren of indigenous palynomorphs.

Discussion. One of the samples contained large amounts of LCM. Noted was the presence of highly altered black organics.

The interval is in an argillitic facies.

# CONCLUSIONS

Palynological analysis of the Phillips Alaska (ARCO) Brontosaurus No. 1/1A well provides the following generalized palynostratigraphic succession:

- Marginal marine strata of Aptian and Albian age occur from 120 feet to 3890 feet.

- Marine strata of Barremian - Aptian age are identified from 3890 feet to 4280 feet.

- Marine strata of Hauterivian and Valanginian ages occur from 4280 feet to 4760 feet.

- Marine Late Jurassic, Kimmeridgian and Oxfordian age, strata are seen between 4760 feet and 5240 feet.

- Marine strata of undifferentiated Early - Middle Jurassic age are identified between 5240 feet and 6200 feet. The strata below 5840 feet are probably of Toarcian age. The P-M24 zonule may begin at 6020 feet.

- Marine strata of Norian age occur in the thin interval from 6200 feet to 6320 feet.

- Nonmarine to marginal? marine strata of Permian? to Triassic age occur from 6320 feet to 6560 feet.

- The section below 6560 feet and extending to the total depth of 6660 feet is of indeterminate age. Highly altered organics indicate the presence of argillitic facies.