



**BioStratigraphics**  
**Consulting Micropaleontology**

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ARCO

NORTH ALEUTIAN SHELF COST NO. 1

JOB #05820107

SILICEOUS MICROFOSSIL REPORT

Received  
DISTRICT  
OIL AND GAS OFFICE

FEB 15 1988

Minerals Management Service  
Alaska

Interpreted by:

Stanley A. Kling

Biostratigrapher Consultant



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January 26, 1983

ARCO Exploration Company  
P.O. Box 360  
Anchorage, Alaska 99510

ATTENTION: Mr. David M. Hite

SUBJECT: Siliceous Microfossil Report - ARCO North  
Aleutian Shelf C.O.S.T. No. 1, Bering Sea,  
Alaska


Submitted here is the Siliceous Microfossil Report  
for the ARCO North Aleutian Shelf C.O.S.T. No. 1 well.

The samples were processed and examined by BioStrat-  
igraphics, San Diego, California. The resultant analysis  
was based on the study of recovered radiolarians.

Please call us if you wish to discuss further any of  
our results.

Sincerely,

  
Stanley A. Kling  
Biostratigrapher Consultant

  
A.D. Warren  
Senior Biostratigrapher  
Manager

SAK:ADW/jam

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## SUMMARY

Indigenous siliceous microfossils are abundant and diverse in the North Aleutian Shelf C.O.S.T. No. 1 well down to about 5000 feet (possibly not in place below 4000 feet). These assemblages range in age from early Pleistocene at 1380 feet (the first sample) to late Miocene. The Pliocene-Pleistocene boundary is recognized 1545 feet and the Miocene-Pliocene boundary at 3210 feet.

From 5136 to 6720 feet sparse, low-diversity assemblages of possible Eocene to Oligocene age occur.

Sporadic occurrences of siliceous microfossils (usually pyritized) in the rest of the well are generally non-diagnostic. The only identifiable forms occur in the depth range of 8000 to 8500 feet where an Eocene to Oligocene age is suggested.

A listing of key biostratigraphic intervals follows:

### 1380-1545'

#### Age.

Early Pleistocene

Approximately Actinocyclus oculatus zone.

1545-2190'

Age.

Late Pliocene

Approximately Denticulopsis seminae  
v. fossilis zone.

2190-2550'

Age.

Late Pliocene

Approximately Denticulopsis seminae  
v. fossilis - D. kamschatica zone.

2550-3210'

Age.

Early Pliocene

Approximately Denticulopsis kamscha-  
tica zone, subzones b and c.

3210-5010'

Age.

Late Miocene

Approximately Denticulopsis kamscha-  
tica zone, subzone a.

5010-5136'

Age.

Indeterminate

Barren of siliceous microfossils.

5136-6720'

Age.

Possible Eocene-Oligocene

6720-8000'

Age.

Indeterminate

Barren of siliceous microfossils.

8000-8500'

Age.

Possible Eocene-Oligocene

8500-17,150'T.D.

Age.

Indeterminate

Barren of identifiable siliceous  
microfossils.

## INTRODUCTION

### Scope

BioStratigraphics prepared and analysed 175 ditch cutting samples, 152 sidewall cores, and 145 conventional core samples from the North Aleutian Shelf C.O.S.T. No. 1 well for siliceous microfossils (diatoms, silicoflagellates, ebridians, and archaeomonads). Ditch cutting samples were composited at 90-foot intervals.

### Procedures

Samples were disaggregated in water with hydrogen peroxide. The resulting material was then centrifuged in zinc bromide to separate the opaline silica (light fraction) from extraneous mineral debris (heavy fraction). Zinc bromide was washed from the light fraction with dilute hydrochloric acid and the acid washed out with water. The cleaned light fraction was finally short-centrifuged to eliminate the unwanted clay-size fraction. The final concentrate was mounted on glass slides for examination in transmitted light.

Ages are determined with reference primarily to the zonation of Koizumi as modified by Barron (1980). However, zone-defining species are often lacking in the North Aleutian Shelf samples, so secondary species, suggested by Barron (1980) and also derived from previous experience in the Bering Sea, have been used to estimate ages and zones. Zonal interpretations should, therefore, be treated with some caution. Datum levels that we consider useful for local (and often long-range) correlation are discussed in the Conclusions section.

#### Format

The complete data on siliceous microfossils are presented in distribution charts (Figs. 1 and 2) for ditch cuttings and sidewall cores. The results are compiled by biostratigraphic intervals in the Biostratigraphic Results section.

Short summary discussions of reworking and paleoenvironments follow and a Conclusions section completes the text of the report.

Results from core samples, most of which fall below the opaline silica-rich section are presented in an appendix.



Visual estimates of relative abundance of species are abbreviated as follows: Abundant (A), common (C), few (F), rare (R), and very rare (V).

### BIOSTRATIGRAPHIC RESULTS

Results are summarized here by intervals within which no significant change in age-diagnostic species was noted. The species cited are those on which the age determination is based.

Complete lists of all species identified in each sample can be found in the distribution charts for ditch cuttings (Fig. 1) and sidewall cores (Fig. 2).

#### 1380-1545'

<u>Age.</u>	early Pleistocene
<u>Zone.</u>	probable <u>Actinocyclus oculatus</u>
<u>Diatoms.</u>	Denticulopsis seminae v. fossilis, Rhizosolenia curvirostris, R. hebetata f. semispina, Thalassiosira gravida, T. g. fossilis, T. g. (flat form)
<u>Silico-flagellates</u> <u>Etc.</u>	Distephanus octonarius
<u>Remarks.</u>	Reworking of Eocene material is suggested by <u>Archaeomonas reticulosa</u> .

1545-2190'

Age. late Pliocene

Zone. Denticulopsis seminae var. fossilis

Diatoms. Coscinodiscus pustulatus, Denticulopsis seminae var. fossilis, Rhaphoneis sachalinensis, Stephanopyxis horridus, Thalassiosira zabelinae.

Silico-  
flagellates  
Etc. Ammodochium retangulare

Remarks. The top of this zone is based on the top of the range of Rhaphoneis sachalinensis which, according to previous experience in the area (E. D. Milow, personal communication) approximates the top of Thalassiosira antiqua.

2190-2550'

Age. late Pliocene

Zone. Denticulopsis seminae var. fossilis -  
D. kamtschatica

Diatoms. Coscinodiscus marginatus f. fossilis, Denticulopsis seminae v. fossilis, D. kamtschatica, Thalassiosira sp. aff. T. convexa, T. usatschevii.

Remarks. Within this interval, several early Pliocene species occur, listed here in order of normal highest occurrences: Cosmidiscus insignis, C. intersectus, Thalassiosira punctata, and Coscinodiscus temperei. According to the highest occurrence of the secondary early Pliocene form Bacteriosira fragilis var. (with large raised umbonal area) at the base of this interval, these represent reworking. But they could alternatively represent an unconformity at about 2370' representing most of the early

2190-2550' (Continued)

Pliocene (Denticulopsis kamtschatica zone, subzones b and c).

Reworked Miocene is indicated by Rhabdonema japonicum sparsicostatum and of Eocene by Archaeomonas reticulosa.

2550-3210'

Age. early Pliocene

Zone. approximately Denticulopsis kamtschatica

Subzone. approximately b and c

Diatoms. Bacteriosira fragilis var.

Remarks. Past experience in the area (E.D. Milow, personal communication) indicates that a large variety of Bacteriosira fragilis with a large raised umbonal area has its highest occurrence near the top of the Denticulopsis kamtschatica Zone. No criteria for differentiating subzones b and c are available in this well.

Reworking of Eocene is indicated by Archaeosphaeridium spp. and Distephanus sp. cf. D. deflandrei.

3210-5010'

Age. late Miocene

Zone. Denticulopsis kamtschatica

Subzone. a or older

Diatoms. Stephanopyxis turris (thick-walled form), Triceratium condecorum, Actinoptychus biformis, Actinocyclus ingens, Stephanopyxis schenckii.

Silico-flagellates  
Etc. Dictyocha pseudofibula, Distephanus pseudocrux.

3210-5010' (Continued)

Remarks.

In other wells in the Bering Sea, a distinctive thick-walled form of Stephanopyxis turris has its highest occurrence near the Miocene-Pliocene boundary. Siliceous microfossils become less abundant toward the bottom of this interval without clear indication of older zones, and according to sidewall cores, may not be in place below about 4000 feet.

Reworking of early Miocene is indicated by Actinoptychus heliopelta, and of Eocene by Melosira architecturalis and Archaeosphaeridium spp.

5010-5136'

Age.

Indeterminate

Remarks.

Barren of siliceous microfossils.

5136-6720'

Age.

possible Eocene-Oligocene

Diatoms.

Stephanopyxis megapora?, S. turris (altered), S. turris v. intermedia.

Remarks.

In this interval, diatoms of Eocene-Oligocene aspect (often altered to crystalline silica) occur sporadically. If they are in place, their occurrences must be separated from the late Miocene above by an unconformity.

6720-8000'

Age. Indeterminate

Remarks. Barren of Siliceous Microfossils.

8000-8500'

Age. Eocene-Oligocene

Remarks. Isolated samples in this interval contain pyritized diatoms of general Eocene-Oligocene aspect, some of which can be identified as follows:

Core 7, 8073.9' - Actinoptychus sp. (R), Biddulphia sp. (R), Coscinodiscus sp. of C. obscurus (R), C. sp. cf. C. oligocenicus (R), Triceratium? sp. (V).

Sidewall Core 8461' - Biddulphia sp. (R), Coscinodiscus cf. oblongus (R), C. sp. (R).

Other occurrences of unidentified pyritized diatoms may be noted in the foraminiferal distribution charts.

8500-17,150' T.D.

Age. Indeterminate

Remarks. Isolated samples in this interval contain pyritized diatoms (see foraminiferal distributional charts), none of which could be identified. Well preserved specimens of the freshwater diatom Melosira granulata in the interval 16,890-17,150' are probably attributable to well-site or laboratory contamination.

## PALEOENVIRONMENTAL INTERPRETATION

The abundant and diverse siliceous microfossil assemblages in this upper 5000 feet of the North Aleutian Shelf C.O.S.T. No. 1 well are dominantly marine. The freshwater species Melosira granulata occurs throughout the well, but it is probably displaced by freshwater runoff or winds.

The upper part of the siliceous-fossiliferous interval, down to about 2500 feet, contains representatives of Sancetta's (1981) Assemblages 1 (coastal to middle shelf), Assemblage 3 (outer shelf) and Assemblage 4 (slope to deep water). The dominant forms belong to shelf assemblages with pelagic forms, particularly the genus Denticulopsis, present only in small numbers. A generally middle to outer shelf environment is suggested.

Below about 2500 feet species of Denticulopsis are no longer encountered and other shelf species are conspicuously less common. The typically coastal species Melosira sulcata and the freshwater species Melosira granulata are more common in this interval as well.

These changes indicate a significantly shallower, more inner shelf environment.

In summary, the siliceous microfossil assemblages indicate a shallowing trend with depth in the upper 5000 with a possible accelerated shallowing event at about 2500 feet.

#### REWORKING

Reworking is indicated in some samples in the North Aleutian Shelf C.O.S.T. No. 1 well by appearances of clearly established older species in younger assemblages. Such occurrences do not seem to show any consistent trend and they are indicated under "Remarks" in the "Biostratigraphic Results" section.

Species which may represent reworking but which may range into younger strata in the Bering Sea (e.g. Cestodiscus spp.) are included in the distribution charts pending clarification of their stratigraphic (and in some cases systematic) significance.

In one part of the section, a significant amount of reworking may be interpreted. At 2370 feet in what otherwise appears to be late Pliocene assemblages,

several early Pliocene species appear out of their normal sequence. These include Thalassiosira punctata, Coscinodiscus insignis and C. intersectus which are normally first encountered (downhole) in the middle part of the early Pliocene. Also included is Coscinodiscus temperei which normally occurs much earlier in the Pliocene near the Miocene-Pliocene boundary. Thus a significant episode of reworking may characterize the earliest to early late Pliocene. However, the termination of this proposed Pliocene reworking interval may alternatively (as discussed in the Biostratigraphic Results section) indicate an unconformity.

#### CONCLUSIONS

Siliceous microfossils are abundant in the upper 5000 feet of the North Aleutian Shelf COST No. 1 well. Where they occur they provide accurate geologic ages and some correlatable horizons.

The highest samples contain an early Pleistocene assemblage, and the sequence extends down into the late Miocene below which siliceous microfossils disappear. The Miocene-Pliocene boundary is interpreted to occur at about 3210 feet.



Attempts are made to identify formal diatom zones, but in many cases the zone-defining species and even secondary markers are lacking. However, for correlation purposes, horizons representing the highest ("top") or lowest ("bottom") stratigraphic occurrences of species should be considered, whether or not formal zones can be recognized. Some such events in the North Aleutian Shelf C.O.S.T. No. 1 well which have been recognized in other wells and outcrop samples in the Bering Sea are listed in below in order of increasing geologic age. Depths in this well are indicated with the type of sample abbreviated D for ditch and SWC for sidewall core.

1. Bottom of Rhizosolenia curvirostris (1545 ft., SWC)

NOTE: This event normally occurs just above the base of the Actinocyclus oculatus and is taken here, in conjunction with the top of Rhaphoneis sachalinensis which occurs in the ditch sample including 1545 ft., as the approximation of that boundary. (see below)

2. Top of Rhaphoneis sachalinensis (1470-1560 ft., D)

NOTE: This horizon is interpreted at the depth of the sidewall core at 1545 ft. where

the bottom of Rhizosolenia curvirostris occurs (see below). It approximates the top of Thalassiosira antiqua (E.D. Milow, personal communication) which defines the top of the Denticulopsis seminae v. fossilis zone and approximates the Pliocene-Pleistocene boundary.

3. Top of Thalassiosira zabelinae (1650 ft. D)
4. Top of Coscinodiscus pustulatus, top of Stephanopyxis horridus (1740 ft., D)
5. Top of Coscinodiscus marginatus, f. fossilis, top of Thalassiosira usatschevii (2190 ft., D)

NOTE: The top of D. kamtschatica defines the top of the D. seminae v. fossilis - D. kamtschatica zone.

6. Top of Thalassiosira punctata (2280 ft., D)

NOTE: This top seems to appear higher in the section than normally in this well (see discussions under Biostratigraphic Results and Reworking sections).

7. Top of Cosmiodiscus insignis, C. intersectus, and  
Coscinodiscus temperei (2370 ft., D)

NOTE: See Note above (6). The top of C.  
temperei normally occurs well below the  
tops of Cosmiodiscus spp.

8. Top of Bacteriosira fragilis var. (2550 ft., D)

NOTE: This top approximates the top of the  
Denticulopsis kantschatica zone (E.D.  
Milow, personal communication).

9. Top of Stephanopyxis turris (thick-walled form).

(3210 ft., D)

NOTE: This top approximates the top of the  
Miocene and of subzone a the Denticulop-  
sis kantschatica zone elsewhere in the  
Bering Sea.

## REFERENCES

- Barron, J.A., 1980. Lower Miocene to Quaternary diatom biostratigraphy of Leg 57, off northeastern Japan, Deep Sea Drilling Project. In: Honza, E. et al., Init. Repts. DSDP 57, Washington (U.S. Govt. Printing Office), 641-685.
- Sancetta, C., 1981. Diatoms as hydrographic tracers: example from Bering Sea sediments. *Science*, 211, 279-281.

APPENDIX  
CORE SAMPLES

The following conventional core samples were examined for siliceous microfossils. Most were barren, and results are listed here for the few fossiliferous samples.

Core 1: 3392.8'

<u>Age.</u>	late Miocene
<u>Zone.</u>	Probable Denticulopsis kamtschatica
<u>Subzone.</u>	Probable a
<u>Diatoms.</u>	Actinocyclus ehrenbergii (R), A. ochotensis (V), Actinoptychus biformis (R), A. bismarckii (R), A. splendens and vars. (R), A. undulatus (R), Arachnoidiscus? sp. (V), Coscinodiscus marginatus f. fossilis (R), C. nodulifer (V), C. oculus-iridis (R), C. radiatus (V), C. temperei (R), Cosmiodiscus insignis (R), Endictya oceanica (V), Melosira sulcata (R), M. granulata (R), Navicula spp. (V), Rhaphoneis amphiceros (V), R. sachalinensis (R), R. surirella (R), Stephanopyxis appendiculata (R), S. dimorpha and vars. (R), S. turris (thick-walled) (R), S. schenckii (V), Triceratium condecorum (R).
<u>Silico- flatellates. Etc.</u>	Ebriopsis antiqua (saccate) (R).

Core 2: 4195.5'

Age. Probable late Miocene

Zone. Indeterminate

Diatoms. Coscinodiscus marginatus f. fossilis (R), C. radiatus (V), Melosira sulcata (R), Raphoneis sp. cf. R. fossilis (R), Stephanopyxis appendiculata (R), Thalassionema nitzschioides (R).

Core 2: 4198.2', 4199.3', 4199.4', - barren except for sporadic altered specimens.

Core 3: 5228.9', 5229.4', 5230.3', 5231.8', 5235.2', 5235.7', 5238.3', 5241.0', 5242.1', 5245.1' - barren except for occasional fragments which are probably contaminants.

Core 4: 5971.5', 5972.6', 5974.3', 5976.8', 5979.9', 5982.4', 5985.6', 5987.7', 5991.6', 5995.5' - barren except for occasional fragments which are probably contaminants.

Core 5: 6666.5', 6667.1' - barren.

Core 6: 8047.1' - barren.

Core 7: 8056.3', 8060.4', 8063.4', 8065.8', 8066.8', 8069.9', 8073.9' (see "Biostratigraphic Results"), 8077.7', 8079.1', 8080.7', 8083.8', 8084.5', 8087.9', 8091.8', 8092.5' - barren except for sporadic pyritized specimens.

Core 8: 8632.4', 8636.2', 8637.8', 8641.7', 8645.3', 8646.7', 8649.5', 8653.4', 8654.1', 8655.8' - barren.

- Core 9: 9255.4', 9257.6', 9262', 9264.1' - barren.
- Core 10: 9945.6', 9948.8', 9949.5', 9952', 9954.3',  
9956.6', 9962.3', 9963.8', 9965.5',  
9969.3', 9971.5', 9974.4', 9976.8',  
9976.9', 9978.1', 9981.3', 9982.2',  
9983.6' - barren except for sporadic  
altered (silica) and pyritized spec-  
imens.
- Core 11: 10,326', 10,327.4', 10,328.9', 10,330.3',  
10,334.7' - barren.
- Core 12: 10,731.2', 10,734', 10,735.8', 10,737',  
10,738.9', 10,739.5' - barren.
- Core 13: 11,085.0', 11,089.4', 11,093.7', 11,098.1',  
11,098.5', 11,100.7', 11,102.4',  
11,103.4', 11,109.4' - barren.
- Core 14: 12,249.0', 12,251.1', 12,253.1', 12,255.8',  
12,259.3', 12,260.8', 12,262.3',  
12,262.6', 12,264.3', 12,265.1',  
12,268.4', 12,269.4', 12,269.7' -  
barren of indigenous forms.
- Core 15: 12,630.4', 12,632.1', 12,633.2', 12,635.3',  
12,637.5' - barren.
- Core 16: 14,167.9', 14,169.1', 14,177', 14,179.7',  
14,183.4' - barren.
- Core 17: 15,347.7', 15,349.6', 15,349.9', 15,354.5',  
15,358.8', 15,364.9', 15,366.1',  
15,367.1', 15,368.4' - barren.
- Core 18: 16,006.8', 16,009.2', 16,011.9', 16,017.5',  
16,020.7', 16,023.0', 16,025.3',  
16,026.9', 16,029.0' - barren.

Core 19: 16,701.2', 16,703.7', 16,705.2', 16,707.5',  
16,714.6', 16,717.9', 16,719.6',  
16,716.2' - barren except for the  
freshwater diatom Melosira granulata  
which is probably attributable to  
well-site or laboratory contamina-  
tion.





