MICROPALEO CONSULTANTS, INC.

TEXACO

COLVILLE DELTA NO. 1/1A

API #50-103-20038

SEC. 17, T13N/R7E UM

NORTH SLOPE, ALASKA

Prepared by:

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BIOSTRATIGRAPHY REPORT

Job No. 21-106 **December, 2001**

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INTEGRATED SUMMARY

390-990'

Tertiary
Probable Eocene

990-2040'

Tertiary
Paleocene

2040-2540'

Late Cretaceous
Campanian to Maestrichtian

2540-3710'

Late Cretaceous
Coniacian to Santonian

3710-4105'

Late Cretaceous
Turonian to Coniacian

4105-4690'

Late Cretaceous
Probable Cenomanian

4690-5775'

Early Cretaceous
Middle to Late Albian

5775-5880'

Early Cretaceous
Aptian to Early Albian

5880-5910'

Early Cretaceous
Barremian
KE_{B}

5910-6000'

Early Cretaceous
Hauterivian
KE_{H}

6000-6170'

Early Cretaceous
Valanginian
KE_{V}

6170-6240'

Late Jurassic
Possible Kimmeridgian
$JL_{K?}$

6240-6655'

Late Jurassic
Oxfordian
JL_{O}

6655-6930'

Middle Jurassic
Aalenian
JM_{A}

6930-7320'

Early Jurassic
Toarcian
JE_{T}

7320-7665'

Early Jurassic
Pliensbachian
JE_P

7665-7800'

Late Triassic
Norian
TL_N

7800-7900'

Late Triassic
Probable Carnian
TL_C

7900-8710'

Early Triassic
TE

Discussion. Sadlerochit Group. Ivishak Fm. tops at 7900 feet and Kavik Fm. tops at 8585 feet.

8710-8760'

Probable Late Permian
PL

Discussion. Echooka Fm.

8760-9457'T.D.

Middle to Late Pennsylvanian
Atokan to Kawvian
Zone M-22 to Zone M-24

Discussion. Lisburne Group. Wahoo Fm.; Upper Limestone Unit.

FORAMINIFERA REPORT

Interpreted by

Michael B. Mickey

FORAMINIFERA SUMMARY

390-2010'

Age.	Latest Cretaceous to Tertiary Undifferentiated
Environment.	Nonmarine to Marginal Marine (Alluvial Plain to Inner Delta Plain)

2010-2550'

Age.	Late Cretaceous Campanian to Maestrichtian
Zone.	F-5
Environment.	Middle to Outer Neritic (Middle to Outer Shelf)

2550-3720'

Age.	Late Cretaceous Coniacian to Santonian
Zone.	F-6
Environment.	Bathyal (Slope)

3720-4080'

Age.	Late Cretaceous Turonian to Coniacian
Zone.	F-7
Environment.	Middle to Lower Bathyal - Some Distal (Middle to Lower Slope & Base of Slope - Some Starved Basin)

4080-4620'

Age.	Late Cretaceous Probable Cenomanian
Zones.	Probable F-7 to F-8
Environment.	Middle to Lower Bathyal - Some Distal (Middle to Lower Slope & Base of Slope - Some Starved Basin)

4620-5790'

Age.	Early Cretaceous Middle to Late Albian	
Zone.	F-11	
Environment.	4620-5430':	Bathyal (Slope)
	5430-5790':	Lower Bathyal - Distal (Lower Slope & Base of Slope - Starved Basin)

5790-5880'

Age.	Early Cretaceous Aptian to Early Albian
Zone.	F-11
Environment.	Lower Bathyal - Distal (Base of Slope - Starved Basin)

5880-5910'

Age.	Early Cretaceous Barremian
Zone.	F-12
Environment.	Distal (Starved Basin)

5910-6000'

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

6000-6150'

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

6150-6240'

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

6240-6600'

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

6600-6930'

Age.	Middle Jurassic Aalenian
Zone.	F-17
Environment.	Outer Neritic to Middle Bathyal (Outer Shelf to Middle Slope)

6930-7350'

Age.	Early Jurassic Toarcian
Zone.	F-18a
Environment.	Upper to Lower Bathyal - Some Distal (Upper to Lower Slope - Some Starved Basin)

7350-7680'

Age.	Early Jurassic Pliensbachian
Zone.	F-18b
Environment.	Inner Neritic to Middle or Lower Bathyal - Some Distal (Inner Shelf to Middle or Lower Slope - Some Starved Basin)

7680-7880'C

Age.	Late Triassic Carnian to Norian
Zones.	F-19b to F-19c
Environment.	Inner to Middle Neritic (Inner to Middle Shelf)

7880C-8670'

Age.	Early Triassic
Zone.	F-20a
Environment.	Nonmarine to Marginal Marine (Alluvial Plain to Transitional)
Discussion.	Sadlerochit Group. Ivishak Fm. tops at 7880 feet and Kavik Fm. tops at 8580 feet.

8670-8760'

Age.	Probable Late Permian
Zone.	Probable F-20b
Environment.	Marginal Marine to Inner Neritic (Transitional to Inner Shelf)
Discussion.	Echooka Fm.

8760-9457'T.D.

Age.	Middle to Late Pennsylvanian Atokan to Kawvian
Zones.	M-22 to M-24
Environment.	Shoaling Shelf (Bank)
Discussion.	Lisburne Group. Wahoo Fm.; Upper Limestone Unit.

INTRODUCTION

Scope

Micropaleo Consultants, Inc. processed, picked and analyzed for Foraminifera 134 ditch samples and three (3) conventional core samples from the Texaco Colville Delta No. 1/1A well. These samples covered the interval 390 to 9457 feet total depth. This work was done as part of M.C.I. Job Number 21-106.

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

390-2010'

Age. Latest Cretaceous to Tertiary
Undifferentiated

Environment. Nonmarine to Marginal Marine
(Alluvial Plain to Inner Delta Plain)

Fauna. Essentially barren of Foraminifera. A single specimen of *Elphidium* cf. *ustulatum* occurs at 570-660 feet. Calcispheres, plant debris and rare to common coal.

2010-2550'

Age. Late Cretaceous
Campanian to Maestrichtian

Zone. F-5

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

Fauna. *Anomalinoides pinguis, Arenobulimina torula, Caucasina vitrea, Eoeponidella strombodes, E. linki, Haplophragmoides rota, Neobulimina albertensis, Praebulimina seabeensis, P. cushmani, Saccammina lathrami, S.* sp. (coarse), *Trochammina albertensis, T. ribstonensis, Verneuilinoides fischeri, Bathysiphon varans, B.* sp. (large, coarse), *Dentalina* sp., *Gavelinella tumida, Nonionella taylorensis, Quinqueloculina sphaera*, shell fragments, ostracods, pyrite and rare to frequent coal.

2550-3720'

Age.	Late Cretaceous Coniacian to Santonian
Zone.	F-6
Environment.	Bathyal (Slope)
Fauna.	*Haplophragmoides excavata, H. rota, H. bonanzaensis, Cyclammina* cf. *pacifica, Trochammina ribstonensis, Bathysiphon varans, Hippocrepina barksdalei, Saccammina lathrami, Verneuilinoides fischeri, Praebulimina venusae*, fish debris, *Inoceramus* prisms, megaspores, paper shale, tar, pyrite and frequent to abundant radiolaria.

3720-4080'

Age.	Late Cretaceous Turonian to Coniacian
Zone.	F-7
Environment.	Middle to Lower Bathyal - Some Distal (Middle to Lower Slope & Base of Slope - Some Starved Basin)
Fauna.	Barren of Foraminifera. Rare to frequent radiolaria, fish debris, *Inoceramus* prisms, megaspores, paper shale and tar.

4080-4620'

Age. Late Cretaceous
Probable Cenomanian

Zones. Probable F-7 to F-8

Environment. Middle to Lower Bathyal - Some Distal
(Middle to Lower Slope & Base of Slope - Some Starved Basin)

Fauna. *Haplophragmoides excavata, H. rota, Hippocrepina barksdalei, Saccammina lathrami, Trochammina ribstonensis, T. rutherfordi, T. whittingtoni, Verneuilinoides fischeri, Inoceramus* prisms, fish debris, paper shale, pyrite and frequent tar between 4260 and 4350 feet.

4620-5790'

Age. Early Cretaceous
Middle to Late Albian

Zone. F-11

Environment. 4620-5430': Bathyal
(Slope)
5430-5790': Lower Bathyal - Distal
(Lower Slope & Base of Slope - Starved Basin)

Fauna. *Conorboides umiatensis, Trochammina mcmurrayensis,* fish debris, *Inoceramus* prisms, pyrite, pyritized radiolaria, rare to frequent coal below 5160 feet and frequent to abundant paper shale below 5340 feet.

5790-5880'

Age.	Early Cretaceous Aptian to Early Albian
Zone.	F-11
Environment.	Lower Bathyal - Distal (Base of Slope - Starved Basin)
Fauna.	Barren of Foraminifera. *Dictyomitra* spp., *Lithocampe* N, *L.* spp., *Spongodiscus* spp. and abundant paper shale.

5880-5910'

Age.	Early Cretaceous Barremian
Zone.	F-12
Environment.	Distal (Starved Basin)
Fauna.	Barren of Foraminifera. Lithocampe spp., abundant paper shale and rare rounded frosted quartz floating sand grains.

5910-6000'

Age. Early Cretaceous
Hauterivian

Zone. F-13a

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

Fauna. *Haplophragmoides duoflatis, H. coronis*, arenaceous spp. (large, coarse), *Ammobaculites reophacoides, Gaudryina tailleuri, G. tappanae, Lenticulina muensteri, Trochammina conicominuta, T. squamata, Conorboides* cf. *umiatensis*, *Inoceramus* prisms, ostracods, pyrite and frequent to common rounded frosted quartz floating sand grains.

6000-6150'

Age. Early Cretaceous
Valanginian

Zone. F-13b

Environment. Marginal Marine to Outer Neritic
(Transitional to Outer Shelf)

Fauna. *Ammobaculites erectus, A. reophacoides*, arenaceous spp. (large, coarse), *Gaudryina leffingwelli, G. milleri, G. tailleuri, Globulina prisca, Glomospirella arctica, Oolina apiculata, Lenticulina muensteri, Haplophragmoides inflatigrandis, H. goodenoughensis, Saracenaria projectura, Trochammina conicominuta, Marginulinopsis jonesi*, pyrite, frequent to common rounded frosted quartz floating sand grains and frequent tar below 6090 feet.

6150-6240'

Age.	Late Jurassic Possible Kimmeridgian
Zone.	F-16a?
Environment.	Outer Neritic to Upper Bathyal (Outer Shelf to Upper Slope)
Fauna.	Arenaceous spp. (large, coarse), *Oolina apiculata, Lenticulina audax, Trochammina kosyrevae, Reophax suevica, R. metensis, Marginulina radiata, Glomospira pattoni, Marginulinopsis carievalensis, Bathysiphon scintillata, Gaudryina milleri, G. leffingwelli, Ammobaculites* cf. *vetusta, A. alaskensis, Ammodiscus orbis*, pyrite, common rounded frosted quartz floating sand grains and frequent glauconite.

6240-6600'

Age. Late Jurassic
Oxfordian

Zone. F-16b

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

Fauna. *Ammodiscus orbis, A. asperus*, arenaceous spp. (large, coarse), *Gaudryina leffingwelli, G. milleri, G. tailleuri, G. topagorukensis, Ammobaculites alaskensis, A. vetusta, A. barrowensis, Haplophragmoides canui, H.* spp., *Lenticulina audax, L. quenstedti, Trochammina sablei, T. canningensis, T. instowensis, T.* sp. (small, high spired), *Marginulina pletha, Astacolus dubius, Saracenaria topagorukensis, Astacolus dubius, Globulina topagorukensis, Lagena liasica, Recurvoides turbinatus, Conorboides* cf. *hofkeri, Lituotuba irregularis, Trochamminoides* sp. (small, thin), *Eoguttulina liassica, Nodosaria detruncata, Inoceramus* prisms, fish debris, gastropods (pyrite casts), glauconite, pyrite, rare to frequent pyritized radiolaria and rare to frequent rounded frosted quartz floating sand grains.

6600-6930'

Age.	Middle Jurassic Aalenian
Zone.	F-17
Environment.	Outer Neritic to Middle Bathyal (Outer Shelf to Middle Slope)
Fauna.	*Ammobaculites alaskensis, Haplophragmoides* spp., arenaceous spp. (large, coarse), frequent tar and frequent to common paper shale.

6930-7350'

Age.	Early Jurassic Toarcian
Zone.	F-18a
Environment.	Upper to Lower Bathyal - Some Distal (Upper to Lower Slope - Some Starved Basin)
Fauna.	*Gaudryina leffingwelli,* arenaceous spp. (large, coarse), *Haplophragmoides* spp., *Ammobaculites barrowensis, A. vetusta, Thuramminoides* sp., rare to frequent pyritized radiolaria, frequent to common paper shale, rare to frequent megaspores, and rare *Tasmanites* at 6990-7020 feet.

7350-7680'

Age. Early Jurassic
Pliensbachian

Zone. F-18b

Environment. Inner Neritic to Middle or Lower Bathyal - Some Distal
(Inner Shelf to Middle or Lower Slope - Some Starved Basin)

Fauna. *Ammobaculites alaskensis, A. barrowensis, A.* sp. (small, nodose), *A.* sp. (small, bell-shaped chambers), *Ammodiscus* sp. (small, thin), *Gaudryina dyscrita, Thuramminoides* sp., *Trochamminoides* sp. (small, thin), frequent to common pyritized radiolaria and common to abundant paper shale.

7680-7880'C

Age. Late Triassic
Carnian to Norian

Zones. F-19b to F-19c

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

Fauna. *Astacolus connudatus, Monotis/Halobia* fragments, echinoid spines and ostracods (medium-large, smooth).

7880C-8670'

Age.	Early Triassic
Zone.	F-20a
Environment.	Nonmarine to Marginal Marine (Alluvial Plain to Transitional)
Fauna.	Barren of Foraminifera. Rare pyrite and rare to frequent white triplitic chert.
Discussion.	Sadlerochit Group. Ivishak Fm. tops at 7880 feet and Kavik Fm. tops at 8580 feet.

8670-8760'

Age.	Probable Late Permian
Zone.	Probable F-20b
Environment.	Marginal Marine to Inner Neritic (Transitional to Inner Shelf)
Fauna.	Barren of Foraminifera. Frequent glauconite.
Discussion.	Echooka Fm.

8760-9457'T.D.

Age.	Middle to Late Pennsylvanian Atokan to Kawvian
Zones.	M-22 to M-24
Environment.	Shoaling Shelf (Bank)
Fauna.	Archaediscids, *Archaediscus krestovnikovi, Biseriella parva, Consorbrinella* sp., *Dainella anivikensis, Earlandia elegans, Endothyra bowmani, Eoschubertella yukonensis, Eostaffella radiata, Globivalvulina bulloides,* glomospirids (large, thick-walled), *Millerella pressa, Neoarchaediscus incertus, Planoendothyra rotayi, Pseudoendothyra britishensis, P. ornata, Pseudoglomospira* sp., *Trepeilopsis* sp., *Volvotextularia, mississippiana, Zellerina discoidea, Asphaltina* sp., *Beresella* sp., *Calcisphaera laevis, Girvanella ducii, Mitcheldeania* sp., *Paleoaplysina* sp., *Stacheoides meandriformis*, ostracods, bird's eyes, chert, common ooids and frequent oolites.
Discussion.	Lisburne Group. Wahoo Fm.; Upper Limestone Unit.

CONCLUSIONS

The Texaco Colville Delta No. 1/1A well penetrated the following biostratigraphic sequence based on foraminiferal analysis:

- 1620+ feet (390-2010') of undifferentiated Latest Cretaceous to Tertiary age (Brookian) alluvial plain and inner delta plain clastics.

- 2610 feet (2010-4620') of Cenomanian to Maestrichtian age (Early Brookian) upward shallowing base of slope bottomsets, slope foresets and shelf topsets shallowing to middle or outer shelf depths at the top.

- 1380 feet (4620-6000') of Hauterivian to Albian age (Early Brookian & Beaufortian - Rift Sequence) slope foresets, base of slope bottomsets and possible shelf topsets in the Hauterivian interval.

- 1680 feet (6000-7680') of Early Jurassic (Pliensbachian) to Valanginian age (Beaufortian - Incipient Rift Sequence) inner shelf to slope and base of slope deposition.

- 1080 feet (7680-8760') of probable Late Permian to Late Triassic (probable Norian) age (Late Ellesmerian) nonmarine to middle shelf clastics.

- 697+ feet (8760-9457'T.D.) of Middle to Late Pennsylvanian age (Early Ellesmerian) bank carbonates.

PALYNOLOGY REPORT

Interpreted by:

Hideyo Haga

PALYNOLOGY SUMMARY

390-930'

Age.	Tertiary Probable Eocene
Zone.	Probable P-M11
Environment.	Nonmarine?

930-2010'

Age.	Tertiary Paleocene
Zone.	P-T10
Environment.	Nonmarine

2010-2550'

Age.	Late Cretaceous Campanian - Maestrichtian
Zones.	P-T12 to P-T11 and marginal marine equivalents
Environment.	Nonmarine to Marginal Marine

2550-3450'

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

3450-4890'

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

4890-5850'

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

5850-5940'

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

5940-6060'

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

6060-6150'

Age.	Early Cretaceous Probable Valanginian
Zone.	Probable P-M20
Environment.	Marginal Marine to Marine

6150-6180'

Age.	Late Jurassic Possible Kimmeridgian
Zone.	P-M21?
Environment.	Marine

6180-6600'

Age.	Late Jurassic Oxfordian
Zone.	P-M22
Environment.	Marine

6600-7650'

Age.	Early - Middle Jurassic Undifferentiated
Zones.	P-M24? to P-M23
Environment.	Marine
Remarks.	The P-M24 zonule is tentatively identified below 7470 feet.

7650-7880'C

Age.	Late Triassic Norian
Zone.	P-M26
Environment.	Marine

7880C-8580'

Age.	Early Triassic
Zone.	P-T16
Environment.	Marine

8580-8760'

Age.	Permian - Early Triassic Undifferentiated
Zones.	P-T18 to P-T17
Environment.	Nonmarine to Marginal Marine

8760-9457'T.D.

Age.	Indeterminate
Environment.	Indeterminate

INTRODUCTION

Purpose and Scope

Micropaleo Consultants, Inc. (M.C.I.) processed for palynological analysis a total of 137 samples from the Texaco Colville Delta No. 1/1A well. This total consisted of 134 ditch and three (3) core samples taken between 390 feet and the total depth of 9457 feet.

Kerogen maturation analyses were also conducted on selected samples. These analyses included T.A.I. (thermal alteration index) estimates on 36 samples and V.R. (vitrinite reflectance) measurements on nine (9) samples.

Procedures

The sample material was obtained from the State of Alaska, Department of Natural Resources, Geological Materials Center in Eagle Creek, Alaska. All processed material is on reposit at that facility.

The samples were processed with standard palynologic techniques using hydrochloric, hydrofluoric and nitric acid treatments. The resultant kerogen residues were further concentrated by sonification, a heavy liquid separation and a sieving/ panning technique. Permanent palynology slide mounts were made for each sample with sufficient organic recoveries. The kerogen maturation samples were processed without nitric acid.

As each palynology slide was examined, an estimate of abundance for each palynomorph taxon was recorded in a microcomputer. These data form the basic elements of the species distribution chart.

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

Report Format

The following Results section gives the age, environment of deposition and significant palynomorphs for each palynostratigraphic subdivision. This is an expansion of the brief Summary at the beginning of this report. Following the Results are some general remarks in the Conclusions section. The last section of the report consists of the Kerogen Maturation Analyses.

A Palynomorph Distribution Chart (Figure P-1) is located in a pocket. This chart records the occurrence and abundance of individual taxa in each sample. Included on this chart are the diversity and abundance curves for spore-pollen and microplankton cysts.

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

RESULTS

390-930'

Age. Tertiary
Probable Eocene

Zone. Probable P-M11

Environment. Nonmarine?

Palynomorphs. The spore-pollen assemblage consists of a nondescript Tertiary flora. The occurrence of *Tiliaepollenites* suggests a probable Eocene age.

The microplankton assemblage consists of very rare, reworked Mesozoic species.

930-2010'

Age. Tertiary
Paleocene

Zone. P-T10

Environment. Nonmarine

Palynomorphs. The Paleocene section is marked by the appearance of *Paraalnipollenites confusus*.

The rare dinocyst species recorded are probably derived from an Albian age bentonitic mud additive.

2010-2550'

Age. Late Cretaceous
Campanian - Maestrichtian

Zones. P-T12 to P-T11 and marginal marine equivalents

Environment. Nonmarine to Marginal Marine

Palynomorphs. This interval is identified by the appearance of *Aquilapollenites fusiformis, A. magnus, A. quadricretae, A. trialatus* and *Wodehouseia spinata*.

The dinocysts make their appearance below 2190 feet. This assemblage includes *Chatangiella biapertura, Isabelidinium cooksoniae* and *Laciniadinium biconiculum*.

Discussion. *Aquilapollenites quadricretae, A. trialatus* and *Laciniadinium biconiculum* appear below 2190 feet. These forms indicate that strata of Campanian age probably tops at about that depth.

The appearance of marine palynomorphs is obvious in the diversity/abundance plots.

2550-3450'

Age. Late Cretaceous
Santonian - Campanian

Zone. P-M14

Environment. Marine

Palynomorphs. This interval is marked by an increase in dinocyst diversity. The assemblage includes various species of Chatangiella such as *C. ditissima, C. granulifera* and *C. spectabilis*. Also present were species such as *Hystrichosphaeridium difficile* and *Odontochitina operculata*.

3450-4890'

Age. Late Cretaceous
Turonian - Coniacian

Zone. P-M15

Environment. Marine

Palynomorphs. This interval is separated by the appearance of *Isabelidinium globosum*. The usually associated P-M15 marker species *Nelsoniella aceras* was not recorded.

4890-5850'

Age. Early Cretaceous
Middle - Late Albian

Zone. P-M17

Environment. Marine

Palynomorphs. The species marking this interval are the dinocysts *Luxadinium propatulum, Ovoidinium verrucosum* and *Palaeoperidinium cretaceum.*

5850-5940'

Age. Early Cretaceous
Barremian - Early Albian

Zone. P-M18a

Environment. Marine

Palynomorphs. This interval is characterized by the abundance of *Odontochitina operculata* and *Oligosphaeridium complex*. Other dinocysts present include *Cyclonephelium distinctum* and *Micrhystridium* sp. A.

5940-6060'

Age. Early Cretaceous
Hauterivian

Zone. P-M19

Environment. Marine

Palynomorphs. Numerous key dinocyst species mark this section. These species include *Dimidiadinium uncinatum, Imbatodinium micropodum, Muderongia* cf. *M. simplex, Oligosphaeridium complex* (thick-wall) and *Pseudoceratium nudum*.

6060-6150'

Age. Early Cretaceous
Probable Valanginian

Zone. Probable P-M20

Environment. Marginal Marine to Marine

Palynomorphs. This interval is characterized by consistent occurrences of *Classopollis* pollen and by the presence of the dinocyst *Pareodinia ceratophora*.

Discussion. The age assignment is qualified due to the relatively limited assemblage and the absence of the usual zonal marker dinocysts.

6150-6180'

Age. Late Jurassic
Possible Kimmeridgian

Zone. P-M21?

Environment. Marine

Palynomorphs. The appearance of *Gonyaulacysta jurassica* and *Tubotuberella apatela* mark the top of the Jurassic section. The absence of *Nannoceratopsis pellucida* is the basis for the tentative Kimmeridgian age assignment.

6180-6600'

Age. Late Jurassic
Oxfordian

Zone. P-M22

Environment. Marine

Palynomorphs. The spore-pollen assemblage reflects a change with the beginning of reworked Paleozoic spores.

The prolific dinocyst assemblage includes the following species: *Chytroeisphaeridia pericompsa, Endoscrinium galeritum, Gonyaulacysta cladophora, Nannoceratopsis pellucida* and species of *Pareodinia*.

Discussion. The datum for the highest occurrence of *Chytroeisphaeridia "verrucosa"* is at 6330 feet. This horizon may be a useful correlation point to other wells of the region.

6600-7650'

Age. Early - Middle Jurassic
Undifferentiated

Zones. P-M24? to P-M23

Environment. Marine

Palynomorphs. The spore-pollen assemblage consists mainly of *Classopollis classoides, Exesipollenites tumulus, Gleicheniidites senonicus* and *Lycopodiumsporites* spp. Reworked spore-pollen of Mississippian and Triassic age occur through most of the interval.

The dinocyst assemblage is distinctive and consists of species such as *Fromea elongata, Nannoceratopsis gracilis, N. senex, Parvocysta cracens* and *P. nasuta*.

Discussion. The assemblage suggests an age of at least Toarcian by the ditch sample interval 6690-6720 feet.

Below 7470 feet there appears to be a decrease in dinocysts and the increase in acritarchs. The interval below this depth is tentatively assigned to the P-M24 zonule.

7650-7880'C

Age. Late Triassic
Norian

Zone. P-M26

Environment. Marine

Palynomorphs. This section is marked by the appearance of a unique dinocyst assemblage. The assemblage included *Noricysta varivallata* and *Suessia swabiana*.

7880C-8580'

Age. Early Triassic

Zone. P-T16

Environment. Marine

Palynomorphs. This interval is identified by the abundant occurrences of *Striatites richteri* and *Taeniaesporites* spp.

Also occurring in this assemblage are numerous acritarchs.

8580-8760'

Age. Permian - Early Triassic
Undifferentiated

Zones. P-T18 to P-T17

Environment. Nonmarine to Marginal Marine

Palynomorphs. This interval is characterized by a diverse spore-pollen assemblage which includes *Dulhuntyispora minuta, Klausipollenites staplinii, Lundbladispora* sp. and numerous small verrucate spores.

Acritarchs were recorded abundantly in the core sample within this interval.

8760-9457'T.D.

Age. Indeterminate

Environment. Indeterminate

Discussion. No indigenous palynomorphs were recovered in this section. This interval consists of Lisburne Group carbonates.

CONCLUSIONS

Palynological analysis of the Texaco Colville Delta No. 1/1A well provides the following generalized palynostratigraphic succession:

- Tertiary (Paleocene and probable Eocene) strata are present from 390 feet to 2010 feet. These strata lack an indigenous marine palynomorph component.

- Late Cretaceous strata occur between 2010 feet and 4890 feet. The marine palynomorphs begin to form a significant part of the assemblages below 2100 feet.

- Early Cretaceous (Albian) strata occur between 4890 feet and 5850 feet.

- Early Cretaceous (Barremian - Early Albian) strata occur between 5850 feet and 5940 feet.

- Early Cretaceous (Neocomian) strata occur from 5940 feet to 6150 feet.

- Jurassic strata occur from 6150 feet to 7650 feet.

- Late Triassic (Norian) strata are identified between 7650 feet and 7880C feet.

- Early Triassic strata are present between 7880C feet and 8580 feet. The nonmarine components become dominant and remain so through the Permian.

- Permian to Early Triassic strata occur from 8580 feet to 8760 feet.

- The bottom interval from 8760 feet to the total depth of 9457 feet is of indeterminate age.

KEROGEN MATURATION REPORT

Interpreted by:

Hideyo Haga

KEROGEN MATURATION
(T.A.I. - VITRINITE REFLECTANCE)

Maturation levels of kerogen residues from the Texaco Colville Delta No. 1/ 1A well were determined by visual methods, Thermal Alteration Index (T.A.I.) and by Vitrinite Reflectance (V.R.) measurements. A chart correlating the measurement techniques and their relationship to hydrocarbon generation is given in Figure 1.

Thermal Alteration Index

Thirty-six (36) T.A.I. samples were prepared and analyzed. The sample spacing is at about 200 foot intervals.

The T.A.I. and percentage estimates for the major organic constituents are presented in Table I. The organic classification used here is very generalized, but can be referred to the following categories:

■	Amorphous	=	Alginite	=	Type I
■	Herbaceous	=	Exinite	=	Type II
■	Woody	=	Vitrinite	=	Type III
■	Fusinitic	=	Inertnite	=	Type IV

The T.A.I. estimates suggest that the well is within the immature/mature transitional level for organic maturation down to about 6000 feet.

Between 6000 feet and about 7600 feet, the T.A.I. levels appear to be in the early stages of mature kerogen alteration. This interval encompasses the Neocomian and Jurassic age strata.

Below 7600 feet, the well enters the mature level of kerogen alteration.

The organic quality is dominantly woody-fusinitic down to 2500 feet. This represents the Tertiary to Campanian - Maestrichtian age units.

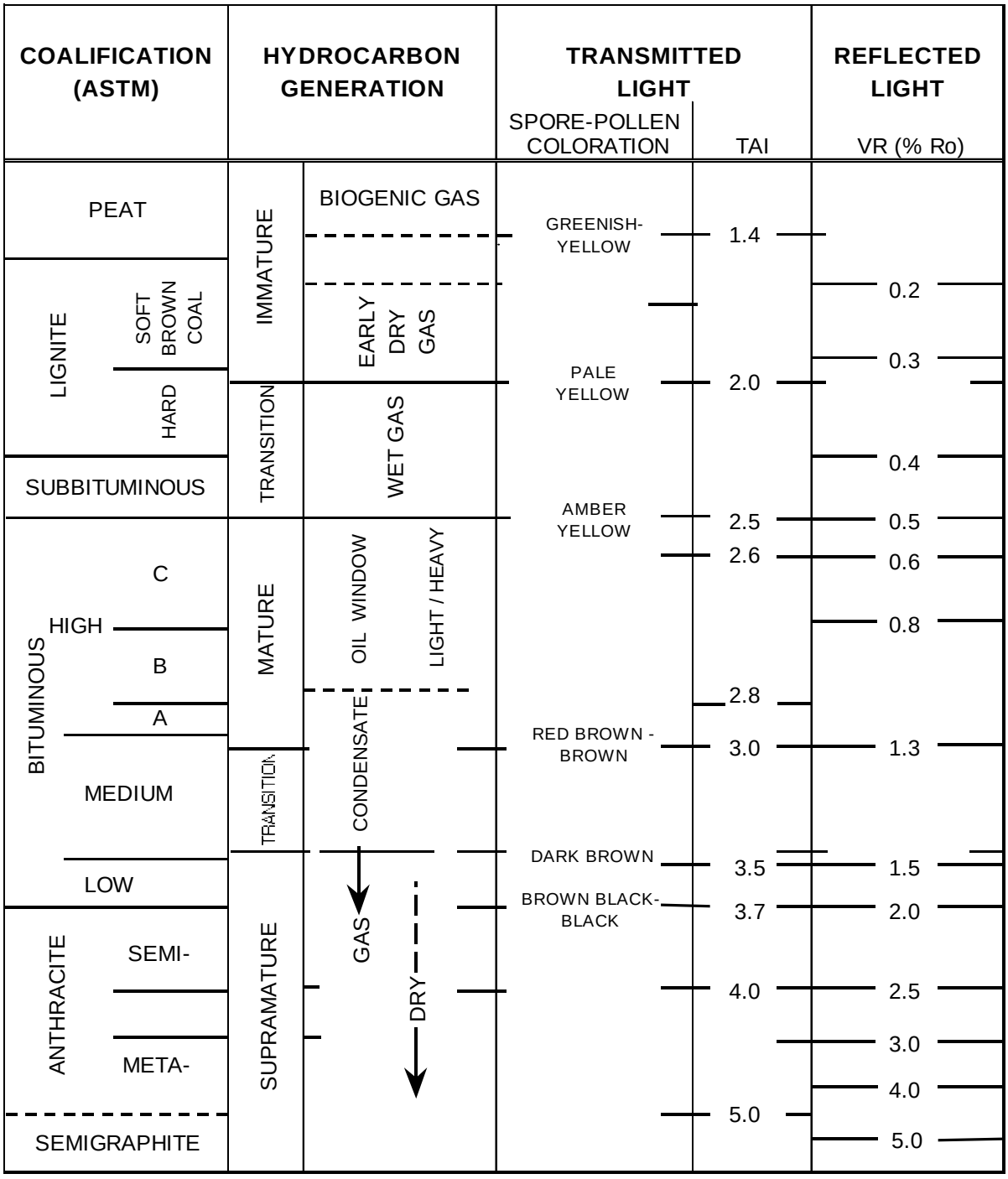


Figure 1. Correlation of Thermal Alteration Index (TAI) and Vitrinite Reflectance (VR) values to hydrocarbon generation. Modified from Heroux, Y., Chagnou, A. and Bertrand, R., (1979).

TEXACO COLVILLE DELTA #1/1A

	SAMPLE (Feet)	TAI	KEROGEN TYPES (% A	H	W-F	VR Avg Ro)	REMARKS
1	570-660	2.0-2.3		20	80?		Poorly preserv woody-fusinitic
2	930-1020	2.0-2.3		10	90	0.28	
3	1200-1290	2.0		10	90		
4	1470-1560	2.0-2.3		20	80	?	Poor VR plug
5	1740-1830	2.0		20	80		
6	2010-2100	2.0		30	70	0.31	
7	2280-2370	2.0-2.3	10?	40	50		
8	2550-2640	2.0	80	10	10		
9	2820-2910	2.0	70	10	20		
10	3090-3180	2.0-2.3	50	20	30	0.40?	Sparse vitrinite
11	3360-3450	2.0-2.3	40	20	40		
12	3630-3720	2.0-2.3	40	20	40	0.35	
13	3900-3990	2.0-2.3	70	10	20		
14	4170-4260	2.0-2.3	70	10	20	?	Insufficient vitrinite
15	4440-4530	2.0-2.3	70	10	20		
16	4710-4800	2.0-2.3	50	20	30	0.45?	Sparse vitrinite
17	4980-5070	2.0-2.3	60	10	30		
18	5250-5340	2.0-2.3	50	20	30	?	Insufficient vitrinite
19	5520-5610	2.3	60	10	30		
20	5730-5760	2.3	70	10	20	?	Insufficient vitrinite
21	5910-5940	2.3	60	20	20		
22	6180-6210	2.3-2.5	50	30	20		Much Cretaceous sloughing
23	6510-6600	2.3-2.5	50	40	10		Much Cretaceous sloughing
24	6780-6870	2.3-2.5	40	30	30		Much Cretaceous sloughing
25	7050-7140	2.5	50	30	20		Much Cretaceous sloughing
26	7320-7410	2.3-2.5	70	20	10		Much Cretaceous sloughing
27	7590-7680	2.5-3.0	60	10	30		Much Cretaceous sloughing
28	7860-7950	2.5-3.0	70	10	20	?	Insufficient vitrinite
29	7880-7940C	2.5-3.0	10	50	40	0.85?	Very sparse vitrinite
30	8130-8220	2.5-2.8	60	10	30		
31	8400-8490	2.5-3.0	70	10	20		
32	8670-8760	2.5-3.0		10	90		
33	8718-8750C	2.8-3.0	20	T	80	1.33	
34	8940-9030	2.5-3.0	T	20	80	0.83	Large deviation
35	9210-9300	2.5-3.0	T	20	80		
36	9390-9457TD	2.5-3.0	10	30	60	1.20	

A = amorphous, H = herbaceous (includes palynomorphs), W-F = woody-fusinitic, T = trace

TABLE 1 Thermal Alteration Index (TAI), percent of kerogen types, and Vitrinite Reflectance (VR).

Oil prone organic material dominates below 2500 feet and continues as the dominant constituents at least down to the base of the core sample 7940 feet. This interval includes Santonian - Campanian down to through Late Triassic strata. The ditch samples from the Early Triassic, below this core, probably contain much sloughed material.

The Permian - Early Triassic strata is dominated by woody-fusinitic or gas prone organics.

Vitrinite Reflectance

Nine (9) samples were used for V.R. measurements. The samples between 2500 feet and 8500 feet produced relatively sparse vitrinite particles. Thus, some of the samples within this interval produced only questionable results.

The V.R. values and the histogram plots for the measured samples are given in the Appendix. The average V.R. values are listed in Table I. Figure 2 displays the depth verses average reflectance values on a semi-log plot. The best fit line is also shown on this plot.

The V.R. averages suggest that the well enters the mature level of organic alteration below 5000 feet. There is a large interval where no V.R. data are available and the actual depth at which mature conditions are reached is probably closer to 6000 feet or 7000 feet, as indicated by the T.A.I. Therefore, the mature levels probably encompasses Neocomian to Late Triassic age strata.

The samples from the Permian and older section suggest overmature conditions in those strata.

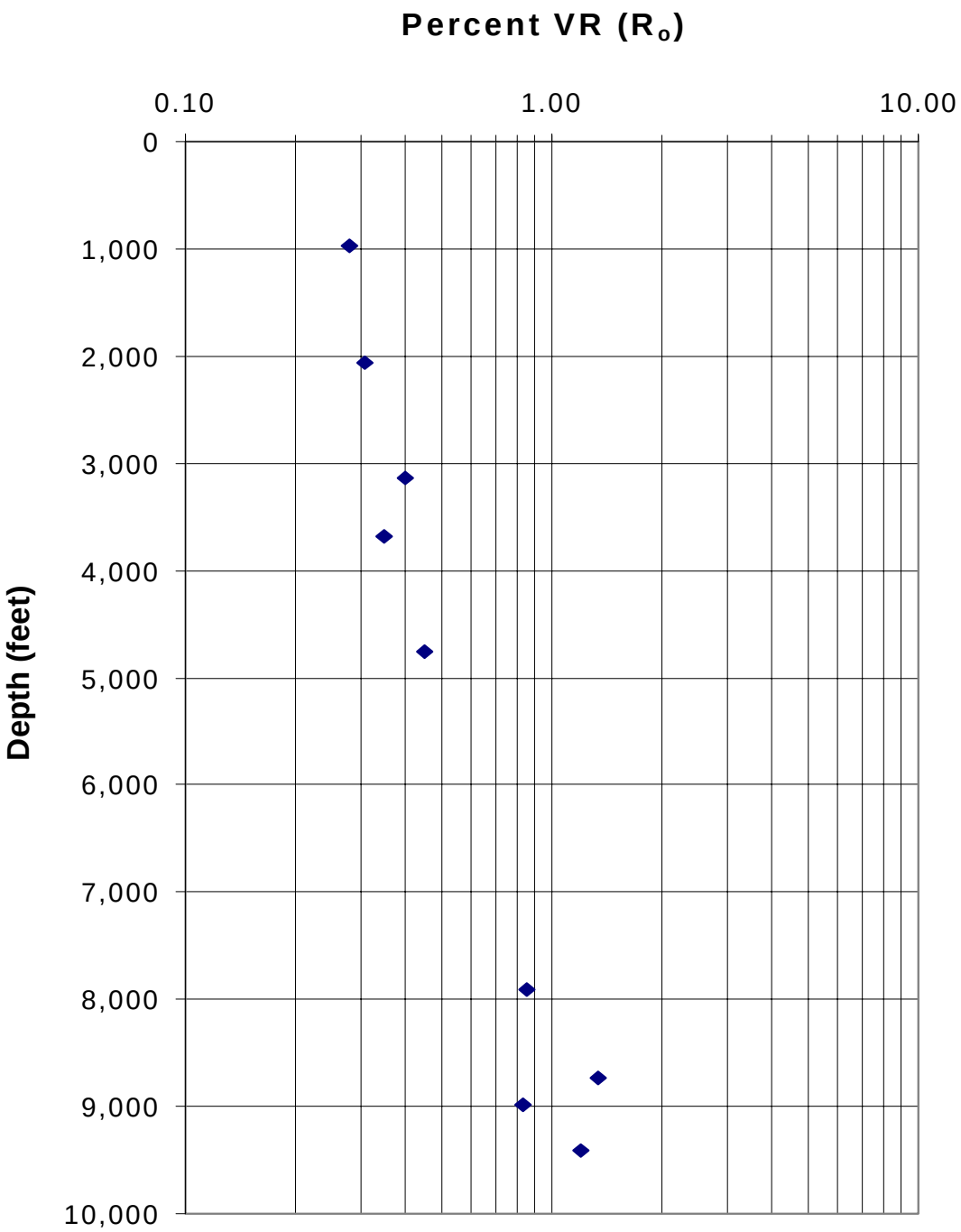


Figure 2. Plot of average R_o (%) verses depth, TEXACO Colville Delta No. 1/1A well.

REFERENCE

Heroux, Y., Chagnou, A. and Bertrand, R., 1979. Compilation and correlation of major thermal maturation indicators: Bull. Am. Assoc. Petr. Geol., 63: pp. 2128-2144.

APPENDIX

VITRINITE REFLECTANCE DATA

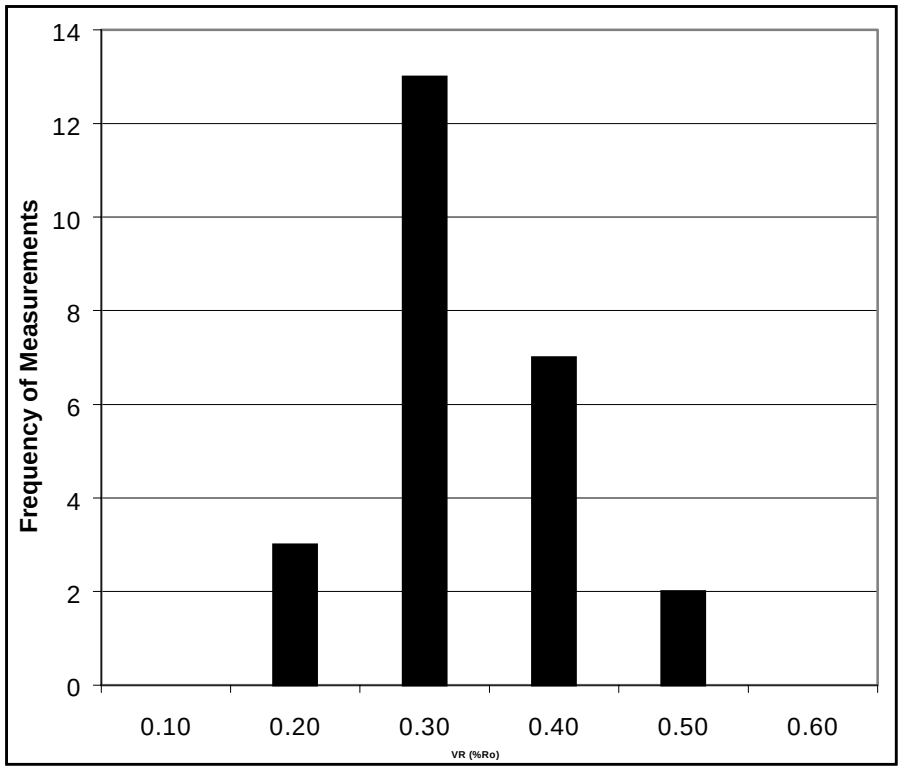
TEXACO COLVILLE DELTA #1/1A

Sample Depth: 930-1020' Ditch

VR Measurements:

0.17	0.24	0.35			
0.19	0.25	0.35			
0.20	0.26	0.40			
0.21	0.26	0.41			
0.21	0.28	0.41			
0.22	0.30				
0.23	0.31				
0.23	0.31				
0.24	0.31				
0.24	0.32				

Number of meas:	25	**Median:**	0.26
Average:	0.28	**Stand. Dev:**	0.07



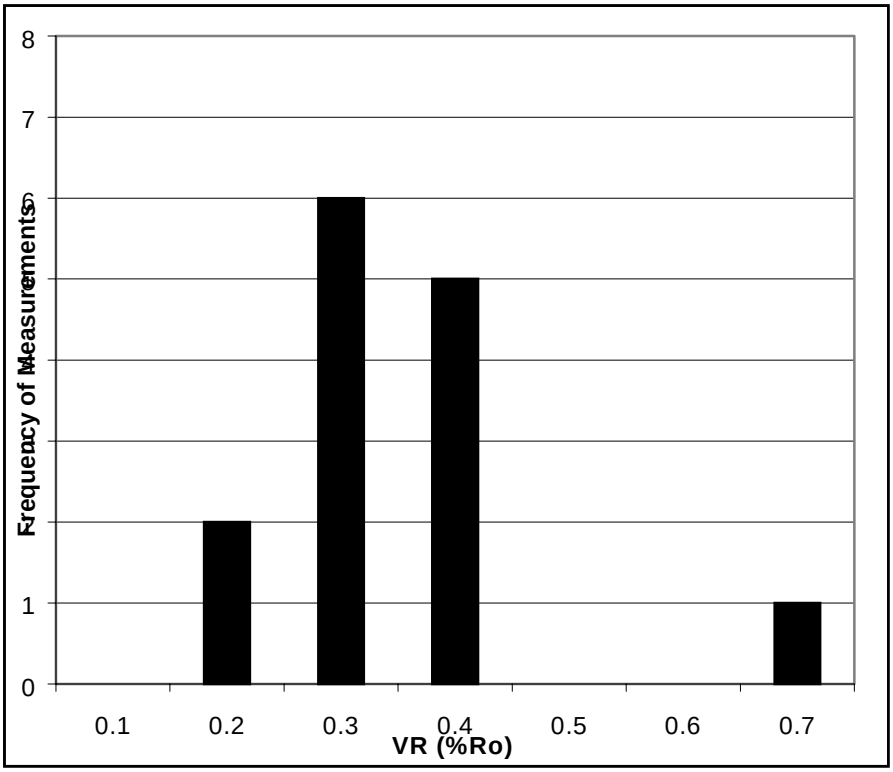
TEXACO COLVILLE DELTA #1/1A

Sample Depth: 2010-2100' Ditch

VR Measurements:

0.20	0.33				
0.20	0.37				
0.23	0.39				
0.25	0.65				
0.26					
0.27					
0.28					
0.30					
0.32					
0.33					

Number of meas:	14	**Median:**	0.29
Average:	0.31	**Stand. Dev:**	0.11



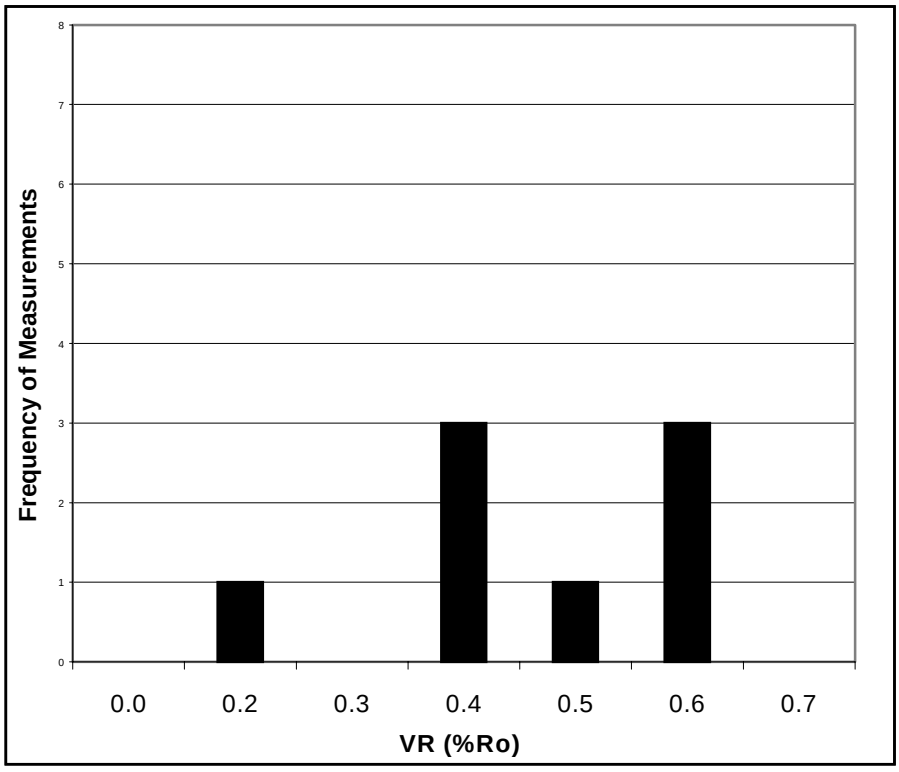
TEXACO COLVILLE DELTA #1/1A

Sample Depth: 2530-2800' Ditch

VR Measurements:

0.17					
0.28					
0.34					
0.34					
0.47					
0.50					
0.53					
0.57					

Number of meas:	8	**Median:**	0.41
Average:	0.40	**Stand. Dev:**	0.14



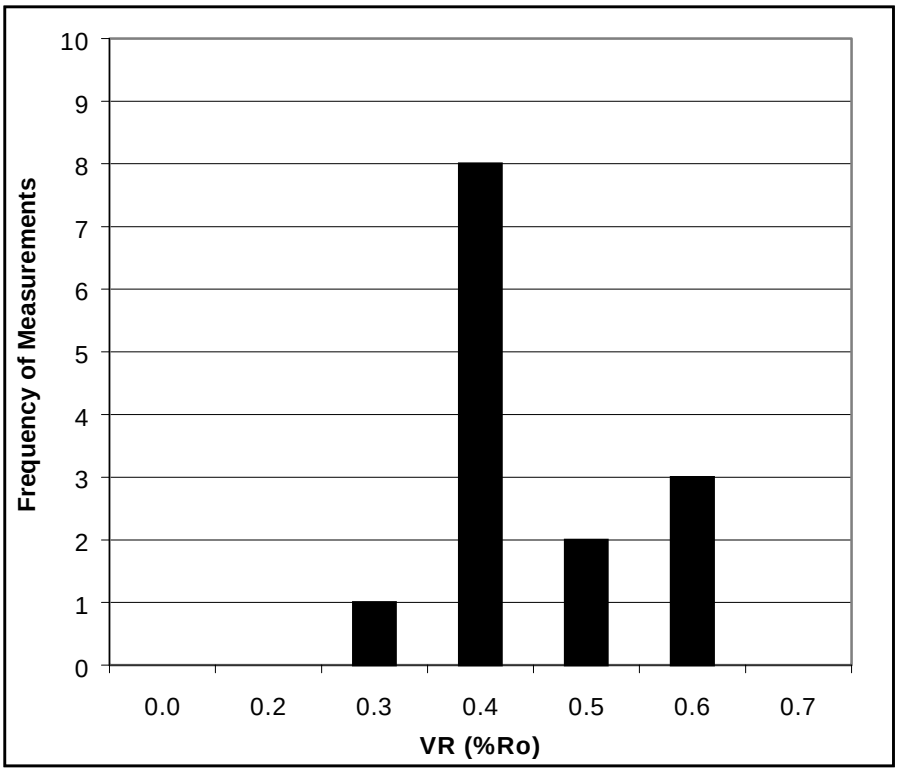
TEXACO COLVILLE DELTA #1/1A

Sample Depth: 3630-3720' Ditch

VR Measurements:

0.25	0.39				
0.26	0.46				
0.26	0.53				
0.26	0.53				
0.27					
0.31					
0.31					
0.34					
0.35					
0.38					

Number of meas:	14	**Median:**	0.33
Average:	0.35	**Stand. Dev:**	0.10



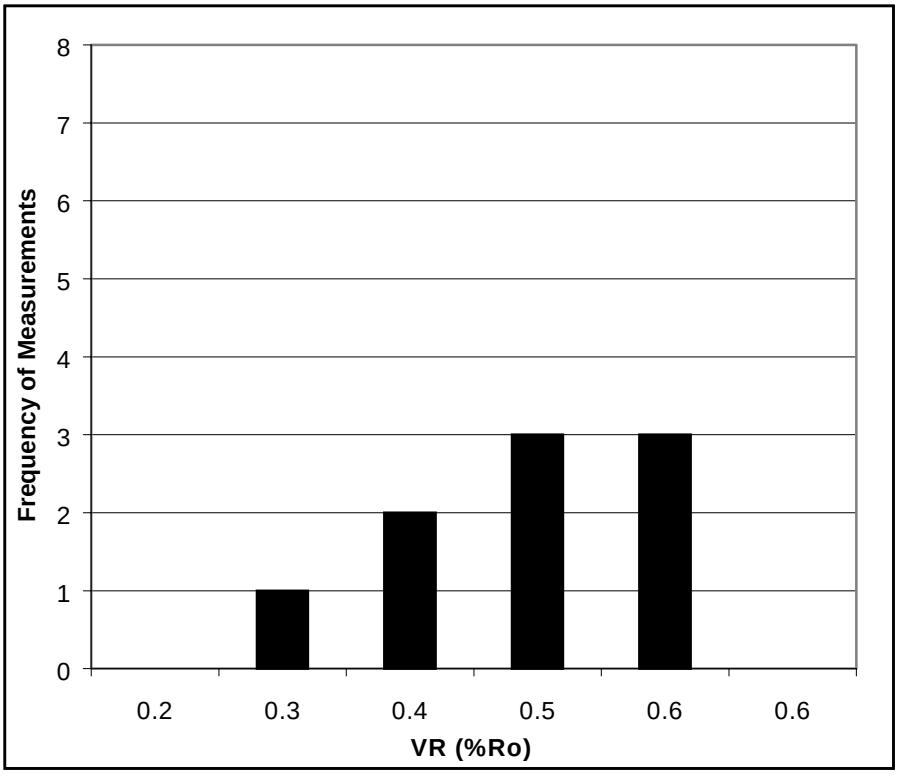
TEXACO COLVILLE DELTA #1/1A

Sample Depth: 4710-4800' Ditch

VR Measurements:

0.31					
0.33					
0.34					
0.45					
0.50					
0.51					
0.52					
0.53					
0.56					

Number of meas:	9	**Median:**	0.50
Average:	0.45	**Stand. Dev:**	0.10



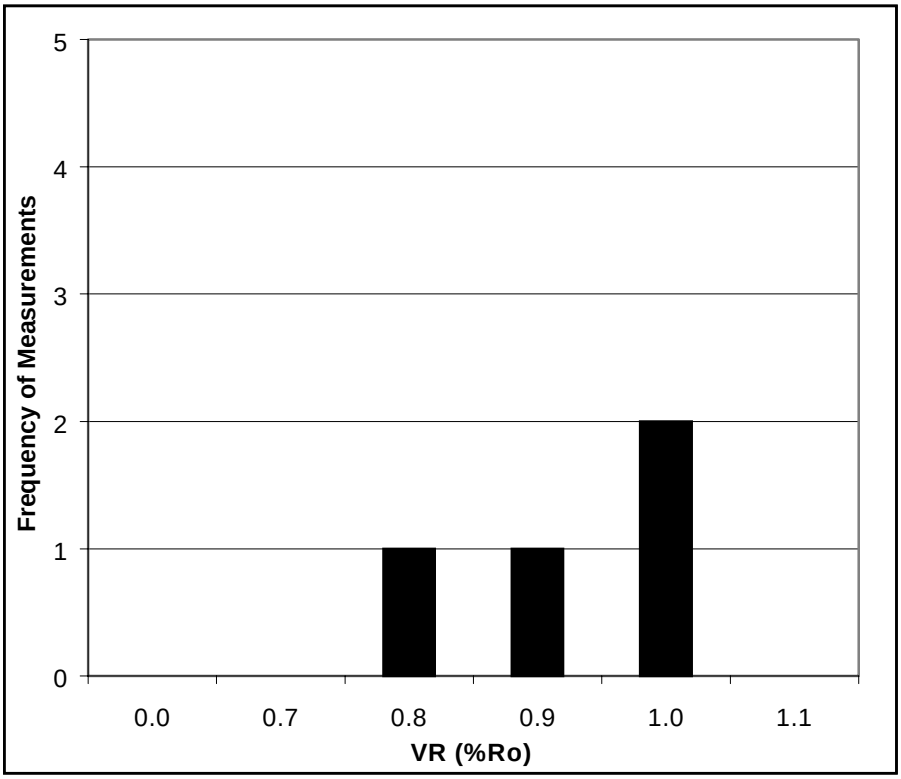
TEXACO COLVILLE DELTA #1/1A

Sample Depth: 7880-7940' Core

VR Measurements:

0.76 0.77 0.91 0.95					

Number of meas:	4	**Median:**	0.84
Average:	0.85	**Stand. Dev:**	0.10



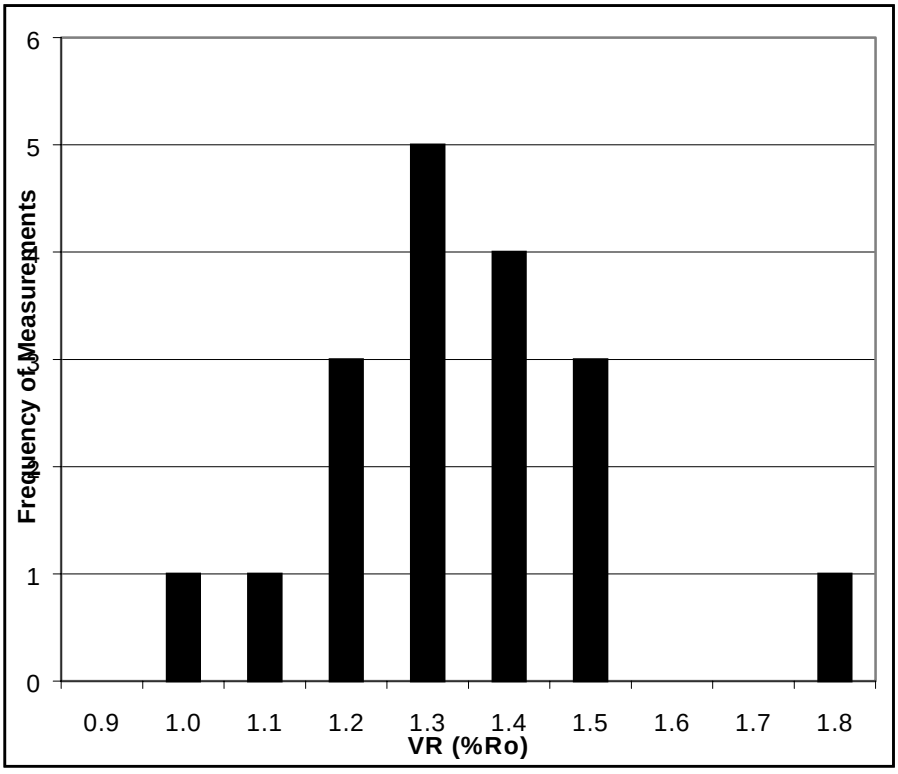
TEXACO COLVILLE DELTA #1/1A

Sample Depth: 8718-8750' Core

VR Measurements:

1.03	1.35				
1.05	1.42				
1.16	1.42				
1.17	1.43				
1.18	1.50				
1.25	1.51				
1.25	1.52				
1.25	1.77				
1.27					
1.32					

Number of meas:	18	**Median:**	1.30
Average:	1.33	**Stand. Dev:**	0.19



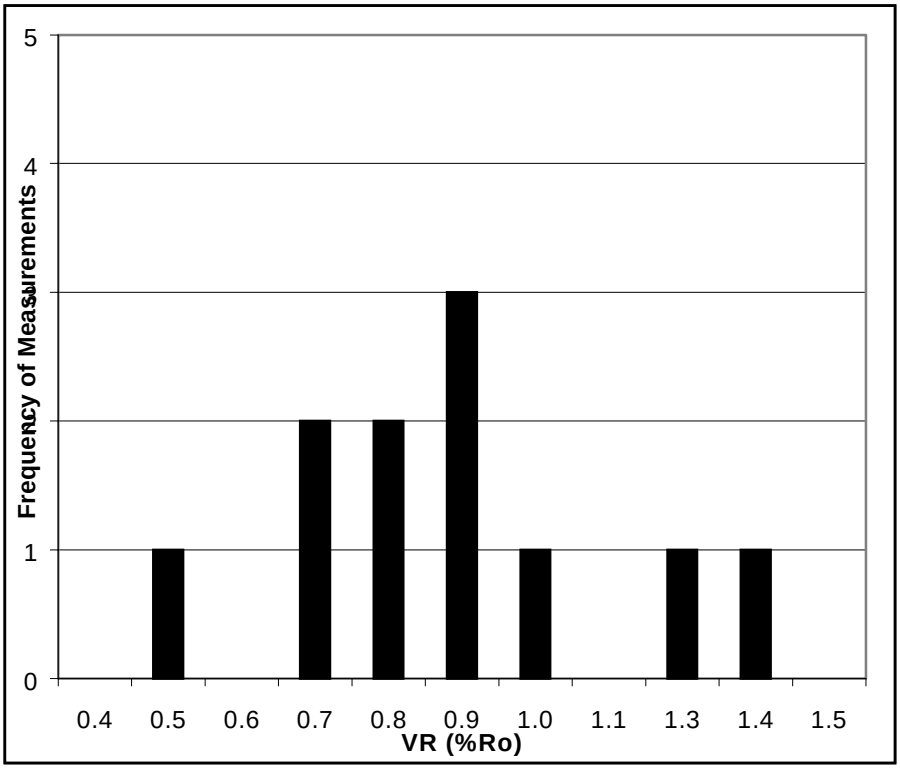
TEXACO COLVILLE DELTA #1/1A

Sample Depth: 8940-9030' Ditch

VR Measurements:

0.47	1.31				
0.60					
0.63					
0.69					
0.70					
0.79					
0.86					
0.86					
0.96					
1.22					

Number of meas:	11	**Median:**	0.79
Average:	0.83	**Stand. Dev:**	0.26



TEXACO COLVILLE DELTA #1/1A

Sample Depth: 9390-9475' T.D.

VR Measurements:

1.02					
1.03					
1.07					
1.10					
1.15					
1.21					
1.30					
1.32					
1.40					
1.41					

Number of meas:	10	**Median:**	1.18
Average:	1.20	**Stand. Dev:**	0.15