MICROPALEO CONSULTANTS, INC.

USGS/HUSKY - NPRA

NORTH INIGOK NO. 1

API #50-103-20017

SEC. 36, T11N/R4W UM

NORTH SLOPE, ALASKA

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BIOSTRATIGRAPHY REPORT

M.C.I. Job No. 99-111 **January, 2001**

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FORAMINIFERA REPORT

Interpreted by:

Michael B. Mickey

FORAMINIFERA SUMMARY

120-1530'

Age.	Late Cretaceous Campanian to Maestrichtian
Zones.	F-5 to F-6
Environment.	Inner to Middle Neritic (Inner to Middle Shelf)

1530-2040'

Age.	Late Cretaceous Cenomanian to Coniacian
Zone.	F-7
Environment.	Middle to Outer Neritic (Middle to Outer Shelf)

2040-5100'

Age.	Early Cretaceous Middle to Late Albian
Zones.	F-9 to F-10
Environment.	Middle Neritic to Upper Bathyal (Middle Shelf to Upper Slope)

5100-7460'

Age.	Early Cretaceous Aptian to Early Albian
Zone.	F-11
Environment.	Bathyal (Slope & Base of Slope)

7460-7580'

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7580-7640'

Age.	Early Cretaceous Hauterivian
Zone.	F-13a
Environment.	Middle Neritic (Middle Shelf)

7640-8180'

Age.	Early Cretaceous Valanginian
Zone.	F-13b
Environment.	Outer Neritic (Outer Shelf)

8180-8630'

Age.	Late Jurassic Kimmeridgian
Zone.	F-16a
Environment.	Outer Neritic to Upper Bathyal (Outer Shelf to Upper Slope)

8630-9020'

Age.	Late Jurassic Oxfordian
Zone.	F-16b
Environment.	Upper Bathyal (Upper Slope)

9020-9110'

Age.	Middle Jurassic Aalenian
Zone.	F-17
Environment.	Upper Bathyal (Upper Slope)

9110-9260'

Age.	Early Jurassic Toarcian
Zone.	F-18a
Environment.	Upper Bathyal (Upper Slope)

9260-9680'

Age.	Early Jurassic Pliensbachian
Zone.	F-18b
Environment.	Outer Neritic to Lower? Bathyal (Outer Shelf to Lower? Slope)

9680-9890'

Age.	Early Jurassic Hettangian to Sinemurian
Zone.	F-18c
Environment.	Middle? to Lower Bathyal (Middle? to Lower Slope)

9890-10,160'

Age.	Late Triassic Probable Norian
Zone.	Probable F-19b
Environment.	Inner to Middle Neritic (Inner to Middle Shelf)

INTRODUCTION

Scope

Data from 381 Foraminifera samples from the USGS/HUSKY North Inigok No. 1 well were incorporated into this report. These samples consisted of 379 ditch and two (2) sidewall core samples covering the interval 120 to 10,160 feet. This work was done as part of M.C.I. Job Number 99-111.

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. Foraminifera Distribution Charts (Figures F-1 and F-2) 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

120-1530'

Age.	Late Cretaceous Campanian to Maestrichtian
Zones.	F-5 to F-6
Environment.	Inner to Middle Neritic (Inner to Middle Shelf)
Fauna.	*Elphidium clavatum, E. bartletti, Elphidiella* cf. *nitida, Trochammina ribstonensis, Haplophragmoides excavatus, H. rota, Verneuilinoides fischeri, Quinqueloculina* spp., shell fragments, plant debris, ostracods, pyrite and frequent to abundant coal.

1530-2040'

Age.	Late Cretaceous Cenomanian to Coniacian
Zone.	F-7
Environment.	Middle to Outer Neritic (Middle to Outer Shelf)
Fauna.	*Elphidiella* cf. *nitida, Haplophragmoides rota, H. excavatus, Trochammina ribstonensis, Neobulimina canadensis*?, shell fragments, *Inoceramus* prisms, fishbone fragments, ostracods, paper shale, pyrite and rare to frequent pyrite oblates.

2040-5100'

Age.	Early Cretaceous Middle to Late Albian
Zones.	F-9 to F-10
Environment.	Middle Neritic to Upper Bathyal (Middle Shelf to Upper Slope)
Fauna.	*Haplophragmoides excavatus, H. gigas, H. topagorukensis, H.* cf. *collyra, H. kirki, Miliammina awunensis, M. manitobensis, M. bisobscura, Ammobaculites wenonahae, Trochammina umiatensis, T. mcmurrayensis, T. rainwateri, Lenticulina macrodisca, L. gryci, L. erecta, Verneuilinoides borealis, Bathysiphon vitta, Ammodiscus rotalarius, Psamminopelta subcircularis, P. bowsheri, Globorotalites alaskensis, Valvulineria loetterlei, Saracenaria navicula, S. trollopei, Marssonella* cf. *trochus, Citharina* cf. *acuminata, Dentalina*? spp., *Marginulinopsis collonsi, Eurycheilostoma grandstandensis, Inoceramus* prisms, ostracods, shell fragments, *Ditrupa cornu*, pelmatozoan fragments, pyrite, pyrite sticks, and common to abundant pyritized radiolaria below 4800 feet.

5100-7460'

Age. Early Cretaceous
Aptian to Early Albian

Zone. F-11

Environment. Bathyal
(Slope & Base of Slope)

Fauna. *Gaudryina nanushukensis, Glomospirella gaultina, Psamminopelta bowsheri, P. subcircularis, Ammobaculites wenonahae, A. fragmentarius, Miliammina manitobensis, M. awunensis, Bathysiphon vitta, Marssonella* cf. *trochus, Verneuilinoides borealis, Haplophragmoides topagorukensis, H. excavatus, Ammodiscus rotalarius, Lenticulina macrodisca, L. gryci, Gavelinella awunensis, Eurycheilostoma grandstandensis, Hippocrepina barksdalei, Textularia topagorukensis, Marginulinopsis jonesi, Inoceramus* prisms, *Ditrupa cornu*, pelmatozoan fragments, echinoid spines, pyrite sticks, pyrite and frequent to abundant pyritized radiolaria.

7460-7580'

Age. Early Cretaceous
Barremian

Zone. F-12

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

Fauna. Arenaceous spp. (large-coarse), *Glomospirella arctica, Haplophragmoides coronis, H. duoflatis, Inoceramus* prisms, pyrite and rare to common rounded frosted quartz floating sand grains.

7580-7640'

Age. Early Cretaceous
Hauterivian

Zone. F-13a

Environment. Middle Neritic
(Middle Shelf)

Fauna. *Oolina apiculata,* arenaceous spp. (large-coarse), *Vaginulinopsis pachynota, Marginulinopsis collonsi, Glomospira subarctica, Saracenaria navicula, Haplophragmoides duoflatis, H. coronis, Glomospirella* sp. S, *G. arctica, Lenticulina macrodisca, Gaudryina tailleuri, Ammobaculites erectus* and common rounded frosted quartz floating sand grains.

7640-8180'

Age. Early Cretaceous
Valanginian

Zone. F-13b

Environment. Outer Neritic
(Outer Shelf)

Fauna. *Haplophragmoides goodenoughensis, H. coronis, H. duoflatis, H. inflatigrandis, Ammodiscus mackenziensis, Trochammina squamata,* arenaceous spp. (large-coarse), *Frondicularia lustrata, Ammobaculites reophacoides, A. erectus, Praebulimina* sp. 2, *Globulina prisca, Lenticulina gryci, L. audax, L.* sp. (large-raised suture), *Glomospirella* sp. S, *Gaudryina milleri, G. leffingwelli, Nodosaria* cf. *orthostoecha, Pseudobolivina* spp., *Marginulinopsis phragmites, Saracenaria valanginiana,* ostracods, pyrite and frequent to common rounded frosted quartz floating sand grains.

8180-8630'

Age. Late Jurassic
Kimmeridgian

Zone. F-16a

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

Fauna. *Trochammina rostovzevi, T. instowensis, Ammobaculites alaskensis, Haplophragmoides inflatigrandis, H. duoflatis, H.* spp., *Gaudryina milleri, G. leffingwelli, G. tailleuri, G. topagorukensis,* arenaceous spp. (large-coarse), *Eoguttulina liassica, Ammodiscus asperus, Lenticulina audax, Globulina topagorukensis, Rectoglandulina brandi, Lituotuba irregularis, Textularia areoplecta, Reophax metensis, Recurvoides turbinatus, Vaginulinopsis muelleri,* ostracods, rare to common pyritized radiolaria, pyrite and rare to frequent rounded frosted quartz floating sand grains.

8630-9020'

Age. Late Jurassic
Oxfordian

Zone. F-16b

Environment. Upper Bathyal
(Upper Slope)

Fauna. *Trochammina instowensis, T. canningensis, Haplophragmoides* spp., *Trochamminoides* spp., *Recurvoides turbinatus, Ammobaculites alaskensis, A. barrowensis, Lenticulina audax, L. quenstedti, L. toarcense, Saracenaria topagorukensis, Ammodiscus asperus, Inoceramus* prisms, pyrite and rare to common pyritized radiolaria.

9020-9110'

Age.	Middle Jurassic Aalenian
Zone.	F-17
Environment.	Upper Bathyal (Upper Slope)
Fauna.	*Lenticulina quenstedti, L. audax, Haplophragmoides* spp., *Trochammina instowensis, Thuramminoides* spp., *Inoceramus* prisms and frequent to common pyrite.

9110-9260'

Age.	Early Jurassic Toarcian
Zone.	F-18a
Environment.	Upper Bathyal (Upper Slope)
Fauna.	*Vaginulina anomala, V. curva, Haplophragmoides* spp., *Nodosaria detruncata, Gaudryina dyscrita, Lenticulina audax, Thuramminoides* spp., *Ammodiscus siliceous, Inoceramus* prisms, pyrite and rare to frequent pyritized radiolaria.

9260-9680'

Age.	Early Jurassic Pliensbachian
Zone.	F-18b
Environment.	Outer Neritic to Lower? Bathyal (Outer Shelf to Lower? Slope)
Fauna.	*Lenticulina audax, L. excavata, Haplophragmoides* spp., *Ammodiscus siliceus, Trochamminoides* spp., *Bathysiphon anomalocoelia, Thuramminoides* spp., *Inoceramus* prisms and rare to common pyrite.

9680-9890'

Age.	Early Jurassic Hettangian to Sinemurian
Zone.	F-18c
Environment.	Middle? to Lower Bathyal (Middle? to Lower Slope)
Fauna.	*Ammobaculites vetusta, Trochamminoides* spp., *Haplophragmoides* spp., *Thuramminoides* spp., *Bathysiphon anomalocoelia, Glomospira perplexa, Inoceramus* prisms, pyrite and rare to common pyritized radiolaria.

9890-10,160'

Age.	Late Triassic Probable Norian
Zone.	Probable F-19b
Environment.	Inner to Middle Neritic (Inner to Middle Shelf)
Fauna.	*Haplophragmoides* spp., *Trochamminoides* spp., *Ammodiscus asperus, Ammobaculites alaskensis, A. barrowensis, Reophax suevica, Bathysiphon anomalocoelia, Nodosaria shublikensis, N. larina, Lingulina alaskensis, L. borealis, Astacolus connudatus, Trochammina helicta, Pseudoglandulina simpsonensis, Inoceramus* prisms, pyrite, frequent to common *Monotis/Halobia* shell fragments below 10,100 feet, and rare medium-sized smooth ostracods in the bottom sample.

CONCLUSIONS

The USGS/HUSKY North Inigok No. 1 well penetrated the following biostratigraphic sequence based on foraminiferal analysis:

- 1920+ feet (120-2040') of Cenomanian to Campanian or Maestrichtian age (Early Brookian) shelf deposition.

- 5600 feet (2040-7640') of Hauterivian to Albian age (Early Brookian & Beaufortian - Rift Sequence) middle to outer shelf topsets, slope foresets and base of slope bottomsets.

- 2250 feet (7640-9890') of Hettangian and/or Sinemurian to Valanginian age (Beaufortian - Incipient Rift Sequence) middle to outer shelf and slope to base of slope sedimentation.

- 270+ feet (9890-10,160') of Late Triassic, probable Norian, age (Late Ellesmerian) inner to middle shelf deposition.

PALYNOLOGY REPORT

Interpreted by:

Hideyo Haga

PALYNOLOGY SUMMARY

120-660'

Age.	Late Cretaceous Probable Campanian
Zone.	Probable P-T12 and marine equivalent
Environment.	Marine

660-1470'

Age.	Late Cretaceous Santonian - Campanian
Zone.	P-M14
Environment.	Marine

1470-1650'

Age.	Late Cretaceous Turonian - Coniacian
Zone.	P-M15
Environment.	Marine

1650-2100'

Age.	Late Cretaceous Cenomanian
Zone.	P-M16
Environment.	Marine

2100-4860'

Age.	Early Cretaceous Middle - Late Albian
Zone.	P-M17
Environment.	Marine

4860-7470'

Age.	Early Cretaceous Aptian - Early Albian
Zone.	P-M18
Environment.	Marine
Remarks.	This separation is based on negative evidence.

7470-7560'

Age.	Early Cretaceous Barremian - Aptian
Zone.	P-M18a
Environment.	Marine

7560-7650'

Age.	Early Cretaceous Hauterivian
Zone.	P-M19
Environment.	Marine

7650-8190'

Age.	Early Cretaceous Valanginian
Zone.	P-M20
Environment.	Marine

8190-8460'

Age.	Late Jurassic - Early Cretaceous Undifferentiated
Environment.	Marine

8460-8990'

Age. Late Jurassic
Oxfordian - Kimmeridgian

Zones. P-M22 to P-M21

Environment. Marine

8990-10,170'T.D.

Age. Triassic - Jurassic
Undifferentiated

Environment. Marginal Marine?

Remarks. This interval is essentially barren of dinocysts.

INTRODUCTION

Purpose and Scope

Data from 128 palynology samples of the USGS/HUSKY North Inigok No. 1 are incorporated in this study. The samples consisted of 119 ditch-cutting composites, two (2) sidewall cores and seven (7) conventional core samples taken between 120 feet and the total depth of 10,170 feet. Originally 21 core samples were examined; however, many of the core data have been combined into larger composites. The compositing facilitated the handling of data from the closely spaced core samples. None of the core compositing affected boundary placements.

The original analysis of this well was completed in May of 1981, as part of the U. S. Government's evaluation program of the NPRA. In subsequent years some of the palynological material has been reprocessed. Most of this material has been examined and the occurrences of important taxa have been included.

This report, therefore, provides new data and an updated format for the original data. Some of the original taxa designations have been changed to reflect the newer taxonomic assignments that have evolved over the years since the well was first analyzed.

Procedures

The original samples were processed in San Diego, California, using techniques standard for the time. The chemical treatments involved the use of hydrochloric, hydrofluoric and nitric acids. The resulting kerogen residues were further concentrated by physical separation with heavy liquids and a sieving/panning technique. Permanent slide mounts were made of the residue concentrates. The coverslip mounting medium was a synthetic resin sold under the brand name of "CoverBond".

Data from the species distribution charts and the more recent palynological preparations were entered in a microcomputer to compile new format charts. These charts are located in the pockets.

The Palynomorph Distribution Chart (Figure P-1) lists the occurrence and abundance of recorded taxa in each sample. Included on this chart are the diversity and abundance curves for the spore-pollen and the microplankton cysts.

High Resolution Biostratigraphy Plots - Foraminifera/Palynomorphs (Figure B-1) are also provided. This chart includes additional palynology parameters in the form of a cumulative plot that illustrates the relative abundance of the nonmarine, marine and miscellaneous palynomorph components.

RESULTS

120-660'

Age. Late Cretaceous
Probable Campanian

Zone. Probable P-T12 and marine equivalent

Environment. Marine

Palynomorphs. The uppermost interval in the well provided sparse pollen evidence that indicates a probable Campanian age for the section. The key forms here are *Anacolosidites* sp. and *Aquilapollenites trialatus.*

The dinocyst assemblage is fairly diverse, but generally sparse. The forms include species of *Chatangiella, Isabelidinium acuminatum, Laciniadinium biconiculum* and *Odontochitina operculata*.

660-1470'

Age. Late Cretaceous
Santonian - Campanian

Zone. P-M14

Environment. Marine

Palynomorphs. The Santonian - Campanian interval is characterized by an increase in dinocyst diversity and abundance. The assemblage includes *Chatangiella ditissima, Cyclonephelium distinctum, Hystrichosphaeridium difficile, Palaeoperidinium cretaceum* and *Trithyrodinium suspectum.*

1470-1650'

Age. Late Cretaceous
Turonian - Coniacian

Zone. P-M15

Environment. Marine

Palynomorphs. The identification of this section is based on the frequent occurrences of the dinocyst *Isabelidinium globosum*.

Discussion. As designated in this well, the Turonian - Coniacian interval is only 180 feet thick. However, there is a shallower occurrence of *Isabelidinium globosum* in the sample 1200-1290 feet. If this sample is used as the top of the interval, the Turonian - Coniacian section would potentially be 270 feet thicker.

1650-2100'

Age. Late Cretaceous
Cenomanian

Zone. P-M16

Environment. Marine

Palynomorphs. The Cenomanian interval is marked by the appearance of *Endoceratium* cf. *E. dettmanniae* and *Pseudoceratium* cf. *P. expolitum*.

2100-4860'

Age. Early Cretaceous
Middle - Late Albian

Zone. P-M17

Environment. Marine

Palynomorphs. This Albian interval is identified by the occurrences of the dinocysts *Luxadinium propatulum, Ovoidinium verrucosum, Spinidinium vestitum* and *Wigginsiella grandstandica*.

Discussion. Usually the Aptian - Albian section contains numerous rare occurrences of reworked palynomorphs. The reworked forms consist of marine and nonmarine species ranging in age from the Mississippian through the Neocomian.

Several single occurrences of reworked Jurassic dinocysts are noted in this interval and continue into the Aptian - Early Albian below.

4860-7470'

Age. Early Cretaceous
Aptian - Early Albian

Zone. P-M18

Environment. Marine

Palynomorphs. The Aptian - Early Albian interval contains most of the same species as the interval above. The distinguishing aspect of this assemblage is the absence of the age restrictive Middle to Late Albian dinocyst markers.

7470-7560'

Age. Early Cretaceous
Barremian - Aptian

Zone. P-M18a

Environment. Marine

Palynomorphs. The Barremian - Aptian section is a very thin unit in the North Inigok No. 1 well. This interval is marked by an increase in dinocyst abundance. Among the species included in this "bloom" are *Cyclonephelium distinctum, Odontochitina operculata* and *Oligosphaeridium complex*.

7560-7650'

Age. Early Cretaceous
Hauterivian

Zone. P-M19

Environment. Marine

Palynomorphs. The Hauterivian interval is separated by the appearance of several age restrictive dinocyst species. The species include *Dimidiadinium uncinatum, Florentinia cooksoniae, Imbatodinium micropodum, Muderongia* sp. N, *Oligosphaeridium complex* (thick-wall) and *Pseudoceratium nudum*.

7650-8190'

Age. Early Cretaceous
Valanginian

Zone. P-M20

Environment. Marine

Palynomorphs. The Valanginian interval reflects the beginning of consistent occurrences of the pollen *Classopollis classoides*.

This section is further marked by the appearance of the dinocyst *Gochteodinia villosa* with occurrences of *Tubotuberella apatela* and *Sirmiodinium grossi*.

Discussion. Reworked Paleozoic spores occur consistently through this interval.

In most subsurface penetrations of Valanginian strata, the dinocyst assemblage is diminished and accompanied by a relative increase in the spore-pollen component. This situation is not obvious in the palynomorph recoveries from the ditch samples; the only type of samples available from this interval.

The base of this interval is placed at the depth where a decrease in dinocyst abundances is noticeable; although, the appearance of older marker species does not accompany the decrease.

8190-8460'

Age. Late Jurassic to Early Cretaceous
Undifferentiated

Environment. Marine

Palynomorphs. The palynomorph assemblage is essentially unchanged from the above interval. The dinocyst abundances reflect a significant decrease. Most of the recorded forms are probably derived from sloughing.

8460-8990'

Age. Late Jurassic
Oxfordian to Kimmeridgian

Zones. P-M22 to P-M21

Environment. Marine

Palynomorphs. Separation of this interval is based on the appearance of a single Jurassic dinocyst species *Endoscrinium galeritum*.

Discussion. The poor recovery of Jurassic dinocysts precludes a more definitive age assignment.

The base of this interval is placed at the apparent base of *Endoscrinium galeritum* occurrences.

8990-10,170'T.D.

Age.	Triassic - Jurassic Undifferentiated
Environment.	Marginal Marine?
Palynomorphs.	The palynomorph assemblage in this interval is very poorly developed and poorly preserved. Indeterminate verrucate spores dominate the spore-pollen assemblage. Three specimens of a Late Jurassic dinocyst *Gonyaulacysta cladophora* were recorded, as well as some specimens of *Micrhystridium*.
Discussion.	The *Gonyaulacysta cladophora* specimens are believed to be sloughed from up-hole. The *Micrhystridium* specimens in sample 9620-9710 feet may be indigenous and would suggest a marginal marine depositional environment.

CONCLUSIONS

Palynological analysis of the USGS/HUSKY North Inigok No. 1 well provided the following generalized palynostratigraphic succession:

- The uppermost interval is of probable Campanian age. These strata are of marine origin and cover the in-hole depths from 120 feet to 660 feet. The palynomorph recoveries are generally sparse.

- The section from 660 feet to 1470 feet consists of Santonian - Campanian age marine strata. Dinocyst diversity and abundance increases significantly.

- The narrow interval from 1470 feet to 1650 feet is assigned a Turonian - Coniacian age. Very weak dinocyst evidence would allow placing the top of this unit as high as 1200 feet.

- Marine strata of Cenomanian age are recognized between 1650 feet and 2100 feet.

- Middle - Late Albian strata are present from 2100 feet to 4860 feet. Several marine dinocyst species mark this interval.

- The section from 4860 feet to 7470 feet is assigned an Aptian - Early Albian age. These strata contain a palynomorph assemblage similar to the above interval, but the more restrictive Albian dinocyst markers are absent.

- The thin interval from 7470 feet to 7560 feet consists of Barremian -Aptian marine strata. This unit is characterized by a dinocyst "bloom".

- Marine strata of Hauterivian age occur between 7560 feet and 7650 feet. This narrow interval is marked by the appearance of several age restrictive dinocyst species.

- The section from 7650 feet to 8190 feet consists of Valanginian age marine strata. These strata usually reflect a decrease in dinocyst abundance and diversity, accompanied by an increase in the spore-pollen components.

- An undifferentiated Late Jurassic to Early Cretaceous marine interval is

identified between 8190 feet and 8460 feet.

- A Late Jurassic, Oxfordian to Kimmeridgian, interval tops at 8460 feet. These strata consist of a marine unit that extends down to 8990 feet. The dinocyst assemblage is sparse, however, a probable Kimmeridgian age is assigned.

- The bottom interval of the well, from 8990 feet to the total depth of 10,170 feet, is poorly fossiliferous. The age of these strata is given as Triassic - Jurassic. The environment of deposition is questioned as marginal marine.