AN ABSTRACT OF THE THESIS OF

Chiye Wenkam for the degree of Master of Science

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Title: LATE QUATERNARY CHANGES IN THE OCEANOGRAPHY OF THE EASTERN TROPICAL PACIFIC

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Jorn Thiede

Factor analysis of radiolarian species from the tops of 34 gravity cores in the area extending from 5°N to 45°N, 95°W to 155°W, yields five factor assemblages which are related to the present surface circulation: 1) a Pacific Equatorial Water assemblage; 2) a California Current assemblage; 3) a North Equatorial Current assemblage; 4) a Tropical Surface Water assemblage; 5) an oxygen minimum layer assemblage. A sixth assemblage appears to be the result of dissolution. The variation of these factors through the late Pleistocene is based on the analysis of samples from two cores. Transfer functions which relate core top assemblages to temperature at the sea surface and at 130 m depth were used to determine paleotemperatures. Stratigraphic control was provided by oxygen isotope analysis of planktonic foraminifera from one core. Synchronous levels in the other core were determined from biostratigraphic correlation of the variations in the abundance of three species of radiolaria between cores. A reconstruction of the paleoceanography based on the results of the above analyses indicates that during the last glacial maximum (18,000 yrs BP): 1) sea surface temperatures were slightly lower than today; 2) the areal

extent of warm Pacific Equatorial water and Tropical Surface water was diminished; 3) the California Current, North Equatorial Current, and the Equatorial Current were stronger than at present; 4) there was an increase in the thermal gradient in the thermocline and/or an increase in the depth of the mixed layer; 5) air and sea surface circulation patterns were constricted and experienced minimal north-south oscillation.

# Late Quaternary Changes in the Oceanography of the Eastern Tropical Pacific

by

Chiye Wenkam

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There is something fascinating about science. One gets such wholesale returns of conjecture out of such a trifling investment of facts.

Mark Twain

# LATE QUATERNARY CHANGES IN THE OCEANOGRAPHY OF THE EASTERN TROPICAL PACIFIC

## INTRODUCTION

In this study an attempt is made to model the oceanography of the eastern tropical North Pacific during the last 75,000 years by determining what changes, if any, occurred in sea surface and subsurface temperatures and in surface water circulation. From these parameters changes in upwelling, productivity and tropospheric circulation are inferred.

The oceanography of the eastern tropical North Pacific and its relationship with the overlying atmospheric circulation is strongly related to the climate of adjacent land regions (for example, Pyke, 1972). Changes in the air and sea circulation can be correlated with changes in the land climate and, in order to understand causal relationships between these changes, it is important to determine the oceanographic conditions that prevailed during times of vastly different land climates, for example, periods of severe cooling and large continental ice accumulations.

Numerous studies have demonstrated that oceanographic changes are recorded on the sea floor by variations in microfossil assemblages. Interpretation of the sediment record in the Pacific has led to the following general conclusions about oceanographic conditions during Pleistocene glacial epochs. Arrhenius (1952) concluded on the basis of increased abundance of foraminifers and coccoliths that there was higher productivity in the Equatorial Pacific and therefore that there was increased upwelling and intensified circulation. Dinkelman (1973) and Molina-Cruz (1975) determined, on the basis of changes in radiolarian faunas, that the Peru Current was intensified due to stronger SE trade winds. Luz (1973) studied changes in foraminiferal faunas and concluded that there was intensified surface circulation in the equatorial and tropical southeast Pacific. Using radiolarian faunas in the North Pacific, Nigrini (1970), Sachs (1975), Moore (1973b) and Johnson and Knoll (1974) have shown that surface water isotherms were shifted toward the equator. The work of Sachs (1973b, 1975) and Moore (1973) also suggest an areal increase in the arctic and temperate surface water masses.

Paleoceanographic investigations of the North Pacific based on faunal analyses are limited to areas where productivity of calcium carbonate and siliceous microfossils in the surface waters is high enough to overcome the effects of dissolution. Analysis of calcium carbonate microfossils is thus restricted to isolated highs where the water is shallow enough to retard dissolution. Because the water depth of most of the North Pacific is greater than 4000 meters and below the calcium carbonate compensation depth, siliceous remains are the most useful. Still, dissolution and general low productivity have restricted studies to basin margins.

To obtain estimates of ancient sea surface and subsurface temperatures, the mathematical method of Imbrie and Kipp (1971), using Q-mode factor analysis and regression analysis is applied to radiolarian faunas. The radiolarian assemblages determined by the factor analysis and interpreted in terms of present-day physical oceanography, can then be used to infer changes in the surface circulation through time as these assemblages vary at a specific location.

# REGIONAL OCEANOGRAPHIC SETTING

This study is concerned with the oceanography of the area from 5°N to 45°N, 95°W to 155°W. The surface water masses in this region are shown in Figure 1. Boundaries and water characteristics have been synthesized from data and figures in Sverdrup and others (1941), Muromtsev (1958) and Wyrtki (1966a,b). The wide range of evaporation, precipitation and land runoff in the North Pacific gives rise to a variety of surface waters whose characteristics are present to depths of 50 to 200 m, dependent on the extent of seasonal mixing and heat exchange with the atmosphere.

The characteristics of subarctic Pacific water (4-9°C, 33.5-34.4 o/oo) are strongly influenced by low insolation and abundant load runoff. Eastern North Pacific Central Water (10-25°C, 34.0-34.5 o/oo) derives its characteristics from higher insolation and evaporation. Warm, Equatorial Surface Water ( >25°C, >34.5 o/oo) results from high insolation. The high precipitation over its latitudinal range somewhat offsets the tendency toward higher salinities produced by evaporation. From 4°N to 15°N, and from the coast of Central America out to 125°W, there is the thin layer of warm, low salinity Tropical Surface Water. The excess of rainfall over evaporation in this region creates salinities generally lower than 34.0 o/oo.

The transition region contains California Current (CC) water and subtropical surface water. The great range of temperature and salinity in these waters is produced by seasonal changes in the circulation of the eastern North Pacific. Figures 2a and 2b show winter-spring and

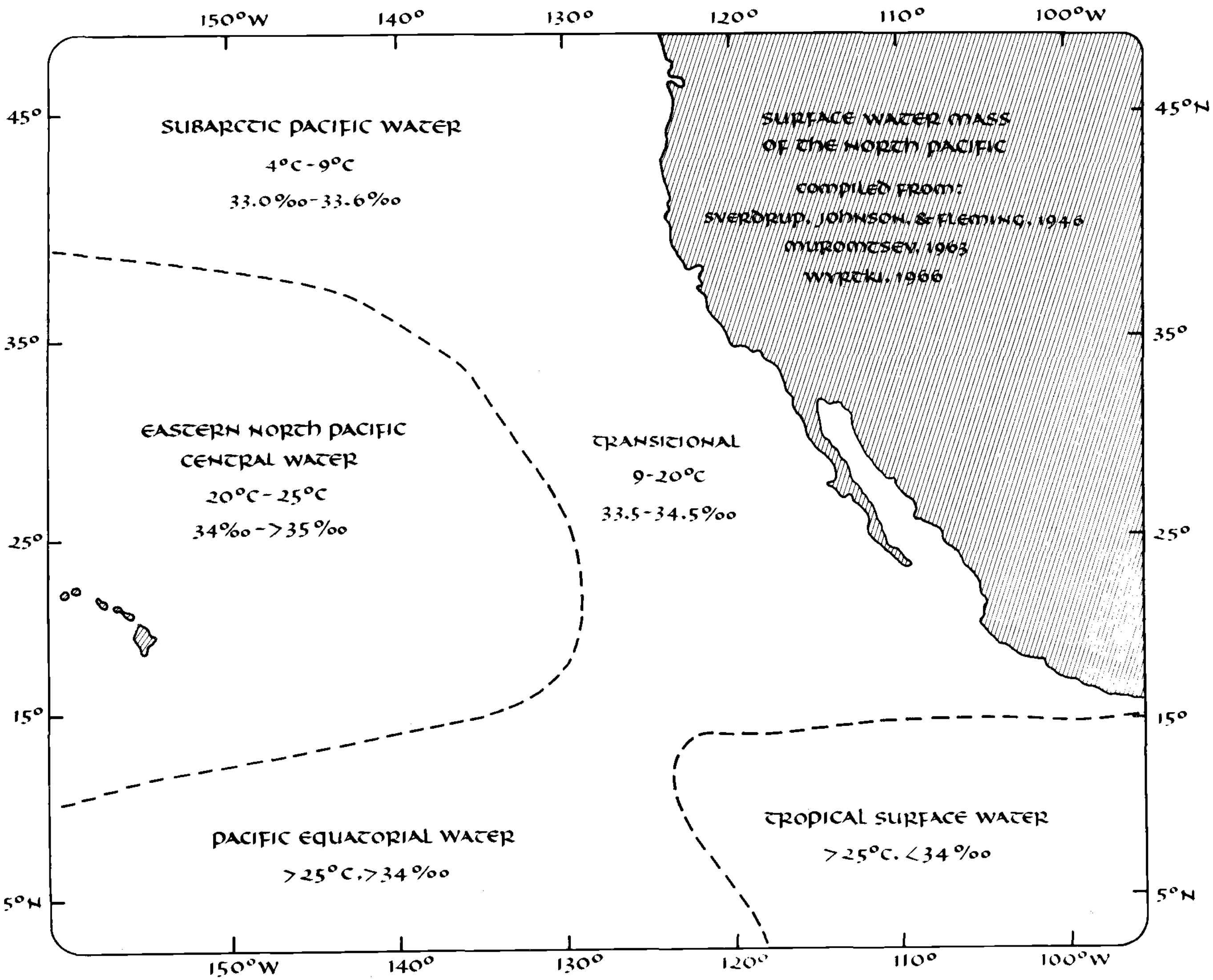



Figure 1. Surface water masses of the eastern North Pacific. Drawn from data of Sverdrup and others (1941), Muromtsev (1958), and Wyrtki (1966).

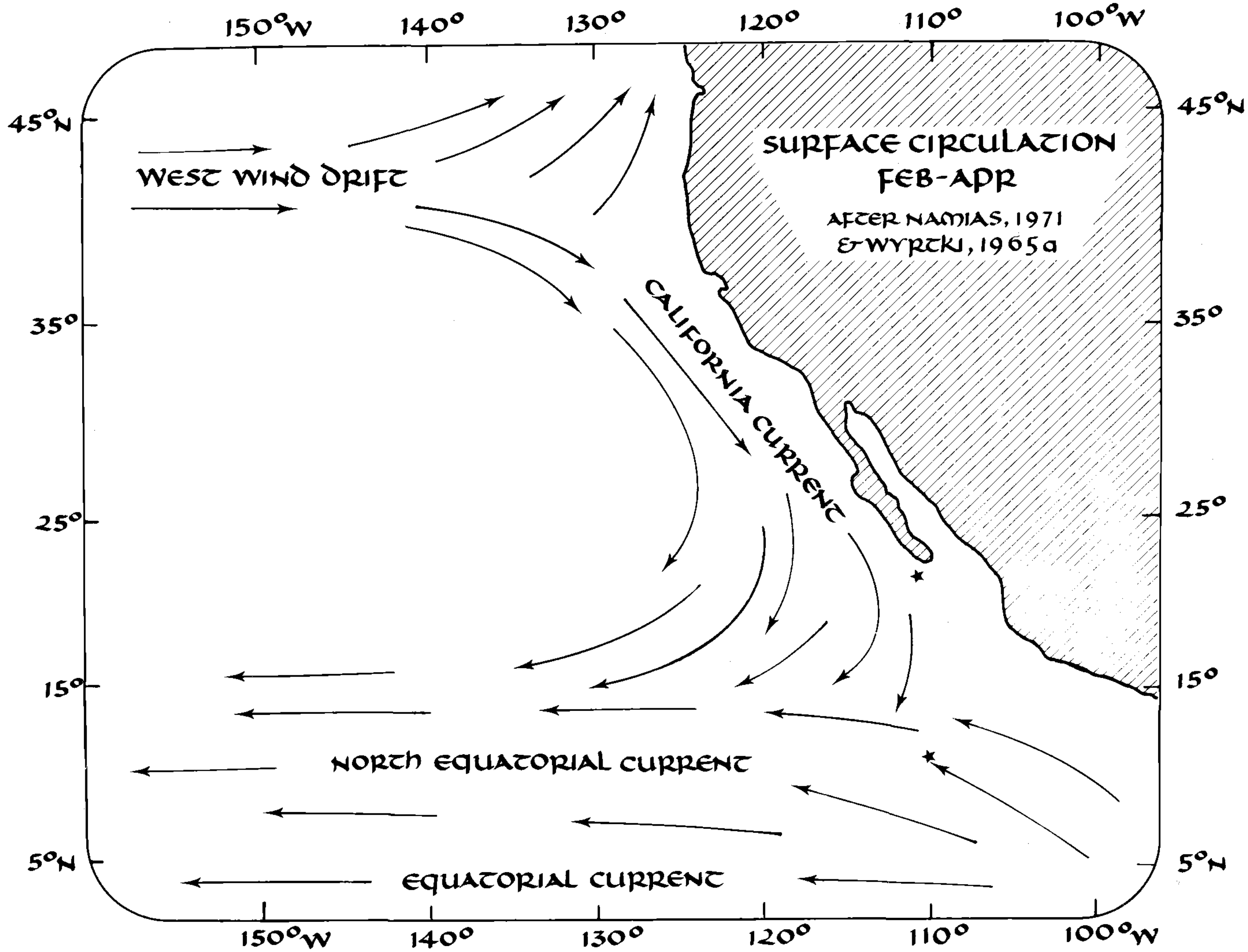



Figure 2a. Surface currents of the eastern North Pacific from February through April. Arrows show current directions, stars show sites of downcore studies.

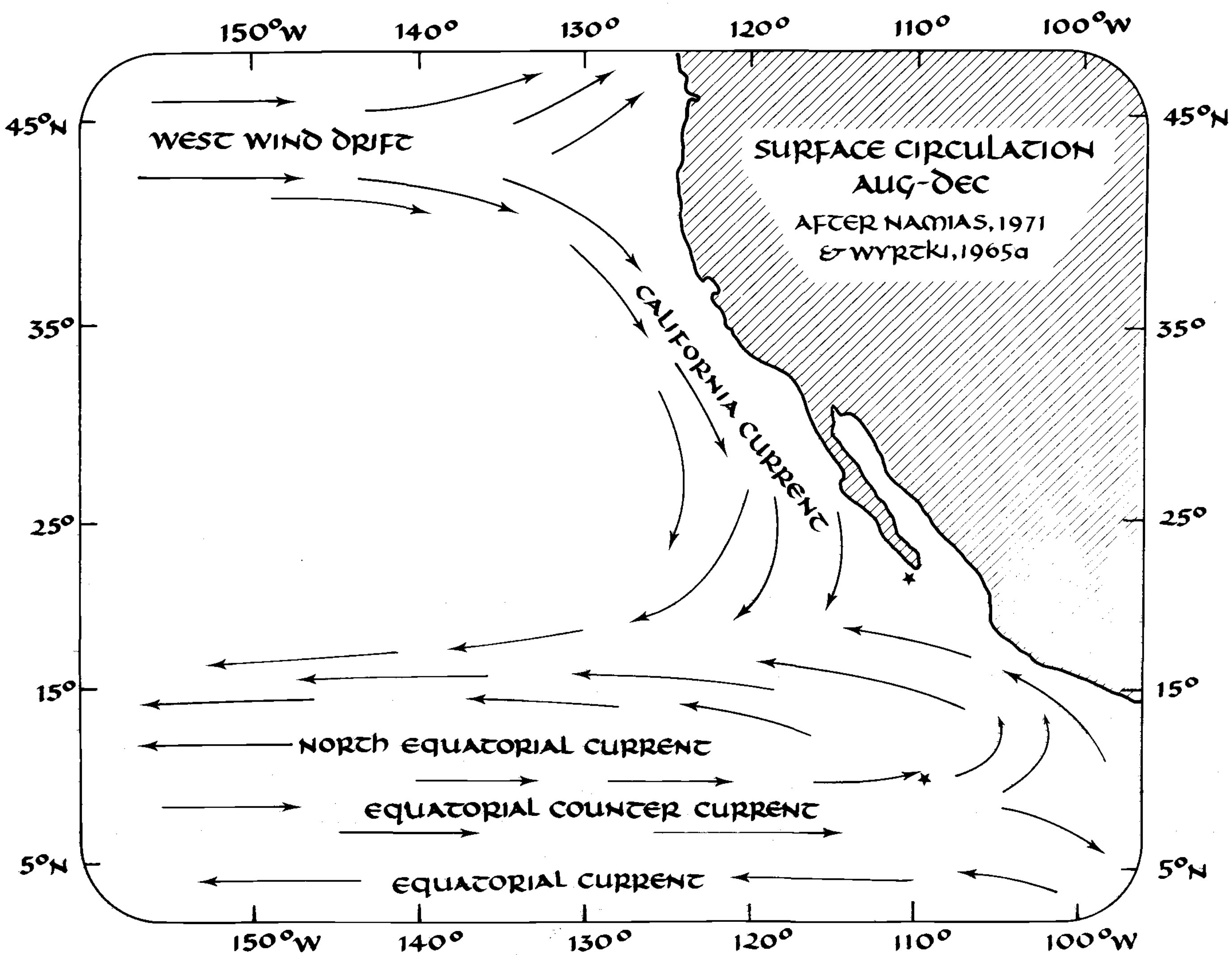
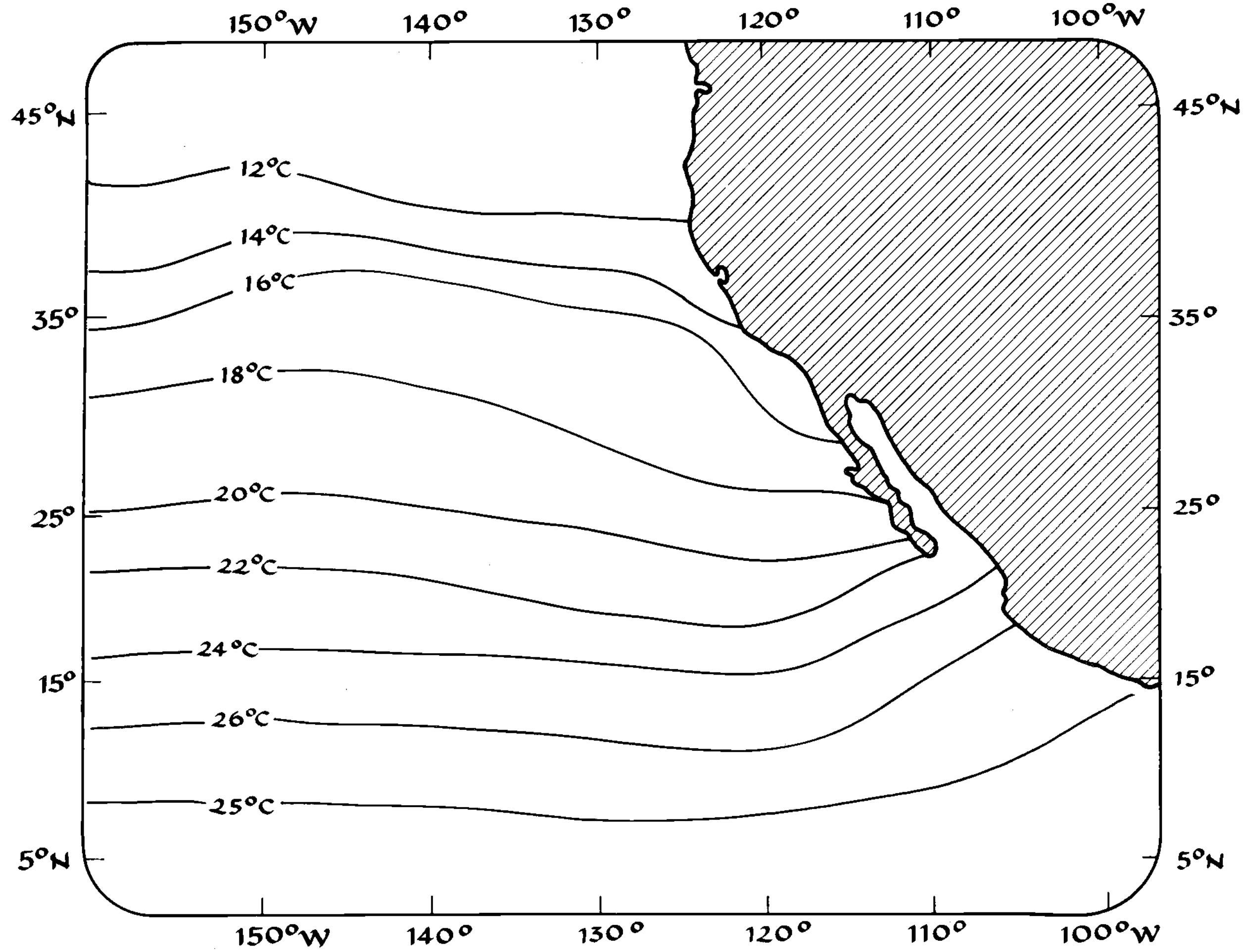



Figure 2b. Surface currents of the eastern North Pacific from August through December. Arrows show current directions, stars show sites of downcore studies.

summer-fall circulation patterns. This wind-driven circulation forces cold, low salinity water in the Westwind Drift to the south (and north) when it meets the west coast of North America. The southerly flow continues as the California Current from 40°N to 25°N. In the summer, when the wind circulation is strong, abundant northerly and westerly winds create a strong California Current, and it brings abundant cold, low salinity water from the North to tropical regions. The August isotherms (Figure 3b) show the pronounced cooling this produces along the coast and out into the open ocean. This cooling is enhanced by upwelling of cool subsurface water, which replaces the surface water carried offshore by Ekman transport.

In the winter, when the position of the North Pacific high pressure system and associated winds is shifted south, and winds from the north are less extensive along the west coast of the United States. During winter, the California Current is strongest (Wooster and Reid, 1963) and its characteristics are apparent further south (Wyrtki, 1966b). It is then that the usually subsurface, northward-flowing California Countercurrent (Reid, 1962, 1963) rises to the surface (Reid and others, 1958; Wooster and Jones, 1970) bringing water from the tropical equatorial regions northward. This warmer, more saline flow along with lower California Current transport helps to change the temperature gradients along the coast: compare Figure 3b with Figure 3a (temperature) and Figure 3c with Figure 3d (salinity).

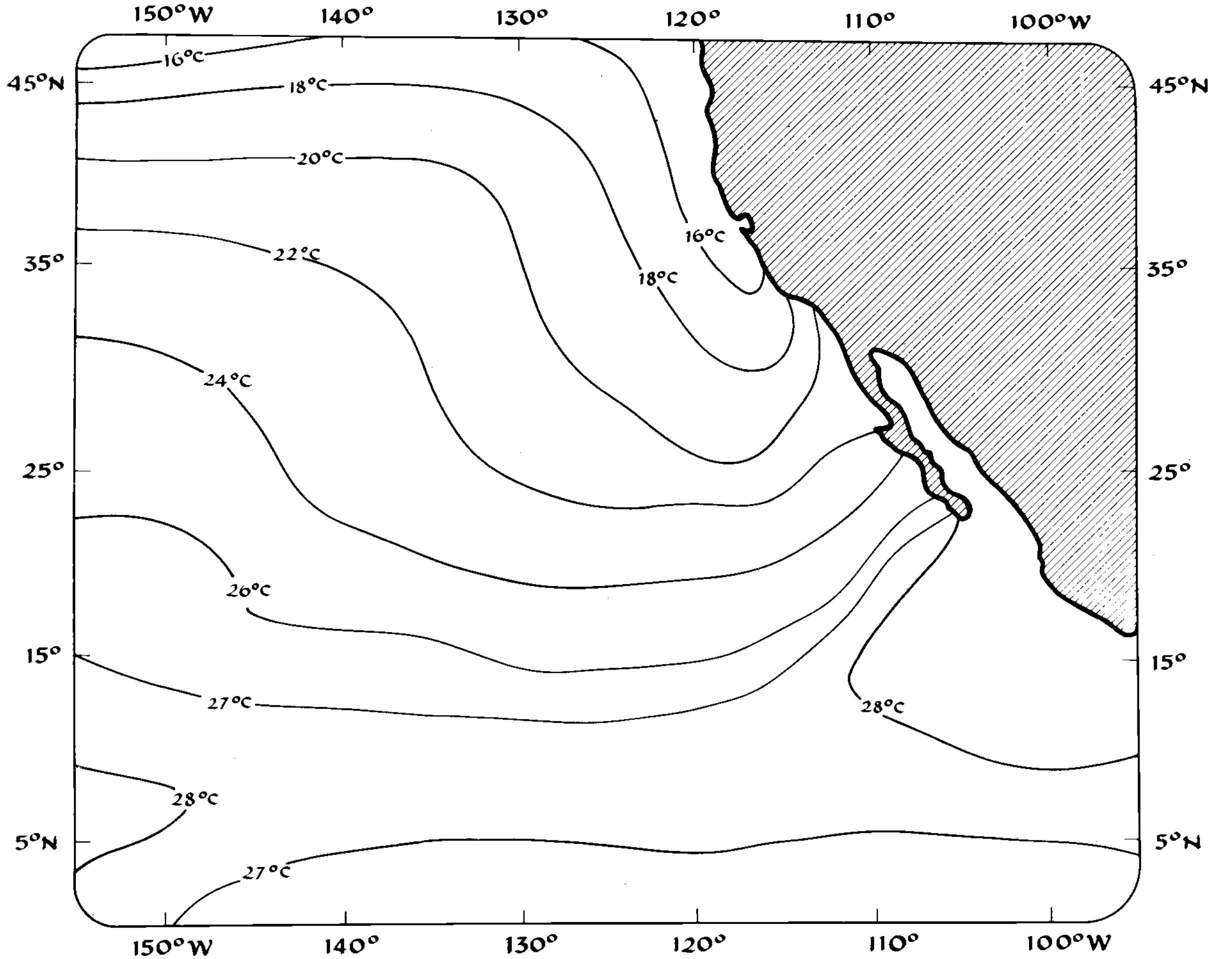
In the region between 15° and 25°N, 120° and 130°W, the California Current swings southwest merging with water supplied by the Equatorial Countercurrent (ECC) (Wyrtki, 1966b) to form the North Equatorial




FEBRUARY SURFACE TEMPERATURE

FROM RAND ATLAS, 1975

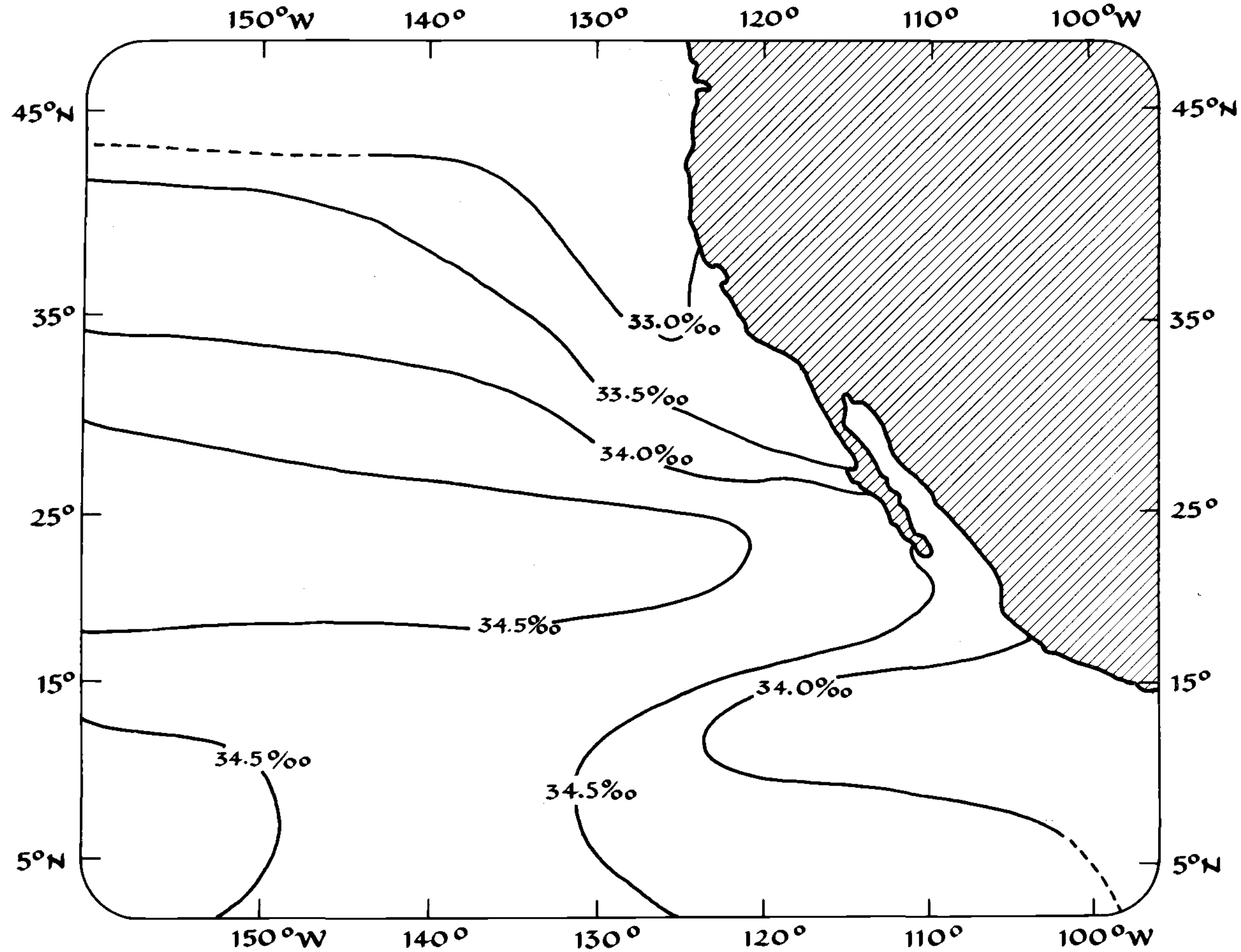
Figure 3a. February sea surface temperatures in °C. After Robinson and Bauer (1971).




AUGUST SURFACE TEMPERATURE

FROM RAND ATLAS, 1975

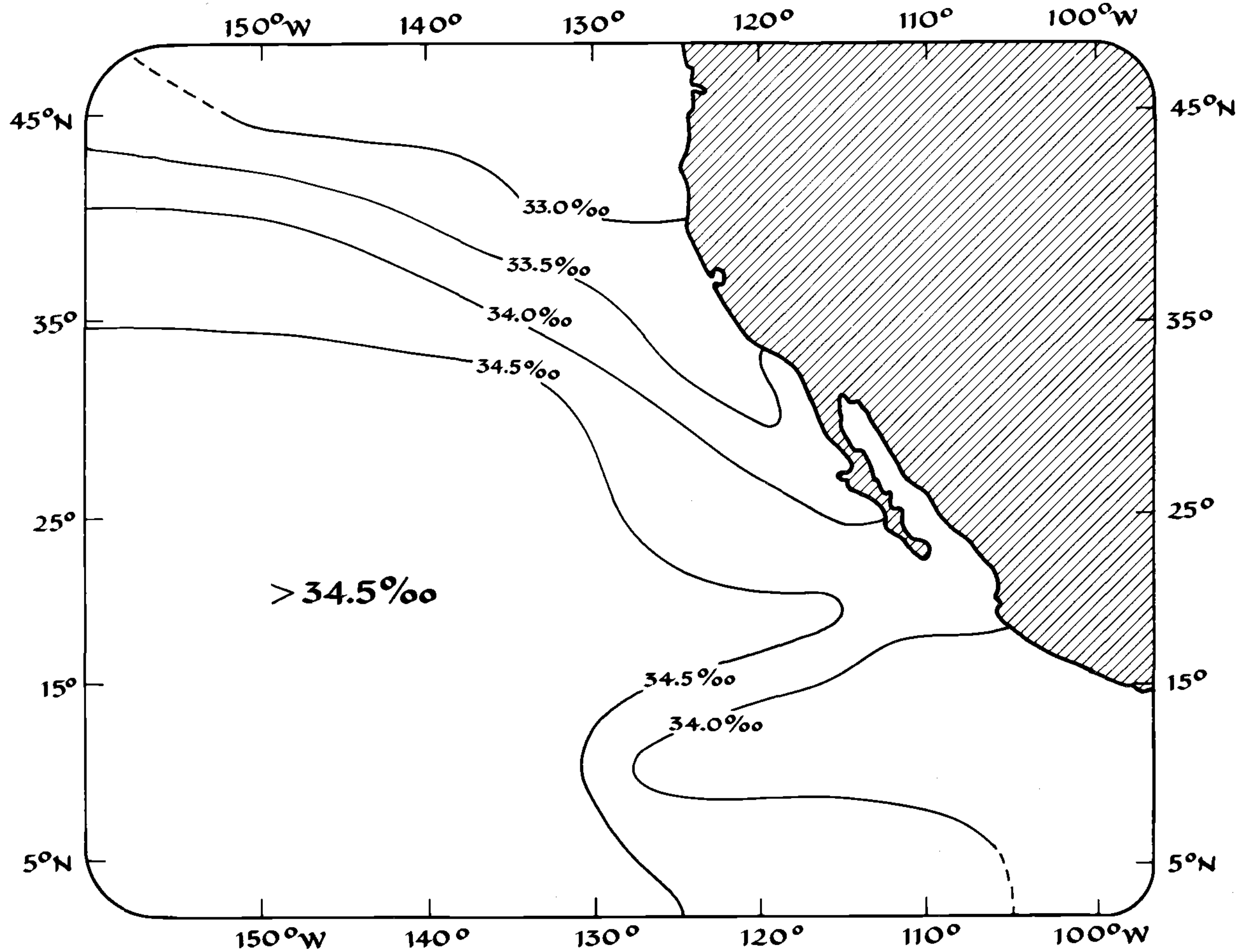
Figure 3b. August sea surface temperatures in °C. After Robinson and Bauer (1971).




FEBRUARY SURFACE SALINITY

AFTER BARKLEY, 1968

Figure 3c. February sea surface salinities. After Muromtsev (1958) and Wyrtki (1966).




AUGUST SURFACE SALINITY

AFTER BARKLEY, 1968

Figure 3d. August sea surface salinities. After Muromtsev (1958) and Wyrtki (1966).

Current (NEC). The cold, less saline California Current is warmed as it flows south and mixes with equatorial waters to produce northern tropical surface water (ibid). The higher salinity of this water results from greater evaporation in this latitudinal band (10°N - 22°N). From February through May, the California Current supplies most of the waters of the North Equatorial Current. During this time the Equatorial Countercurrent does not penetrate the eastern Pacific beyond 14°W, and the remainder of the westward transport is supplied by upwelling in the eastern tropical Pacific. From August to December, the California Current contributes to the North Equatorial Current north of 20°N, and the Equatorial Countercurrent contributes much to NEC transport.

## Meteorology

The overlying atmospheric circulation that drives the ocean surface currents in this region is dominated by the North Pacific high pressure system (Figure 4). This large anticyclonic gyre is on the average centered at 35 - 45°N, 160 - 145°W; it shifts approximately 10° latitude and 15° of longitude during the year. The Westerlies blow along the northern flank of the gyre. The NE trades are noted along the southern flank of the anticyclone.

The position of the NE trades governs the strength and to some extent the position of the North Equatorial Current (NEC) and the Equatorial Countercurrent (ECC) (Wyrtki, 1974; Hickey, 1974). In October, the trades are in their most northerly position and do not counteract the eastward flowing ECC. In April, the trades extend further south.

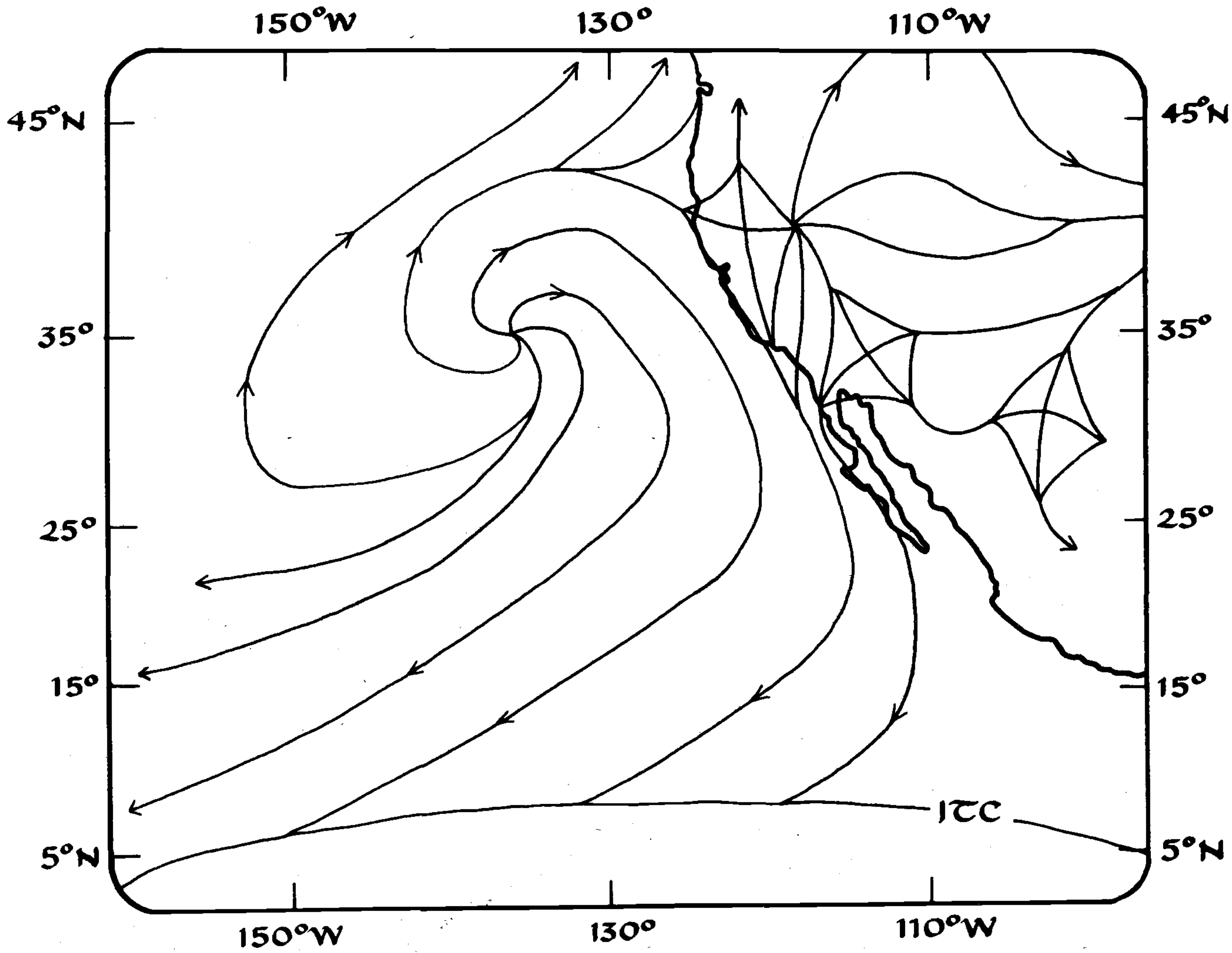
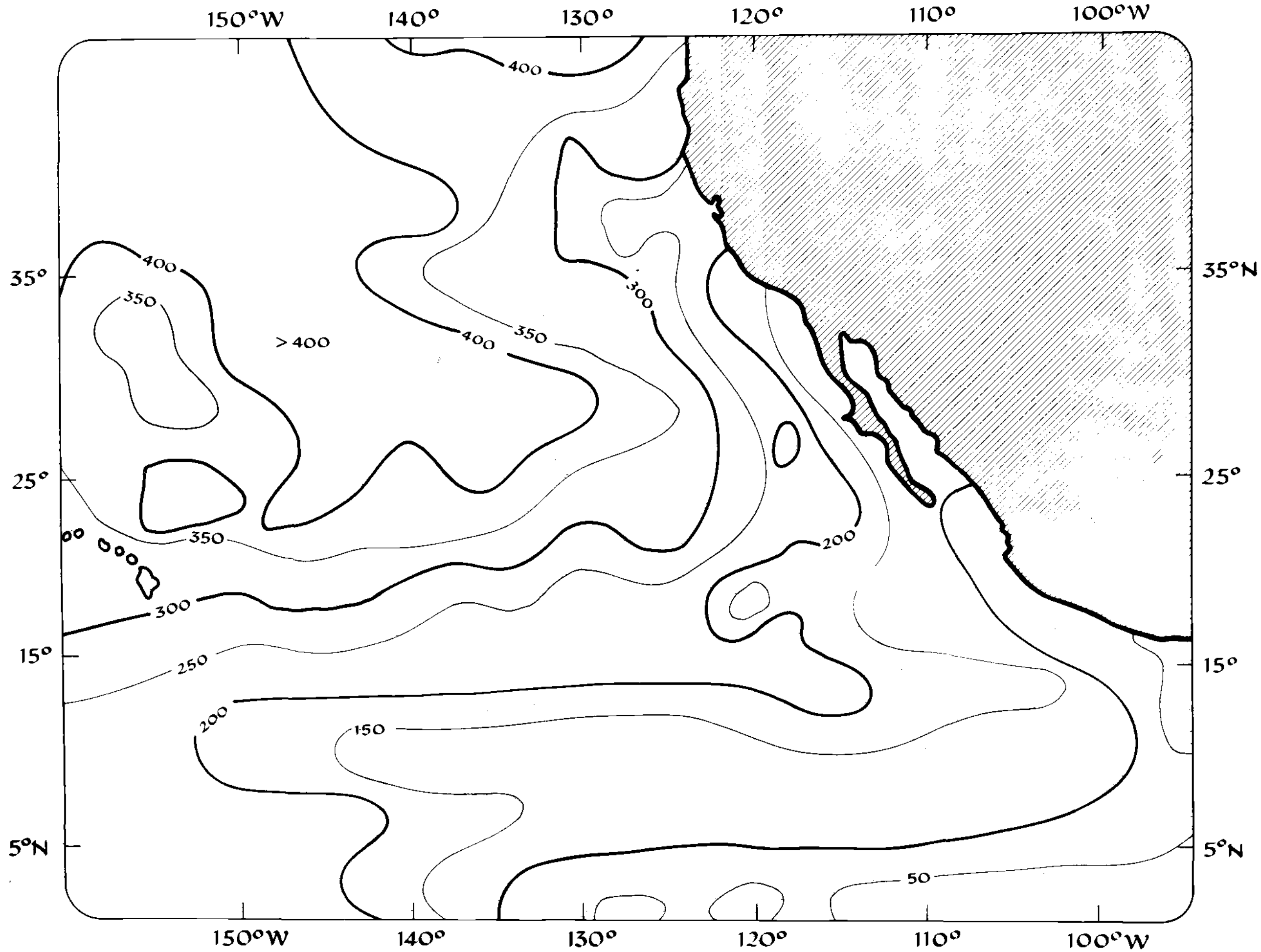



Figure 4. Resultant mean surface wind streams during January. Arrows show wind direction. ———ITC——— Intertropical Convergence. After Mintz and Dean (1952).

The strength and consistency of the wind circulation greatly affect the mixing of the underlying ocean waters. The Westerlies and the NE trades cause the mixed layer to vary seasonally in thickness as a function of wind stress and its variability (Figures 5a and 5b). South of the Intertropical Convergence Zone (ITCZ), in the region of the doldrums, weak and variable winds never contribute to the formation of a thick mixed layer.

## Sea Floor Physiography

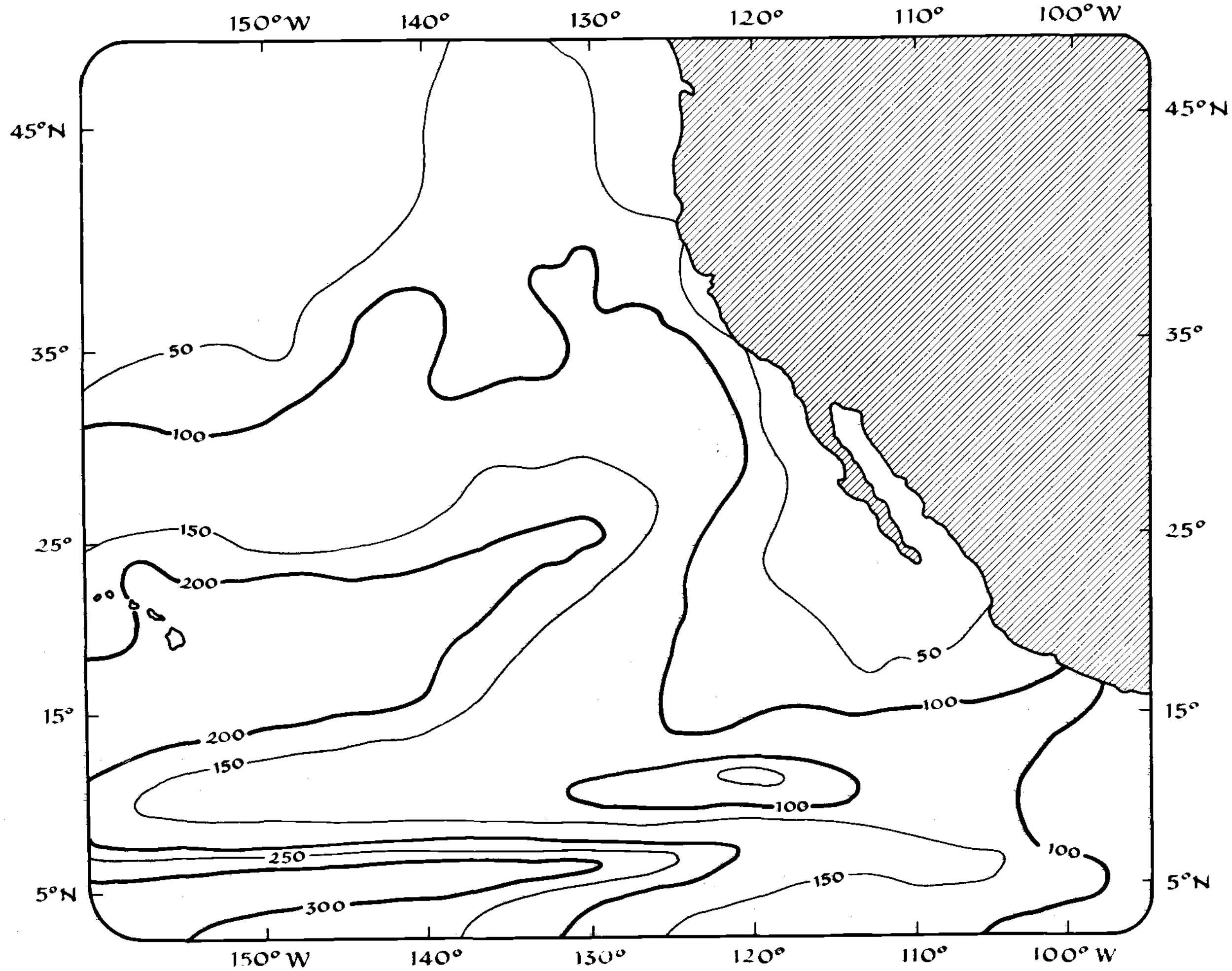
A simplified picture of the bathymetry and structure of this area is shown in Figure 6. The 1000 meters contour generally parallels the coast at an average distance of 120 km, creating a narrow shelf in most places. A narrow, steep continental slope coupled with the narrow shelf results in 80% of the sea floor deeper than 4000 meters. The six major fracture zones of the North Pacific divide this deep floor into five bands bounded by rifts 5000 meters deep. This disruption of the sea floor should have some effect on the distribution of sediments covering them. The rough terrain of the Baja California Seamount Province (130°W to 150°W) should also affect the sediment distribution between the Murray and Molokai Fracture Zones. Sediment input into the area by rivers is of little significance. The Columbia contributes its sediment load to the ocean at 46°N but this input is restricted to the Cascadia Plain.




FEBRUARY DEPTH TO THERMOCLINE IN FEET

AFTER ROBINSON & BAUER, 1971

Figure 5a. Thickness of the mixed layer in February. Contours in feet. After Robinson and Bauer (1971).




AUGUST DEPTH TO THERMOCLINE IN FEET

AFTER ROBINSON & BAUER, 1971

Figure 5b. Thickness of the mixed layer in August. Contours in feet. After Robinson and Bauer (1971).

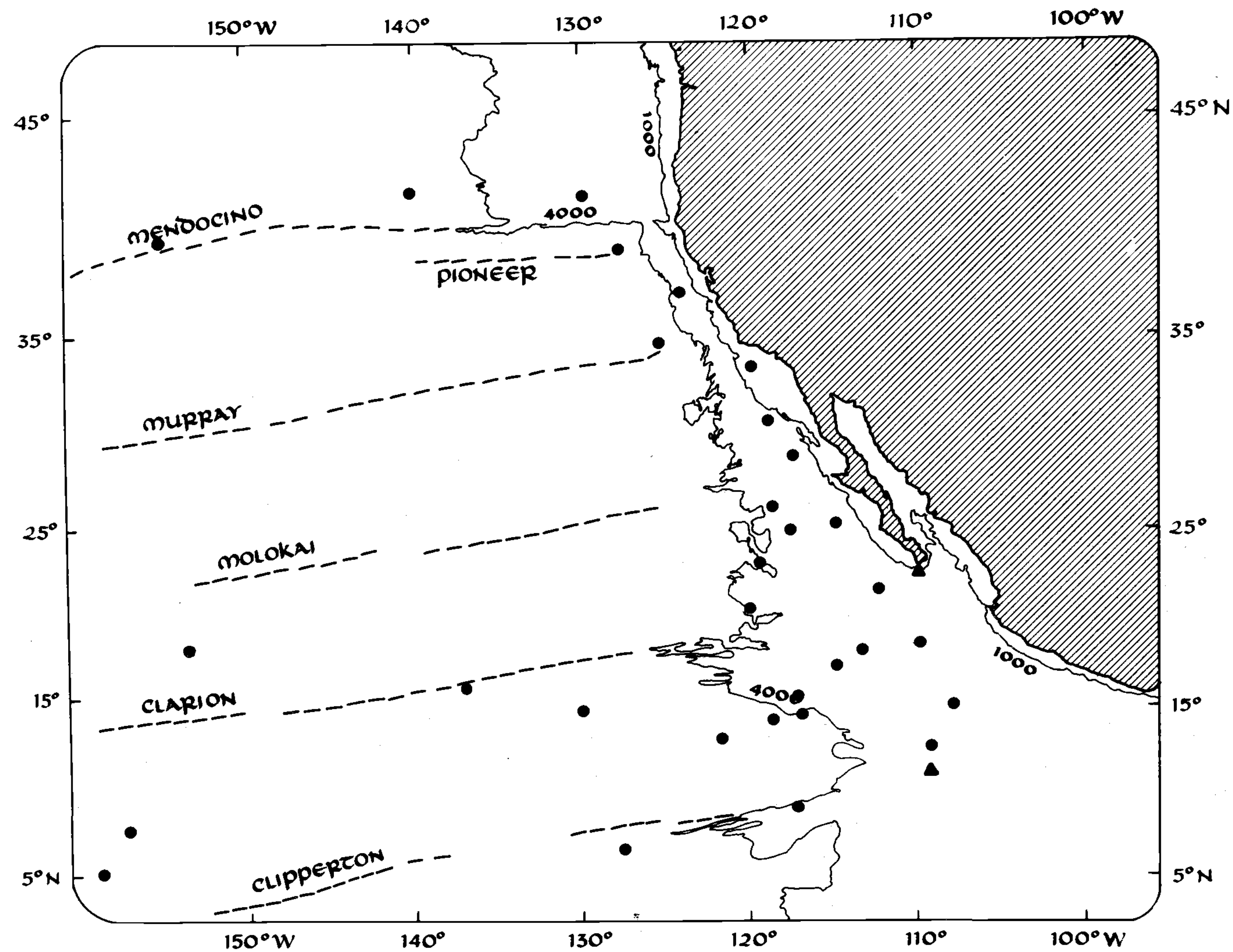



Figure 6. Bathymetry and sample locations. ● Sample locations. ▲ Sites of downcore studies. --- fracture zones. Contours in meters. After Chase and others (1971).

# METHODS

## Sampling

The upper few centimeters of gravity cores from the collections of Lamont-Doherty Geological Observatory, Scripps Institution of Oceanography and Oregon State University were used to determine distributions of radiolarian assemblages and weight percents of opal and quartz in modern sediments of the northeastern tropical Pacific. Samples containing reworked older microfossils were eliminated from the surface study. Additional samples were eliminated from the faunal study because radiolaria were absent or rare. Forty-seven surface sediment samples were analyzed for opal and quartz; thirty-four were used to determine the distributions of radiolarians. Their locations are shown in Figure 6 and are given in detail in Appendix I.

Two cores were determined suitable for paleoceanographic study based on their geographic position in relation to the present day distributions of radiolarian assemblages and atmospheric and oceanographic parameters and on the presence of fairly well preserved radiolarian assemblages down core. These cores are:

| | | | |
|---|---|---|---|
| BNFC 43 PG | 10°29'N | 109°17'W | 2720 m |
| LAPD | 22°53'N | 110°22'W | 2253 m |

The sediments in these cores are expected to reflect any significant changes in radiolarian faunas due to shifting oceanographic boundaries. A complete list of samples from the cores and their OSU sediment laboratory accession numbers is given in Appendix II.

## Opal and Quartz Determinations

The opal and quartz content of the sediment was determined by an X-ray diffraction method based on that of Goldberg (1958), Calvert (1966), Till and Spears (1969) and modified by Ellis (1972). The bulk sediment was treated with buffered acetic acid to remove carbonates. An amount of $\alpha$ -alumina internal standard equal to half the sample weight was added. The samples were heated at 1000°C for 24 hours to convert the amorphous opaline silica to cristobalite. Random powder mount of the sample were then X-rayed using a Norelco X-ray diffraction unit interfaced with analog and digital data acquisition systems. The intensities of the cristobalite 101 peak (3.34 Å), $\alpha$ -alumina 102 peak (3.48 Å), and quartz 101 (3.34 Å) were determined by a Canberra digital data reduction unit. The cristobalite proportion of the overlapping cristobalite and feldspar peaks was determined from the analog record using a Dupont analog curve resolver. The $CaCO_3$ free weight percents of opal and quartz were then calculated by computer from measured peak intensity ratios relative to standard curves.

To enhance the quartz "signal" in the surface sediment and in the down-core analysis quartz percentages were recalculated to "opal free quartz" values using the formula:

$$\text{Opal free quartz} = \frac{\text{wt \% quartz}}{\text{100-wt \% opal}}$$

Appendix II contains the results of opal and quartz determinations of the samples.

## Stratigraphy and Age Determinations

The oxygen isotope composition of foraminiferal tests varies in relation to the amount of water stored as ice and the temperature of the water in which the tests formed (Shackleton and Opdyke, 1973; Emiliani and Shackleton, 1974). Isotopic compositions are reported in delta notation ( $\delta^{18}O$ in o/oo), a comparison of the composition of foraminiferal tests with that of some standard. When there is a large amount of water stored as ice, the test will be enriched with the heavy isotope relative to some standard (ie. the delta value will be larger). The extent of glacial ice is a function of climate, and extremes of $^{18}O$ values have been correlated with periods of climatic (specifically temperature) minima and maxima (Luz and Shackleton, 1975; Sachs, 1975; Molina-Cruz, 1975). Characteristic downcore maxima and minima in the oxygen isotope values have been given absolute ages by various methods (Broecker and van Donk, 1970; Shackleton and Opdyke, 1973) resulting in a useful stratigraphic tool.

Oxygen isotope analyses of <u>Globigerinoides</u> <u>sacculifer</u> from BNFC 43 PG were provided by N. J. Shackleton (University of Cambridge, England). The $\delta^{18}O$ curve of this core has been correlated with those of V28-238 (Shackleton and Opdyke, 1973) and RC11-230 (Luz and Shackleton, 1975) (Figure 7), and provides the stratigraphic basis of this study. Oxygen isotope stages one through five of Emiliani (1966) are used to subdivide the 75,000 year record of the core. The ages and depth in core of the stage boundaries are given in Figure 7. Stages five through two are considered "glacial" and cooler; stage one is considered "interglacial" and warmer.

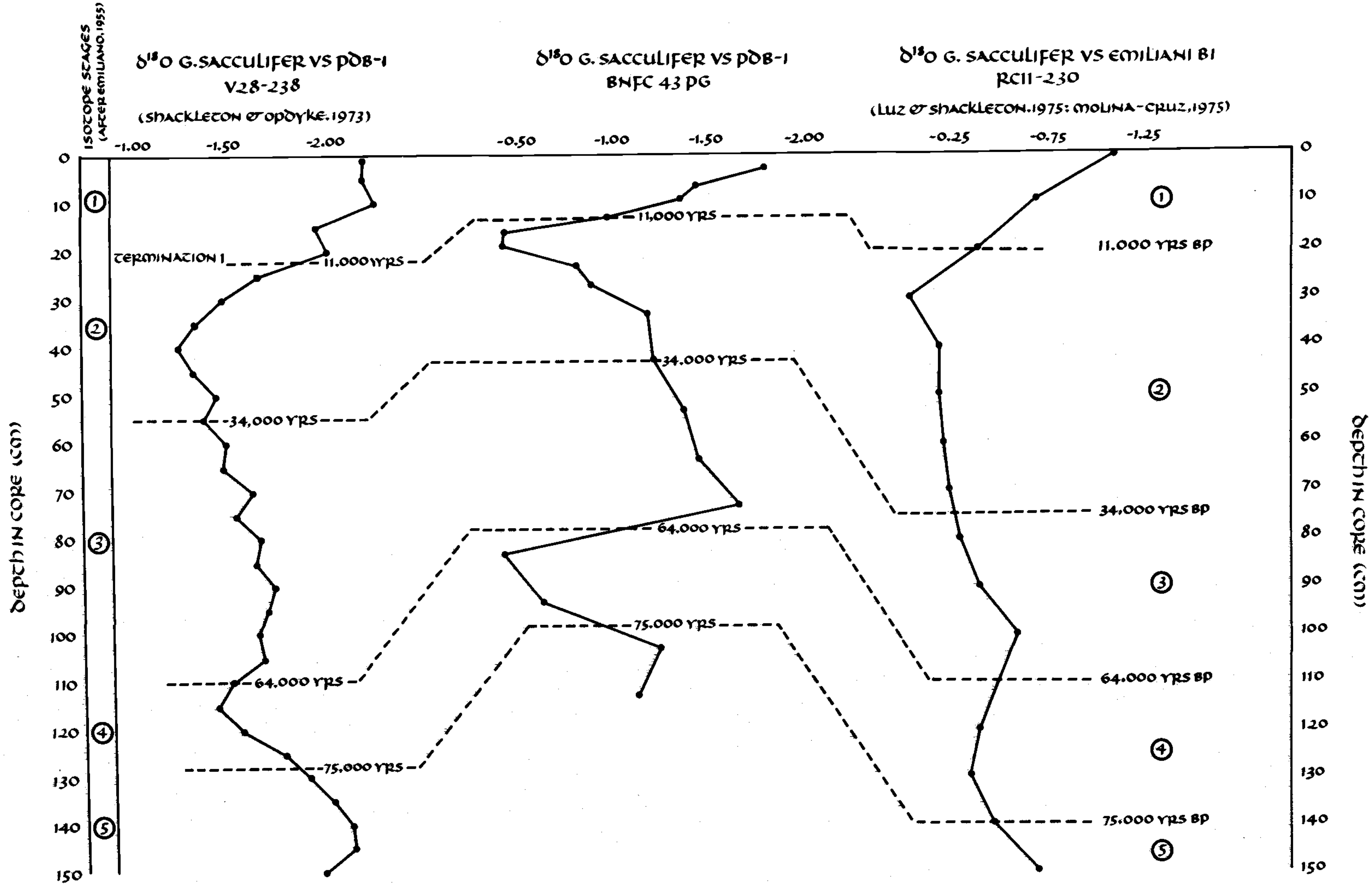



Figure 7. Correlation of $\delta^{18}O$ curve of BNFC 43 PG with those of RC11-230 and V28-238. $\delta$ values in o/oo. Circled numbers are isotope stages of Emiliani (1966).

The age levels in LAPD IG are the average of the levels determined by the correlation of the downcore variation of Tetrapyle octacanthum plus Octapyle stenozoa and Carpocanium sp. A. between LAPD IG and BNFC 43 PG (Figures 8a,b; Appendix VIII, XII). T. octacanthum plus O. stenozoa are abundant, easy to recognize tropical species. Carpocanium sp. A. is also an easily recognizable tropical species. Despite its low abundance, its distinctive appearance makes misidentification unlikely. It was not possible to use Cycladophora davisiana as a stratigraphic marker. This species is never as abundant in the tropics as it is at high latitudes, and does not exhibit downcore variations in this area correlative with the high latitude curves.

## Radiolarian Sample Preparation and Sample Counts

The great diversity of radiolaria yields sediment assemblages containing up to 85 different species many of which never comprise more than 2% of the total radiolaria present. This diversity requires counts of large numbers of skeletons from a statistically random subsample of the radiolarian fauna to properly account for the ecologic information provided by each species.

A random settling technique similar to that used in grain size studies was used to prepare the radiolarian slides (Moore, 1973b). The carbonate-free portion of the total sample was treated with hydrogen peroxide to disperse aggregated particles and to remove organic matter. The sample was then placed in an ultrasonic bath for 10 seconds to remove fine sediment from around and within the radiolarian tests. After sieving at 62 microns, the coarse fraction was poured into a

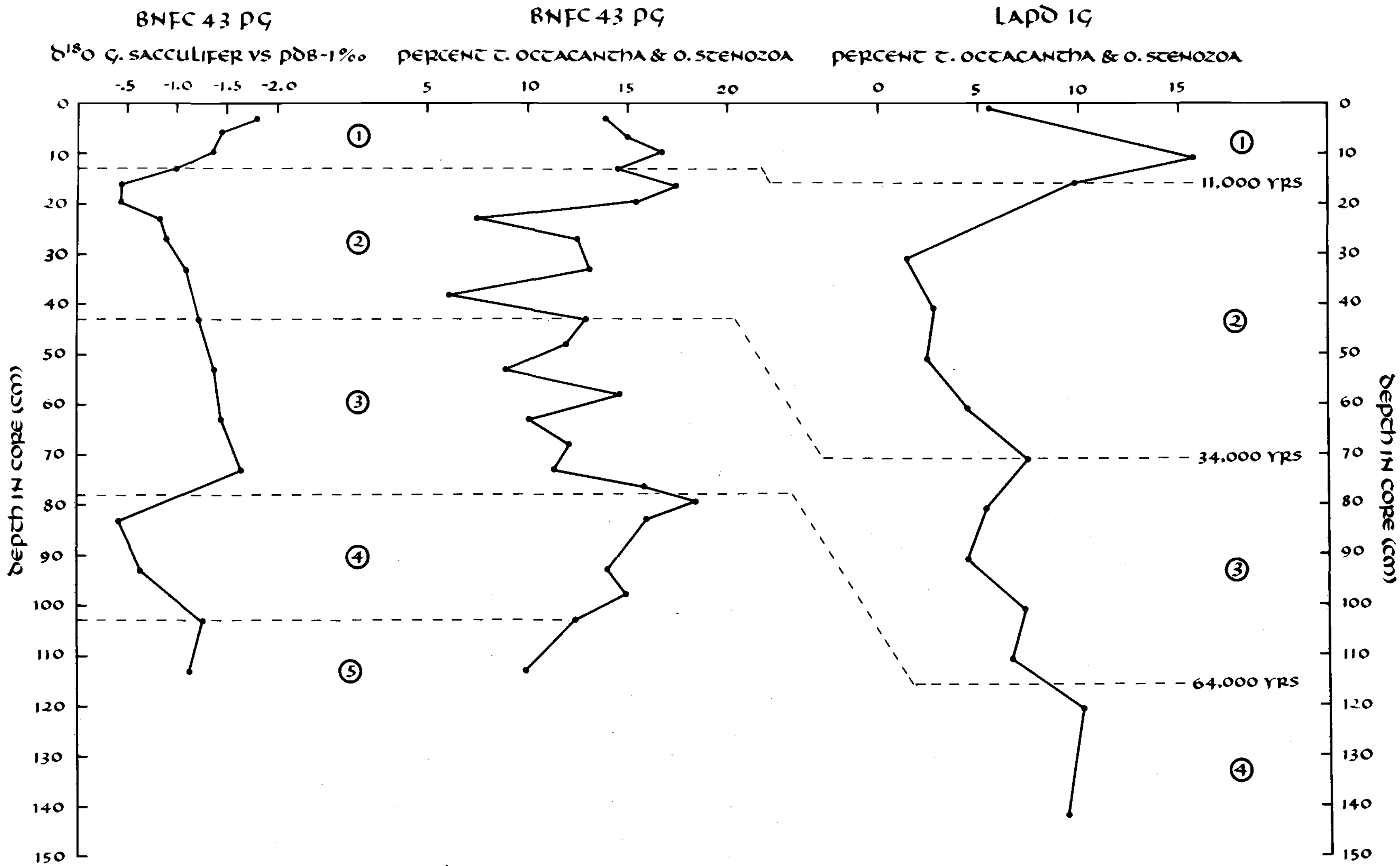



Figure 8a. Biostratigraphic correlation of LAPD 1G with BNFC 43 PG using the downcore variation of *Tetrapyle octacantha* plus *Octopyle stenozoa*.

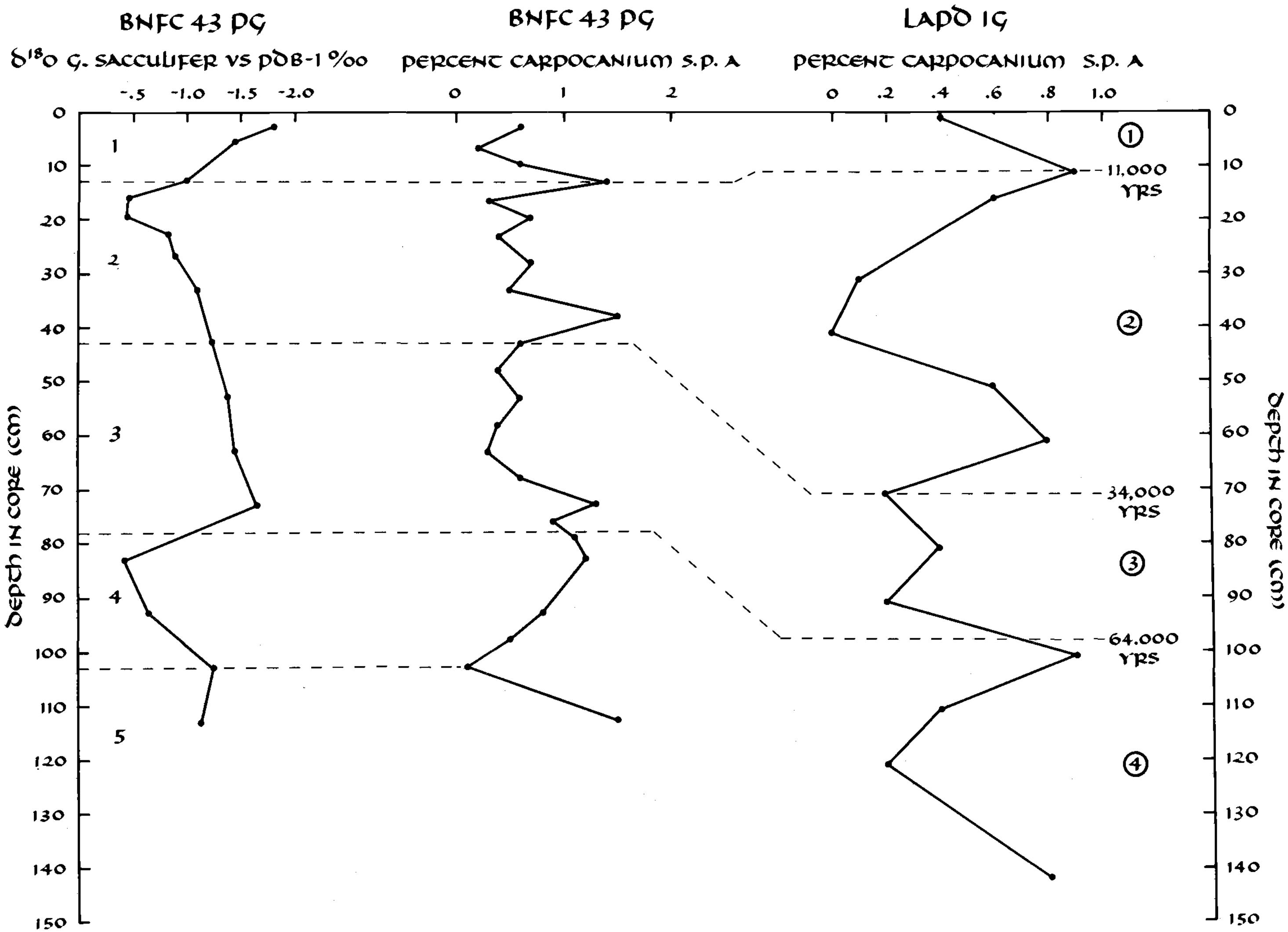



Figure 8b. Biostratigraphic correlation of LAPD 1G with BNFC 43 PG using the downcore variation of Carpocanium sp. A.

beaker with a glass slide (or cover slip for small samples) on the bottom and filled three-fourths full with water. A thin plastic plunger was used to thoroughly mix and suspend all the particles. After all the grains had settled all but 2 cm of the overlying water was siphoned off. Heat lamps were used to evaporate the remaining water. The slides were finished with Canada Balsam and xylene, and cured at 55°C for 24 hours to set the Balsam.

At least 800 tests per slide were counted, unless fewer than 800 were present, in which case the whole slide was counted. Using a reference scheme based on several more recent radiolarian studies (Appendix IV) 123 taxonomic categories were recognized which accounted for an average of 88% of the radiolaria present. Species comprising less than 2.0% were not used in the faunal analysis, leaving 44 species as the basis of the ecologic study.

## Mathematical Treatment of Radiolarian Data

In order to deal with the large number of species (variables) and more accurately determine their response to ecologic conditions, the mathematical procedures involving Q-mode factor analysis and regression analysis as devised by Imbrie and Kipp (1971) for foraminifera and extended to radiolaria by Sachs (1973a) was used to group the species into assemblages and relate these assemblages to oceanographic conditions.

The factor analysis was done with the computer program CABFAC (Klovan and Imbrie, 1971). A detailed explanation of Q-mode factor analysis is given by Harmon (1967). The variability of each sample is expressed as a combination of mathematically orthogonal vectors called "factors"; the variables considered are the percentages of each radiolarian category occurring in the sample. The factors can be thought of as assemblages of species as determined by the value of the factor score for each species from the "scaled principal factor score matrix" or F matrix (Appendix V). The higher the factor score, the more important a species is in a factor. A species can be important in more than one assemblage but it is usually considered an "essential" member of the factor in which the species has the highest score. The factor loadings given in the "varimax" factor matrix or B matrix (Appendix V) indicate the importance of each factor in a sample: the greater the loading, the larger amount of sample variance a factor explains. In factor analysis, the sample variance accounted for is equal to the square of the factor loading. The term factor-assemblage will be used to designate the different assemblages of radiolarian species determined by the factor analysis.

Correlation of factor loadings and oceanographic parameters as well as similarity of areal distributions of factors and oceanic parameters are used to determine the ecologic significance of the factors. Regression analysis is used to investigate and quantify the relationship between the factor loadings and the observed oceanographic parameters. Equations to estimate ancient oceanographic variables were determined by regressing modern day oceanographic variables on factor loadings of surface samples.

From the percentages of radiolarian species present in downcore samples, values of the surface (=present day) factors are determined.

These are used in the equations produced by regression analysis to estimate paleo-oceanographic parameters. This assumes that the ecologic requirements of radiolarian species used have not changed the time interval studied.

The relationship between surface radiolarian assemblages (factors) and measurable oceanographic parameters can be numerically expressed by regression equations (Imbrie and Kipp, 1971). In the equations the factors are considered the independent variables and the oceanographic parameters are the dependent variables. Since equivalents of surface factors are determined for each down core sample, it is possible to estimate paleoceanographic parameters from the equations obtained by regression analysis using the down core factors as independent variables. Equations to estimate the sea surface temperatures for February and August and the temperature at 133 m depth for February and August. The statistics for these equations are given in Appendix IX.

# RESULTS

## Distribution of Sedimentary Components

### Opal

Opaline silica in sediments is composed of diatom frustules, radiolarian and silicoflagellate skeletons, and sponge spicules. The pattern of opal distribution in surface sediments is thought to reflect primary productivity patterns (Murray and Renard, 1891; Heath, 1974), except in nearshore areas where high productivity and correspondingly high siliceous test input to the sediment is masked by the large terrigenous input. The distribution of opal (Figure 9, Appendix III) shows some visual correlation with the productivity phosphate data of Reid (1962). Moore and others (1973) found that opal concentrations in sediment do not reflect exactly the productivity of the overlying waters, and concluded that local reworking and dissolution dominate controls on sediment concentrations of opal in the Panama Basin. It is highly likely that reworking and dissolution affect the opal distribution in this region also. The sedimentation rates for the central portion of this area are low--on the order of .5 mm to 1.5 mm/1000 yr (Goldberg and Koide, 1962). Thus siliceous tests spend thousands of years in the upper centimeters of the sediment column where silica concentrations of pore waters are very low (Heath, 1974) and concentration and diffusion gradients are steep (Hurd, 1973). Although diffusion is not a rate controlling step in silica dissolution, Wollast (1974) and Hurd (1973) conclude that 90% of the amorphous silica input to the sediment is dissolved in the upper few centimeters.

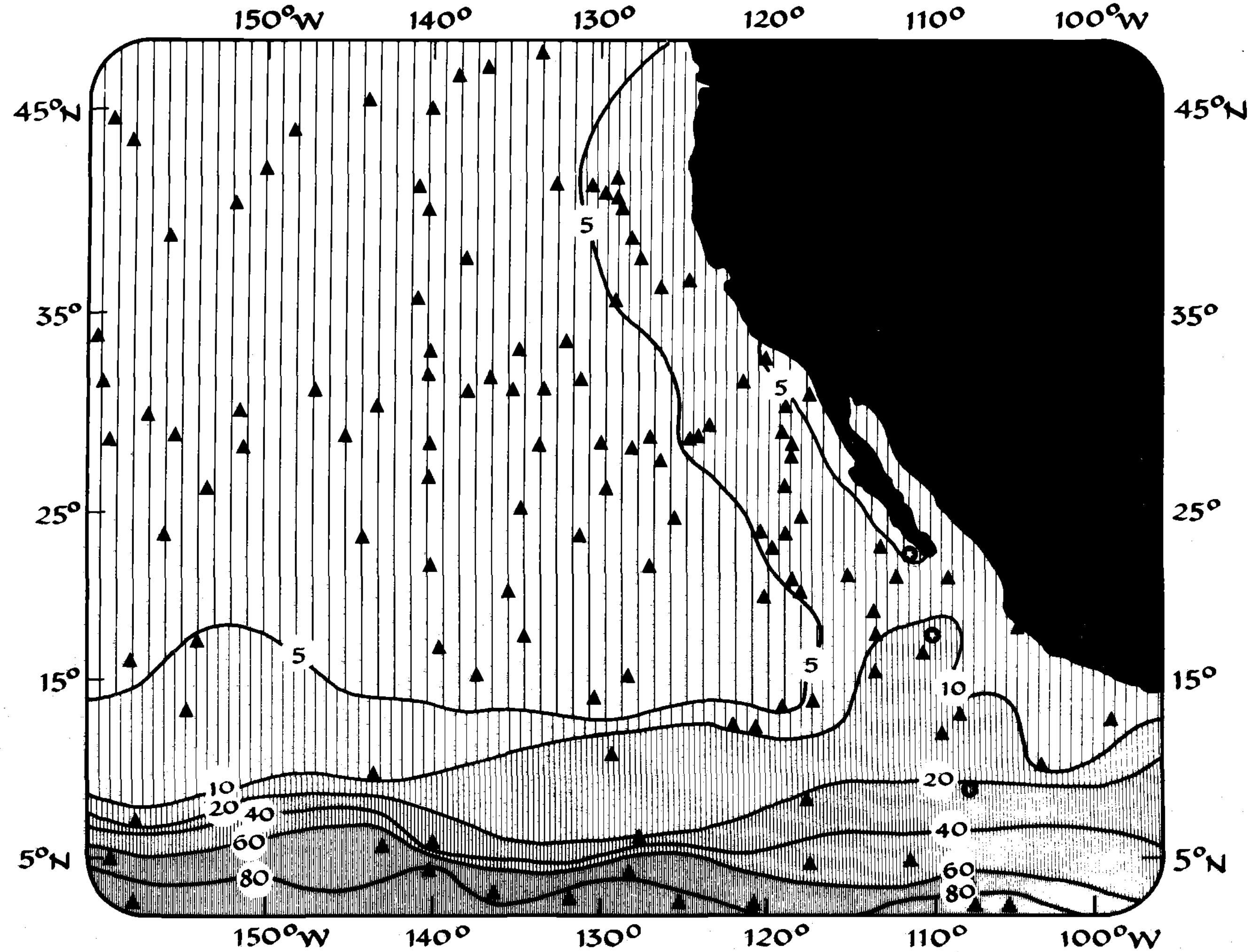



Figure 9. Concentration of opal in carbonate-free fraction of sediments. Contours in weight percent. ▲ surface samples. ★ sites of downcore studies. Data from this study and unpublished data from G. Ross Heath (University of Rhode Island).

Dissolution yields poorly preserved radiolarian assemblages for most of the subtropical North Pacific, restricting faunal analysis to regions under zones of higher productivity where there is enough test input to compensate for dissolution effects.

Quartz

Previous workers have demonstrated that the eolian transport of quartz is responsible for most of the quartz in pelagic sediments of the world ocean. For example, Radczewski (1939), Rex and Goldberg (1958), Griffin and others (1968), Rex and others (1969), Mokma and others (1972), Parkin (1974) and Bowles (1975) have shown the great similarity between atmospheric circulation patterns and quartz distributions. On the basis of $O^{18}$ measurements, Jackson and others (1971) and Clayton and others (1972) have shown convincingly that quartz in the soil of Hawaiian soils and the surrounding North Pacific sediments is derived from tropospheric fallout of dust carried by the prevailing westerlies and NE trades.

The grain size of most quartz in pelagic sediments falls in the range 2 to 40 m with a maximum around 10 m (Rex and Goldberg, 1958; Windom, 1969; Mokma and others, 1972). Particles in the size range 1 - 10 μm dispersed in the atmosphere are considered aerosols, that is they are a permanent part of the atmosphere until they are rained out. Therefore the quartz distribution in sediments should be a function of the amount of precipitation in an area, as well as the prevailing winds. Nearer continental sources the direction and strength of surface winds (lower troposphere winds) which carry larger particles (coarse silt 20-50 μm) are important in determining the quartz distribution. As one moves away from source areas, middle and upper troposphere winds which carry fine particles (aerosols: 10 μm, fine silt: 10-20 μm) become more important. Grains of this size cannot reach the sea-floor by single particle settling and still reflect circulation patterns (McCave, 1975). They must somewhere be incorporated into fecal pellets and sediment.

The quartz distribution of the North Pacific shows a striking similarity to the wind systems that move over it. A band of high quartz values stretching across the ocean at 35°N to 45°N lies under the belt of westerly winds which generally prevail from the earth's surface up through the troposphere (Mintz and Dean, 1952; Riehl, 1962). These westerly winds most likely entrain quartz (and other minerals) from the Gobi Desert, the loess deposits of central China, and other areas on the Asian continent. One would therefore expect coarser grains in the western Pacific and decreasing grain size moving across the ocean. This is tentatively borne out by the finding of Clayton and others (1972).

Figure 10 shows in greater detail the quartz distribution in the subtropical northeastern Pacific. The most likely source of the lobe of high values between 32° and 42°N is the north and northeasterly flow along the east side of the North Pacific anticyclone (Figure 4). The trades carry some quartz from the westerlies (which have probably entrained dust from the Asian continent) as they move southwest. Silt grains less than 40 μm have "used up" their residence time in the lower to middle troposphere (days to weeks) and fall out due to

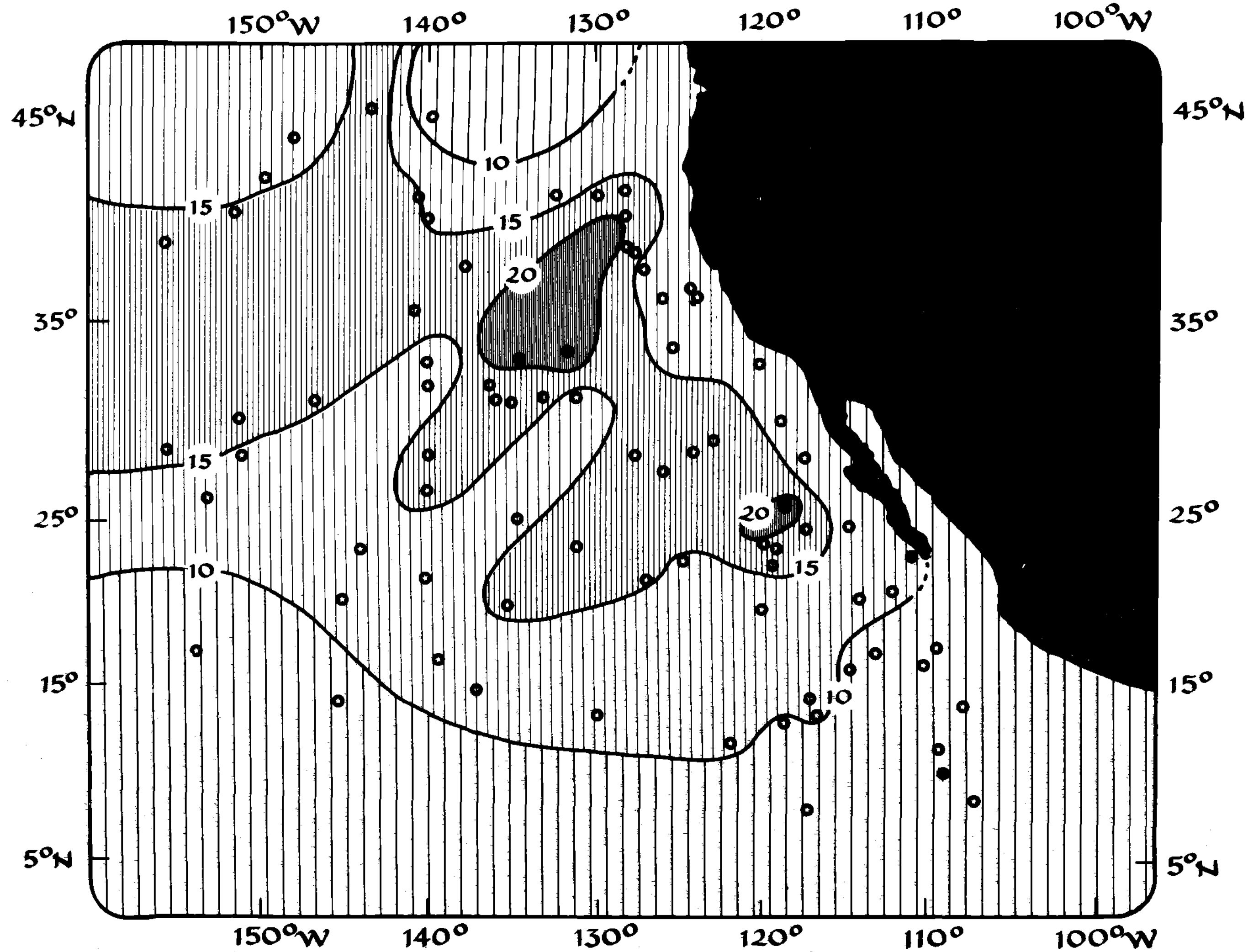



Figure 10. Concentration of quartz expressed as weight percent of carbonate-free sediment (see methods section). Contours in weight percent. o data points; ▲ sites of downcore studies. Data from this study and unpublished data from G. Ross Heath (University of Rhode Island).

gravity. The meteorological conditions conducive to increased precipitation (relative to the central Pacific) are fulfilled in the coastal region and rain washes smaller grains out of the high tropospheric levels.

The other lobe of high values between 20°N and 30°N is probably derived from the deserts of southwestern United States and northern Mexico. However, the prevailing winds over the source area are not directed offshore. The most likely mechanism for dust transport out of this area are the local periodic foehn or "Santa Ana winds" that blow from across the interior deserts out to sea and the major regional dust storms that occur in the southwestern United States (Danielsen, 1964). Any dust carried to the coast by land breezes will be picked up by the NE trades and carried out to sea. The meteorological conditions necessary for "Santa Ana winds," and dust storms are described in detail by Fosberg and others (1966), and Jackson and others (1973) and Danielsen (1964), respectively.

Thus the mechanism of eolian quartz transport in the subtropical Pacific is not exactly analogous to that of the trade wind area in the Atlantic. In the Atlantic, the "Harmarttan winds" that blow across the Sahara entrain grains and carry them out to sea and across the ocean. Quartz distribution in the Atlantic is therefore a direct reflection of the strength of the trade wind system. In the Pacific the corresponding deposit reflects the occurrence and intensity of aberrant atmospheric flow as well as the prevailing trade wind system.

Because the quartz distribution is closely tied to the wind systems that transport the mineral, many workers have used the time variation of quartz and other eolian grains to study paleocirculation and related paleoclimates. Parkin (1974), Parkin and Shackleton (1973) and Shaw and others (1974), have determined that there are significant variations of eolian grains through time and have tried to gauge the strength of paleowinds. Bonnati and Arrhenius (1965), Rex and Goldberg (1958), Hays and Peruzza (1972), Parmenter and Folger (1974), and Bowles (1975), have related such fluctuations to the differences in wind strength in the past.

It was hoped that a model of paleocirculation based on the down-core variation of quartz accumulation rates could be part of this study but suitable cores were not available. Cores within the area of high quartz values have extremely low sedimentation rates (Goldberg and Koide, 1962) which makes late Pleistocene studies difficult. The sediments are also essentially devoid of microfossils. Therefore the quartz study is limited to surface sediment samples.

Distribution of Radiolarian Assemblages

Radiolarian tests in pelagic sediments are the opaline silica skeletons of two orders of planktonic protozoa, Spumellaria and Nassellaria. Specis of radiolaria are distributed geographically according to temperature and salinity conditions in the surface waters where most of the biomass is presumed to live. Reschetnjak (1955), Casey (1966), Petrushevskaya and Bjørklund (1973), and Renz (1973) have found that most radiolaria have preferences for specific temperature and salinity (and therefore probably density) conditions that prevail at specific levels in the water column. The availability of food must also control where the radiolaria are most abundant. Casey (1966), Petrushevskaya (1968) and Renz (1973) have shown that sediment assemblages of species are quite similar to plankton assemblages. Other studies have clearly demonstrated the correspondence between water mass characteristics and grouping of radiolaria (Moore, 1973a; Sachs, 1973a, b; Dinkelman, 1974; Molina-Cruz, 1975).

In this study, Q-mode factor analysis was used to place 44 species from 34 core tops into 6 groups (factors) (Appendix V) which account for 91% of the variability of the sample assemblages. The geographic distributions of these species groups can be related to surface water circulation, and in some cases substantiated by statistical correlation of the various factors and measureable oceanographic parameters. The lack of good statistical correlation is probably due to the position of radiolarian in the secondary trophic level rather than in primary production, as well as to the various processes which affect the change from plankton assemblages to sediment assemblages (Renz, 1973; Johnson, 1975). In addition, the complex surface oceanography of the eastern Tropical Pacific is not defined by single parameters such as temperature but by differing combinations of temperature, salinity, nutrients as they are affected by insolation, precipitation, transport and mixing. Thus the ecological meaning of the factors has been inferred from the correspondence between geographical distributions of factors and surface oceanographic features. The presence in a factor-assemblage of a species whose distributions are well documented lends support for the inferred ecologic meaning of a factor. The association of these species with those whose geographic distributions are poorly defined yields information on the ecologic preference of the lesser known species.

Five of the six factors can be related to upper water characteristics as well as mixing and circulation patterns. The sixth factor bears no obvious relationship to the surface physical oceanography of the region and is thought to reflect the effects of dissolution. The ecological significance of the six factors is summarized below.

The first factor (Figure 11) accounts for 32.7% of the sample variation and dominates where water temperatures are warm. This factor probably reflects the extent of Pacific Equatorial Water (Figure 1). Its distribution is strikingly similar to the August temperature pattern (Figure 3b). The highest loadings are found in the southern portion of the area where the surface water temperatures are the highest. This factor is also dominant near the mouth of the Gulf of California where warm salty water flows out into the open ocean (Roden, 1958). Gulf of California water is essentially Pacific Equatorial Water whose salinity has been increased by evaporation (ibid). The assemblage is found further offshore between 17°N and 35°N as warm water is diverted away from the coast. This is especially pronounced during August when upwelling along the northern California coast is most intense (Reid and others, 1958; Wyrtki, 1965). This assemblage of radiolarian should predominate in summer and fall.

On the basis of factor scores (Appendix V), *Tetrapyle octacantha* plus *Octopyle stenozoa* (S54), *Giraffospyris angulata* (N4) *Ommatartus tetrathalamus* (S25) and *Stylochlamidium astericus* (S50) are the dominant species in this assemblage. This species grouping is in

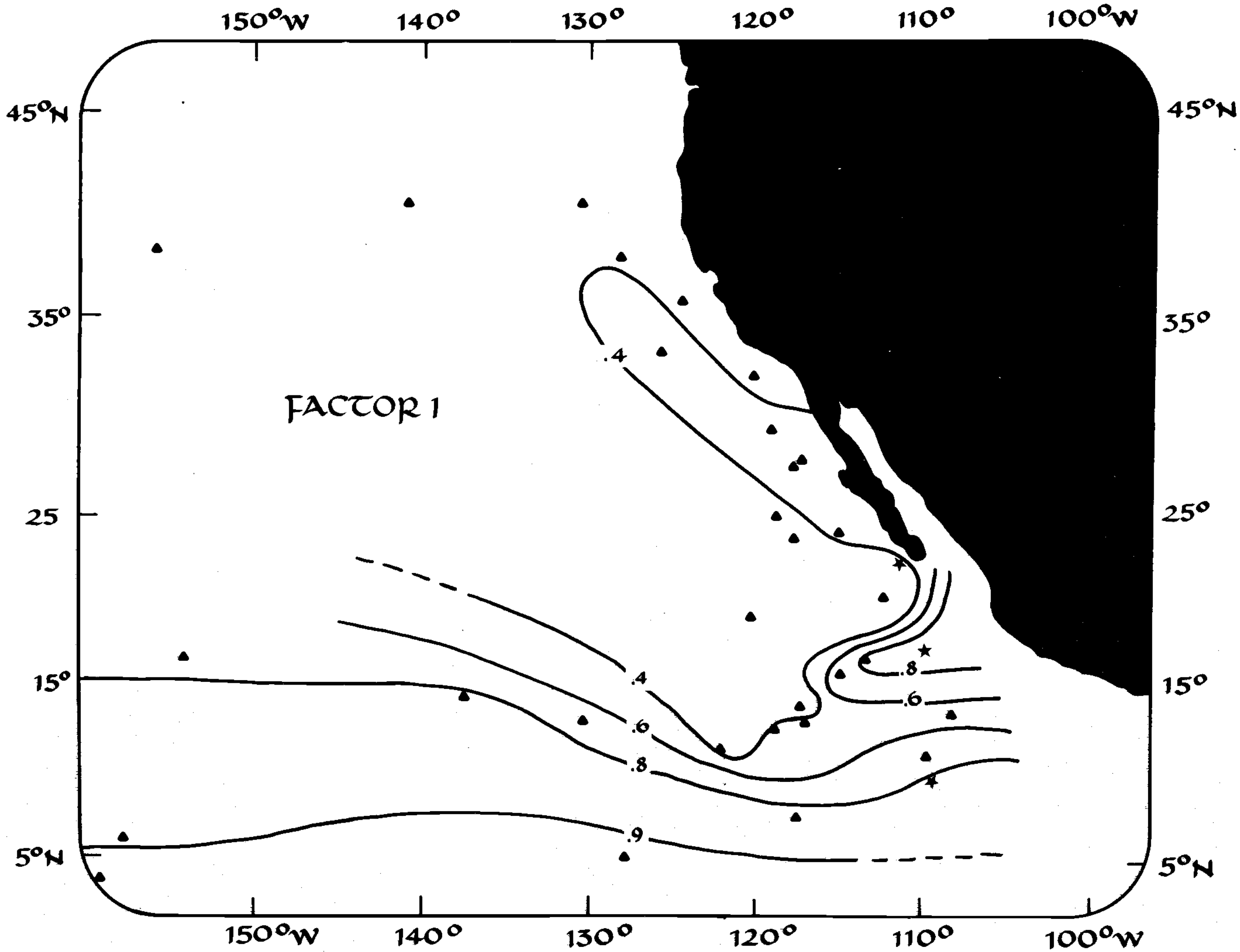



Figure 11. Distribution of radiolarian assemblage-factor 1. Contours are values of factor loadings (Appendix V). ● are surface samples; ★ are sites of downcore studies.

excellent agreement with the distributions determined by other workers. For example, Renz (1973) finds the Pyloniide group (equivalent to S54) in warm water. T. octacantha and O. stenozoa (S54) is dominant in the warm water assemblages of Dinkelman (1974) and Molina-Cruz (1975). These workers, along with Nigrini (1967, 1970) have also demonstrated the warm water preference of O. tetrathalamus, G. angulata, and S. astericus.

The second factor (Figure 12) accounts for 19.3% of the sample variation and is dominant where the California Current is best developed. The factor has high negative correlations with August ($r = -.85$) and February ($r = -.84$) sea surface temperatures and with August ($r = -.82$) and February ($r = -.84$) salinities. In the winter when the California Current is the strongest (Reid and others, 1958; Wyrtki, 1965a; Wyllie, 1966), surface temperatures and salinities are lower than at any other time of the year. In the summer when the current flow is less coherent (Reid and others, 1958) and further offshore, the temperatures and salinities are controlled by upwelling. Thus this factor should predominate during winter and spring when temperatures and salinities are low. The most important species are: Siphocampe aquilonaris (N48), Cycladophora davisiana (N29), Actinomma medianum (S9), Lithelius minor (S58), and Echinomma delicatum (S16). All of these species show a preference for cold water. The most important species in this assemblage, S. aquilonaris is important in the cold water assemblages of Moore (1973a), as is A. medianum. Robertson (1975) documented the cold water nature of C. davisiana in the Sea of Okhotsk , where it is abundant in surface sediments. L.

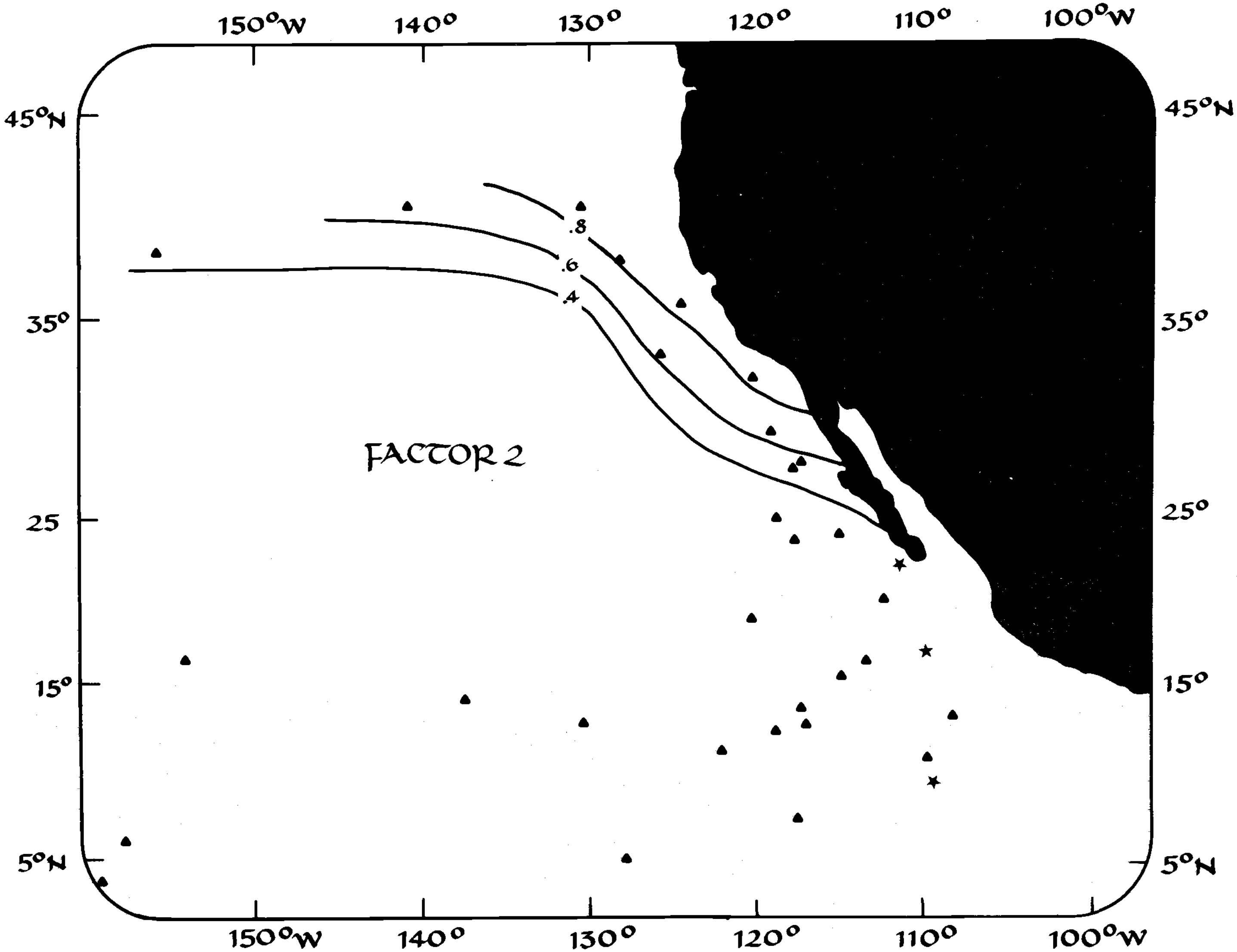



Figure 12. Distribution of radiolarian assemblage-factor 2. Contours are values of factor loadings (Appendix V). Symbols as in Figure 12.

minor dominates the "Chile factor" of Molina-Cruz (1975). The Chile Current is formed in a manner similar to the California Current, as high latitude low salinity cold water flows toward the equator. Moore (1973a), Sachs (1973a) and Dinkelman (1974) find this species is important in regions where temperatures and salinities are low, i.e. the subarctic North Pacific and the Panama Basin.

Factor three (9.9% of the sample variation) is most important where the California Current turns SSW under the influence of the NE trade winds (Figure 13). Here its waters are beginning to lose their characteristic low temperature and salinity due to mixing with waters from the west and south (Tibby, 1941; Reid and others, 1958) and flow west as the North Equatorial Current (Wyrtki, 1966). There is a strong front in this region where cool, low salinity California Current water meets warm, higher salinity water flowing out of the Gulf of California (Roden, 1958, 1971). This factor is believed to reflect the balance between the different water types.

D. pyriformis (S15), O. tetrathalamus (S25), Echinomma delicatum (S16) Hexacontium sp. c (S22) Actinomma medianum (S9), and Ommatodiscus sp. A. plus Stylodictya sp. A (S43) are the most important species in this assemblage. D. pyriformis (S15) dominates the warm water assemblage of Molina-Cruz (1975). E. delicatum (S16) prefers colder water (Moore, 1973a; Molina-Cruz, 1975). A. medianum is considered "transitional" of the mid-latitude species by Nigrini (1967). This combination of species with different temperature preferences suggests a mixing of radiolarian habitats. The great abundance of D. pyriformis and O. tetrathalamus in the sediment in this area suggests that these

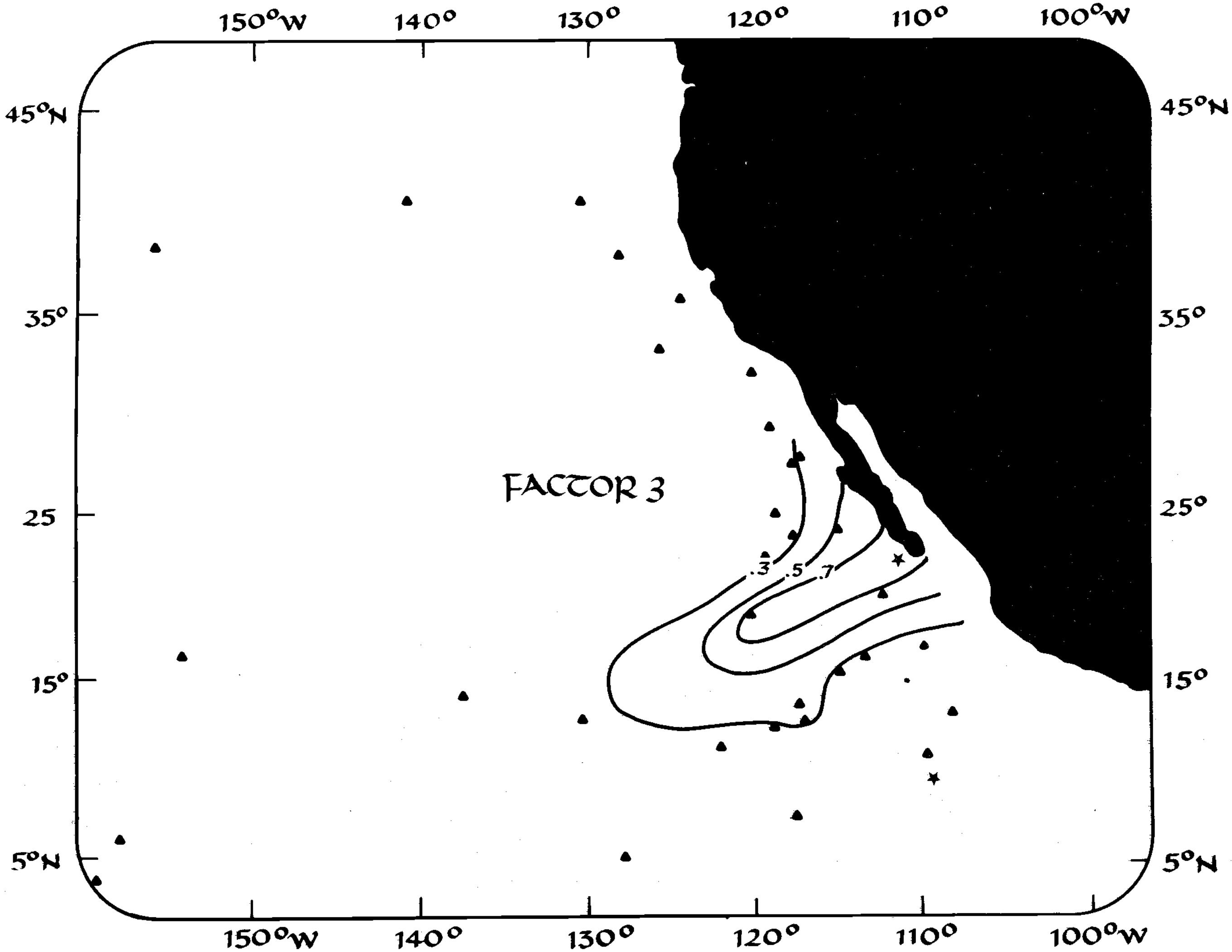



Figure 13. Distribution of radiolarian assemblage-factor 3. Contours and symbols as in Figure 12.

species live deeper in the water column in warm waters and their abundance increases when upwelling increases the fertility of their habitat. These species probably travel with tropical water as it moves north. Their presence in sediments may not always indicate overlying warm surface water. A similar situation, that of increased abundance due to increased fertility, superimposed on less favored temperature and salinity conditions, has been documented for the planktonic foraminifera Globorotalia menardii of the west coast of Africa by Thiede (1974).

There is a marked similarity between the isopleths of factor four (8.8% of the sample variance) (Figure 14) and those of the subsurface oxygen minimum layer ($O_2$ less than 10 ml/l) in this region (Figures 15a, b). Where this factor is dominant, the $O_2$ content of the water is less than 0.25 ml/l (Reid, 1962; Wyrkti, 1966a). This layer is thought to originate at levels where residence time of water is long due to slower circulation and the utilization of $O_2$ is high due to high productivity in the overlying surface layer (Reid, 1962). Changes in this factor may therefore reflect changes in $O_2$ content, in subsurface circulation and possibly changes in productivity.

The shape of this factor distribution may also reflect transport of tropical surface water by the California Countercurrent. This countercurrent flows all year and gives the waters beneath the California Current higher salinities and temperatures (as well as lower $O_2$ content) than they would have as a result of exchange processes only with waters of the California Current and of the North Pacific gyre (Wooster and Reid, 1970).

Ommatodiscus sp. A and Stylodictya sp. A (S43), Spongopyle

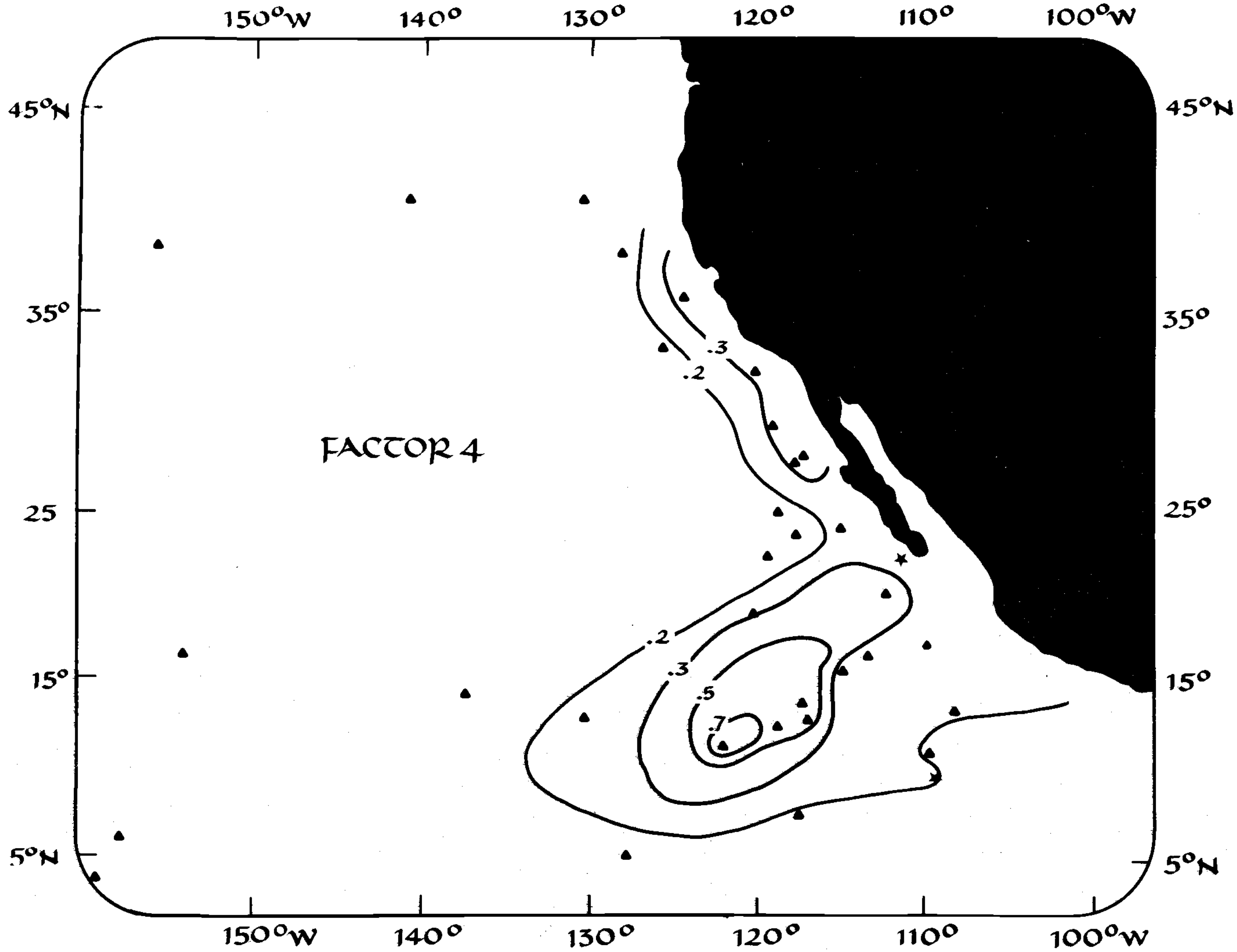



Figure 14. Distribution of radiolarian assemblage-factor 4. Contours and symbols as in Figure 12.

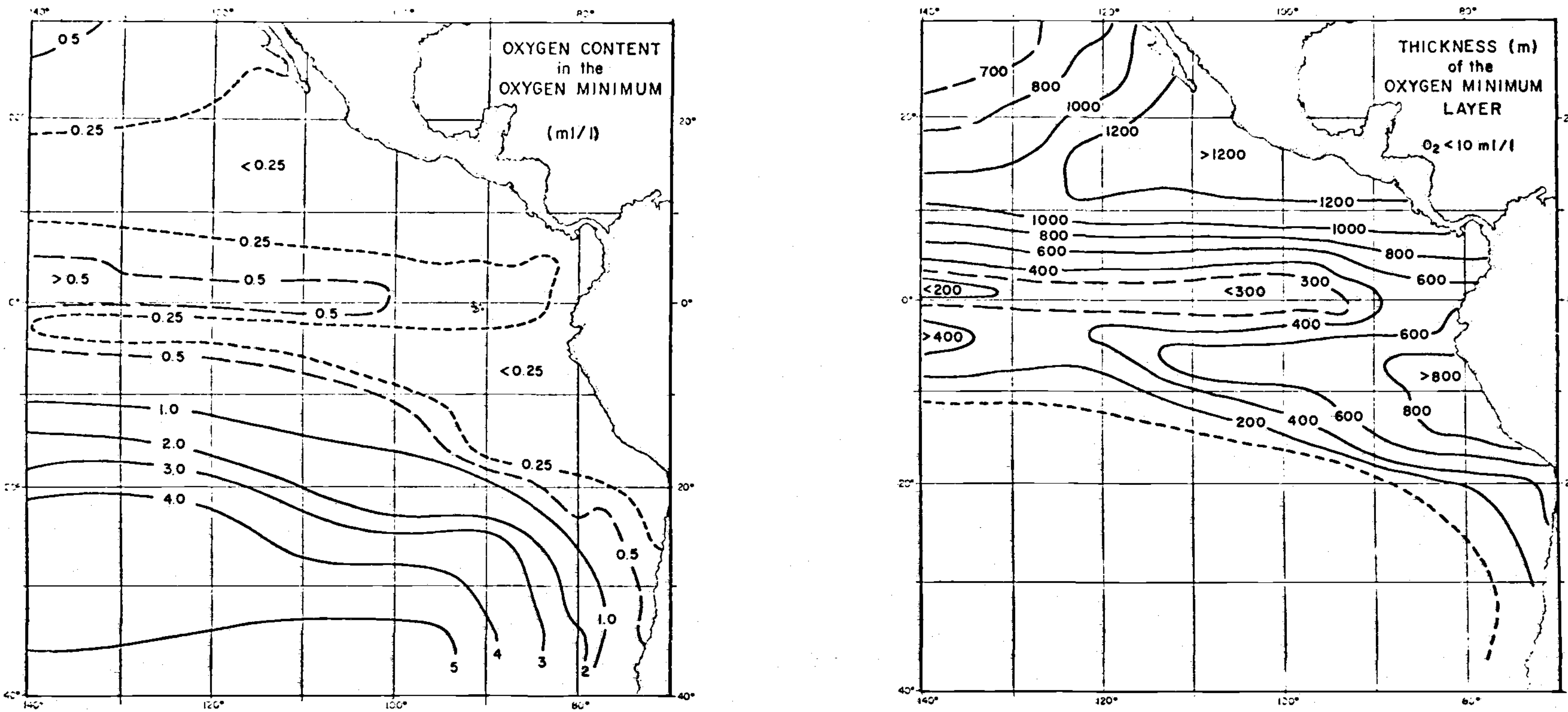



Figure 15. a. Oxygen content at 400-500 m. Contours in ml/l. From Wyrtki (1966).
b. Thickness of the layer in which oxygen content is less than 10. ml/l. Contours in meters. From Wyrtki (1966).

osculosa (S48), Spongodiscus setosus (S53), Stylodictya sp. B (S44), Carpocanium sp. A (N30), Theoconus minythorax (N41) and Euchitonia triangula (S39) comprise assemblage four. Unfortunately the most important species, Ommatodiscus sp. A, Stylodictya sp. A, S. osculosa, S. setosus, and Stylodictya sp. B, are among the most poorly defined taxonomically. Their genetic relationships to each other are unknown; their complex skeletal structures have only been minimally investigated. Therefore their geographic distributions are not well defined. The co-occurrence of them with the definitely tropical species. Corpocanium sp. A, T. minythorax and E. triangula (Nigrini, 1970; Moore, 1973a; Molina-Cruz, 1975) suggest that they have tropical affinities.

Casey (1966) found S. osculosa in plankton tows from 200 to 400 meters below the surface. Renz (1973) found that genera similar to Stylodictya have their maximum concentrations from 100 to 200 m below the surface. This plankton data lends credence to the idea that the subsurface California Countercurrent brings its endemic tropical fauna with it as it moves north, and supports the interpretation that factor four reflects subsurface oceanographic parameters rather than surface ones. It is logical that radiolaria show strong relationships with subsurface oceanographic parameters since the largest concentrations of living radiolaria in plankton are from below 75 m (Renz, 1973: Beers and Stewart, 1969, 1971).

In this part of the Pacific there is a shallow permanent thermocline (Wyrtki, 1965b) and hence a well stratified, stable water column. Without the development of a deep mixed layer, the radiolarian population is seldom exposed to the overlying surface conditions, and may respond mainly to oceanographic conditions at the level where they reside.

The area where factor 5 (6.0% of the sample variation, Figure 16) is important coincides with the presence of Tropical Surface Water (Wyrtki, 1966). This area is characterized by water temperatures greater than 25°C (Figures 2a, b) and average salinities are 34 o/oo (Figures 3a-d). Here there is an annual sea surface temperature variation of 2°C (Wyrtki, 1965b) and salinities are low because rainfall exceeds evaporation (Tully, 1964). In this part of the eastern tropical Pacific, Tropical Surface Water is found between 4°N and 15°N (Wyrtki, 1966). This water mass is limited in vertical extent to the thin mixed layer and is usually less than 50 m thick. The minor importance of this factor is probably due to the geographically restricted associated water characteristics and to the shallow nature of the water mass. Beers and Stewart (1969, 1971) have found the largest numbers of living radiolarians much deeper in the water column, ie. 100-150 m.

The most important species in assemblage five are Tholospira sp. (S59), Stylochlamidium venustum (S51), Polysolenia murrayana (S3), Theoconus minythorax (N41) and Theocorythium trachelium (S46). Molina-Cruz (1975) finds P. murrayana dominant in upwelling areas. P. murrayana, T. minythorax, and T. trachelium have similar distributions in equatorial sediments (Nigrini, 1968). P. murrayana and T. trachelium live very near the surface in waters overlying the Catalina Basin of the California coast (Casey, 1966).

The distribution of these species geographically and in the water

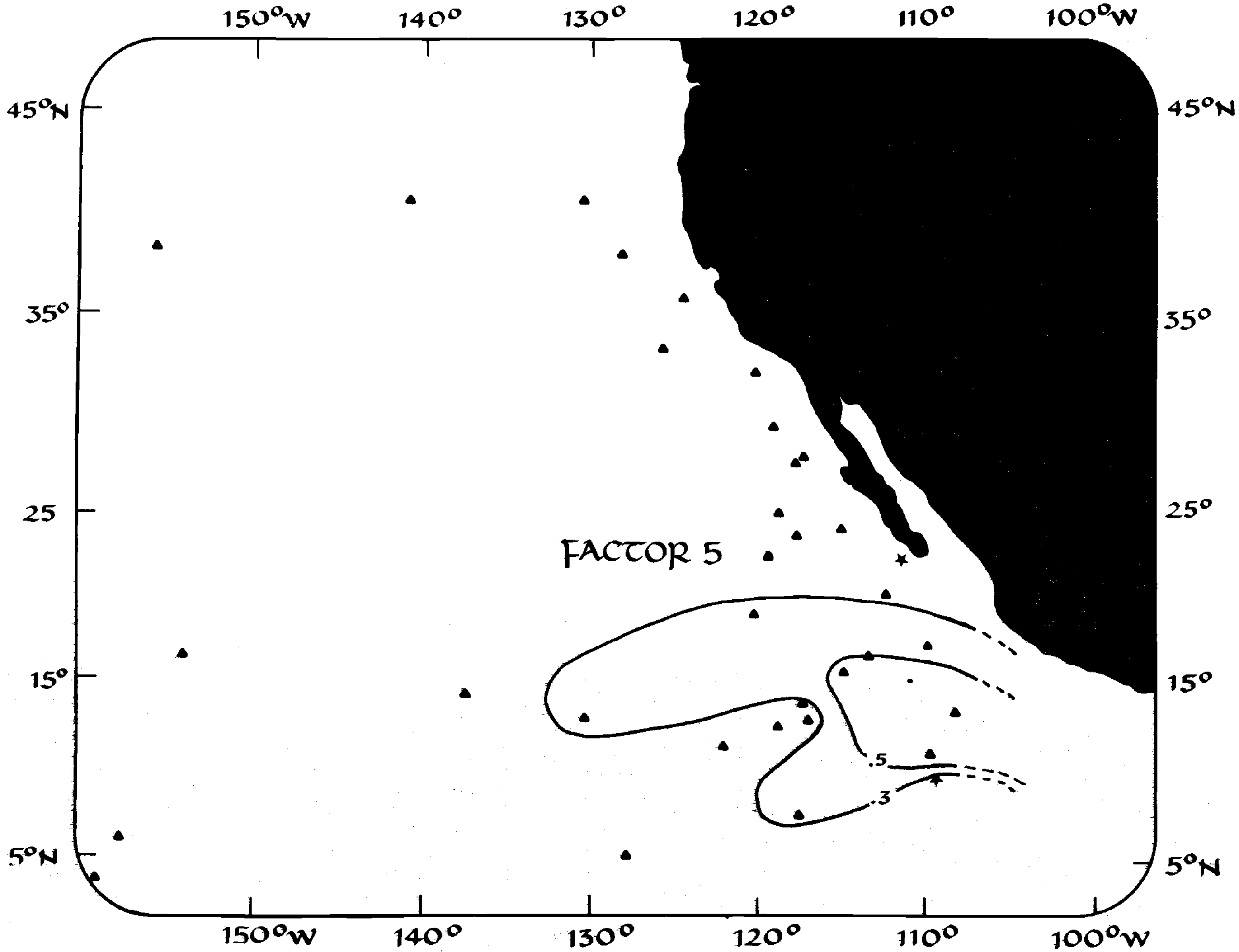



Figure 16. Distribution of radiolarian assemblage-factor 5. Contours and symbols as in Figure 12.

column lends support to the interpretation that this factor reflects the influence of the uppermost portion of the tropical water column. Tholospira sp. is considered a transitional form by Moore (1973a) and by Sachs (1973b) -- representing neither "cold" nor "warm" water. The presence of this species does not contradict the tropical water interpretation of this factor; to a great extent this water mass is transitional between warmer water to the south and colder water to the north.

Factor six (Figure 17) bears little resemblance to oceanographic conditions of the area but does bear inverse resemblance to the opal distribution (Figure 9). The samples in which this factor is important are very poorly preserved (visual inspection and comparison with other samples). This factor is most important where the opal in the sediments (and therefore input from above) contains some radiolarian but where dissolution has removed all but the most robust tests. As discussed previously the low sedimentation rates in most of this area combined with minimal input of siliceous tests lead to rapid dissolution of silica and poorly preserved and/or non-existant radiolarian taphocoenoces for most of this area. Johnson (1975) discusses this "balance" between rate of opal input and rate of dissolution. The samples in which this factor is of minimal importance contain a much more diverse fauna in which more delicate species are present.

Stylatractus sp. A (S30), Axoprunum stauraxonium (S11), Lithelius minor (S 58), Giraffospyris angulata (n4), Echinomma delicatum (S16), Cenosphaera sp. (S12) comprise assemblage six. All of these species, have thick tests and/or thickened structural elements which have minimal surface area compared to the thin, lacey tests of most other

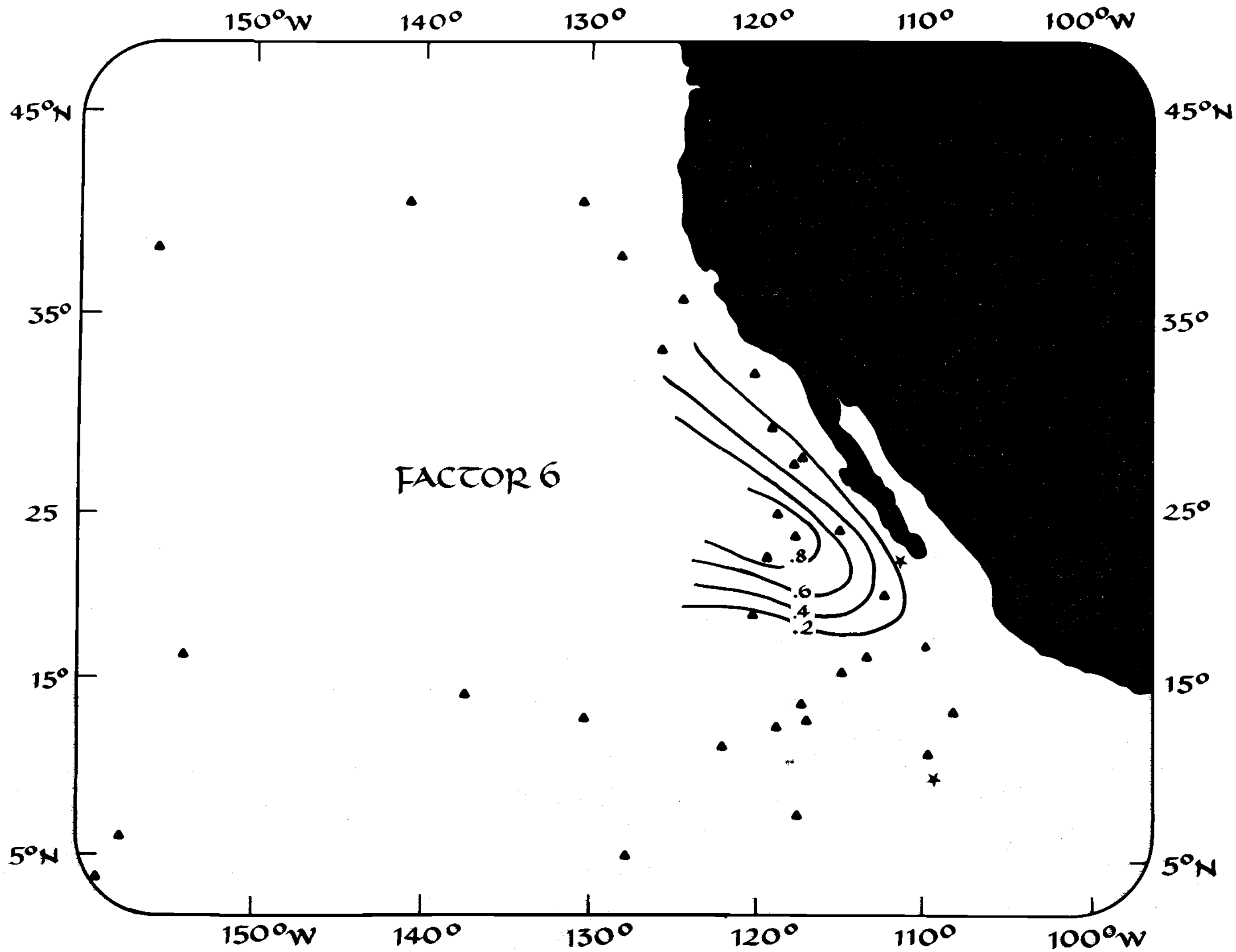



Figure 17. Distribution of radiolarian assemblage-factor 6. Contours and symbols as in Figure 12.

radiolaria. The dominant species of this assemblage, *Stylatractus* sp. A, is the most solution resistant polycistine radiolarian (Johnson, 1975). The samples dominated by this factor also contain a large proportion of the other siliceous fossils that Johnson (1975) ranks as highly resistant to dissolution: Collosphaerid radiolaria, Orosphaerid fragments, and sponge spicules. Many of the samples eliminated from tha faunal analysis contain these resistant skeletal elements fragments as their only biogenic siliceous remains.

## RESULTS OF DOWNCORE STUDIES

### BNFC 43 PG

Core BNFC 43 PG was taken at 10°29'N, 109°1.71'W in 2720 m of water. The sea surface temperature at this location ranges from a minimum of 26.7°C in winter to a maximum of 28.5°C in summer (Wyrtki, 1965b). The sea surface salinity ranges from a low of 33.5 o/oo after the rainy season to a high of 34.5 o/oo at the end of the dry season. This site lies on the edge of the Central Pacific Dry Zone, a band of ocean that extends from the west coast of Peru and Chile from 5° -10°S and south along the equator to 175°W (Palmer and Pyle, 1966), and receives essentially no rainfall from May to December. From February to April (Figure 2a) the Intertropical Convergence Zone (ITCZ) occupies its most southerly position; the associated atmospheric mixing causes rain. This area is characterized by a shallow permanent thermocline, the center of which ranges from approximately 60 m to 90 m in depth, and a thin mixed layer, seldom thicker than 50 m (Wyrtki, 1965b). This area is under the influence of the eastward flowing Equatorial Counter Current from June through October and from November through May under the westward moving return flow of the ECC as it joins the water of the California Current to form the NEC.

The age levels (Figure 7) in BNFC 43 PG were determined by correlating the $\delta^{18}O$ curve of the core with the $\delta^{18}O$ curves and time scales determined by Broecker and van Donk (1971), Luz and Shackleton (1975) and Molina-Cruz (1975). This core contains a record of the Wisconsin glacial epoch from 75,000 yrs. BP.

Analysis of Radiolarian Fauna

The present-day radiolarian fauna of this core is dominated by factor-assemblage 1 which accounts for 79% of the variance of this sample. The other factor-assemblages contribute little to the characteristics of this sample today. Therefore, any increase in these other assemblages should represent significant changes in the oceanography of overlying waters.

During the last 75,000 years B.P. represented by the core, factor one loadings are lower than at present (Figure 18; Appendix VII) as the radiolaria comprising this assemblage are not as abundant downcore. Because this factor has been shown to reflect the presence of the warmest waters of the Eastern Tropical Pacific, the Equatorial Pacific Water, it can be inferred that this water was somewhat cooler than today, and/or that less of it was transported into the locality of this station. The values of correlation coefficients of sea surface temperatures and this factor are on the order of 0.6, implying that lower water temperatures can be only part of the explanation. The average correlation coefficient between factor one and surface salinities is 0.5, indicating that salinity changes may also be indicated by the lower factor one loadings.

Factor two has been related to the influence of cool, low salinity waters of the California Current. Obviously, the California Current never penetrates as far south as 10°N, but the strong negative correlations between factor two and February and August sea surface temperatures and salinities ($r = -0.84$) are still of significance. From

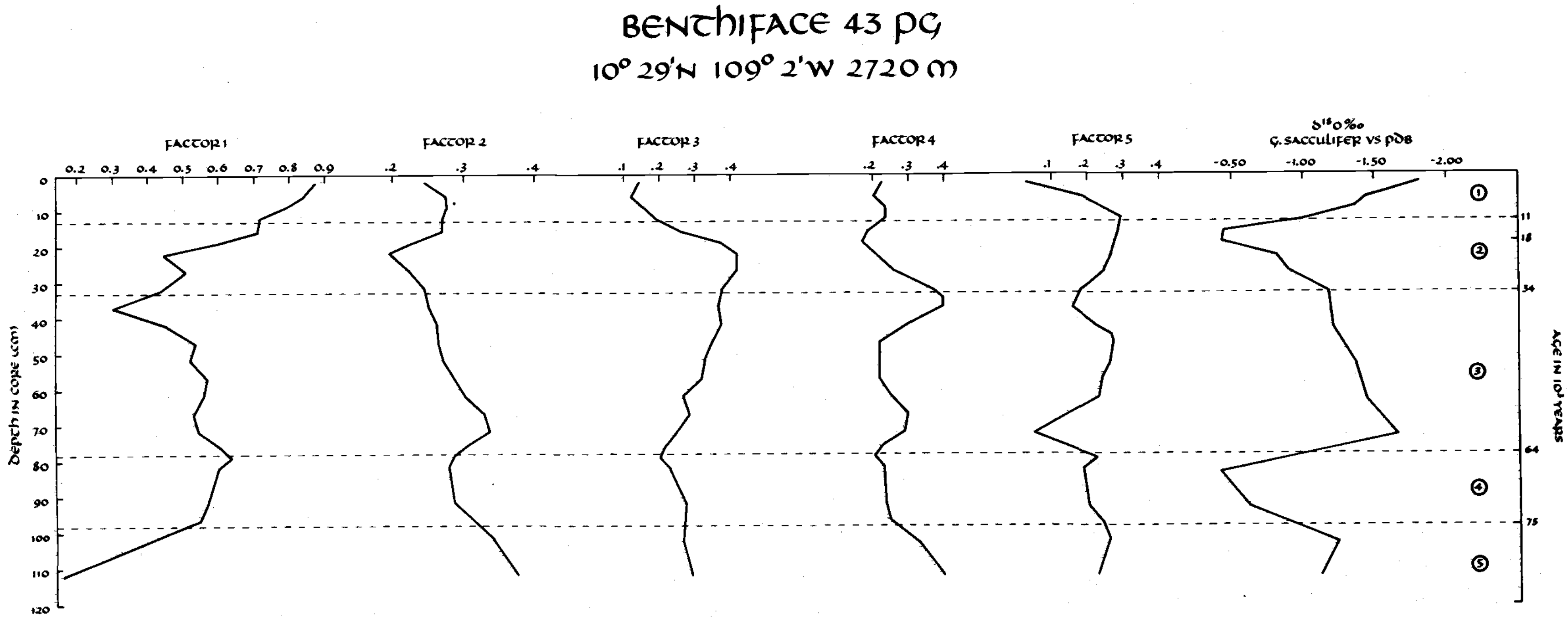



Figure 18. Downcore variation of factors for BNFC 43 PG. Curves shown are three-point moving averages of individual sample values. Circled numbers are isotope stages of Emiliani (1966).

Figure 18 it can be seen that during stage 4 and most of stage 3, factor two was more important than today. The variations in factor two indicate that a radiolarian fauna which preferred somewhat cooler, less saline water was more abundant at this station during most of the last glacial. This again implies cooler, less saline water at that time than now.

Factor 2 decreases just before the glacial maximum 18,000 years BP. This decrease coincides with the increase in the $\delta^{18}O$ values (greater $^{18}O$ content of foraminiferal tests) at this time. This is significant in relating $\delta^{18}O$ variations to climatic changes. The increase in $^{18}O$ (relative to some standard) in a foraminifera shell means an increase in the amount of $^{18}O$ present in the shell and may be the result of an increase in the amount of isotopically light water stored in ice sheets or a lower temperature at which the shell growth and fractionation occurred. If a decrease for factor two is accepted as an increase in water temperature, then at least at this station the $\delta^{18}O$ values are a record of ice volume.

During isotope stage three, factor three becomes increasingly dominant and reaches a maximum just before the glacial maximum at 18,000 yrs BP. This factor has been related to the water of the NEC which is formed as the CC turns westward under the influence of the tradewinds and mixes with the northeastward flowing water of the ECC. It reflects the strength of the NEC and thus the position of the NE trades. Wyrtki (1974) has shown that when NE trades are more northerly (during the fall) the winds coincides with the position of the NEC and reinforces its flow. The time variation of factor three therefore indicates a NEC growing in strength and constrained position of the NE trades. The rather sharp decrease in factor three after 18,000 yrs BP could indicate an easing or "loosening" of tight atmospheric gyre circulation -- ie. the NE trades could advance south and retreat north again. It may also indicate a decrease in the strength of the trades.

During stage four, factor four which shows an inverse correlation to $O_2$ concentrations had the same low loadings it has today, indicating perhaps a similar distribution of $O_2$ concentrations. During stage three, the average value of the factor loadings is higher and the peaks are significantly higher, suggesting a "stronger" $O_2$ minimum layer. This suggests a possible decrease in the $O_2$ content due to sluggish subsurface circulation outside the gyre margin and minimum lateral replacement. In addition, any increase in fertility may have strengthened the $O_2$ minimum layer by increasing the amount of organic debris falling through the water column and being oxidized.

From 75,000 to 11,000 years BP factor five, which is associated with warm, low salinity water, was much more dominant on the average than today. This suggests a more southerly position of the water characteristics associated with this factor, as the location of the highest loadings at present (Figure 18) is north of the core site. This in turn suggests a decrease in the northern extent of warm surface waters, and a constriction of the tropics. The three large decreases in this factor come after 64,000 yrs BP (the four-three boundary), before 34,000 yrs BP (the three-two boundary) and after 11,000 yrs BP (Termination I). It appears that near the isotope stage boundaries, the conditions (no large decrease in insolation between seasons and an excess of rainfall over evaporation) required for the formation of Tropical Surface Water were altered. At these times there apparently were much larger seasonal differences in insolation and either a balance between rainfall and evaporation or perhaps evaporation exceeded rainfall.

Factor six (Appendix VII), the dissolution factor, has an average downcore loading of -0.06 and a maximum loading of -1.3 at one level in the core. The lack of significant downcore variations in this factor suggest little change in dissolution of radiolaria at this station, and generally good preservation of radiolaria throughout the last 75,000 years.

## Estimated Paleotemperatures

Ancient temperatures at the sea surface and at 133 m depth for February and August were estimated for the age levels represented by downcore samples. Variations in sea surface temperatures are the most readily interpreted in terms of climatic change (ie. warmer or colder). Temperatures deeper in the water column combined with sea surface temperatures should provide insights into changes in the circulation and thermal structure of the uppermost ocean layer.

Since the standard error of estimate of the paleotemperatures is of the same order of magnitude as the differences between past and present temperatures (see Appendix X), it is difficult to state with certainty that at any given time in the past the sea surface temperature was 2.0 C colder than today. It seems more reasonable to accept the sense of the temperature change, warmer or colder, than its numerical value.

During isotope stages 4, 3, and 2 the average February sea surface temperature at BNFC was about 2°C colder than at present (Figure 19; Appendix X). The average August temperature is only slightly cooler than at present. This larger seasonal difference implies less heating during winter, perhaps due to more cloud cover. The large decreases in August temperature coincide with the decreases in February temperature at approximately 60,000 yrs BP and at 20,000 yrs BP. According to Wyrtki (1965b) the lower boundary of the permanent thermocline is just above 133 m ($\Delta T°C < 0.3°C/10$ meters). This level of February temperatures during the last 75,000 yrs were generally colder than they are today. Toward the end of isotope stage 5 and through stage 4, the winter temperature increased slowly and then suddenly decreased just after the stage four-stage three boundary at 64,000 yrs BP. It increased again through stage three, dropped sharply near Termination I (11,000 yrs BP) and subsequently rose to the present value.

Estimated colder temperatures at 133 m depth indicate a rising of the thermocline or an increase in the vertical thermal gradient. Both imply a more stable, well-stratified ocean below the mixed layer. Summer temperature at 133 m shows a somewhat similar trend, but is about 1°C warmer. If the temperature difference is real, this may indicate the presence of a shallow summer thermocline, or a thicker mixed layer. It is possible that during glacial times this area had a deeper mixed layer and the shallow summer thermocline.

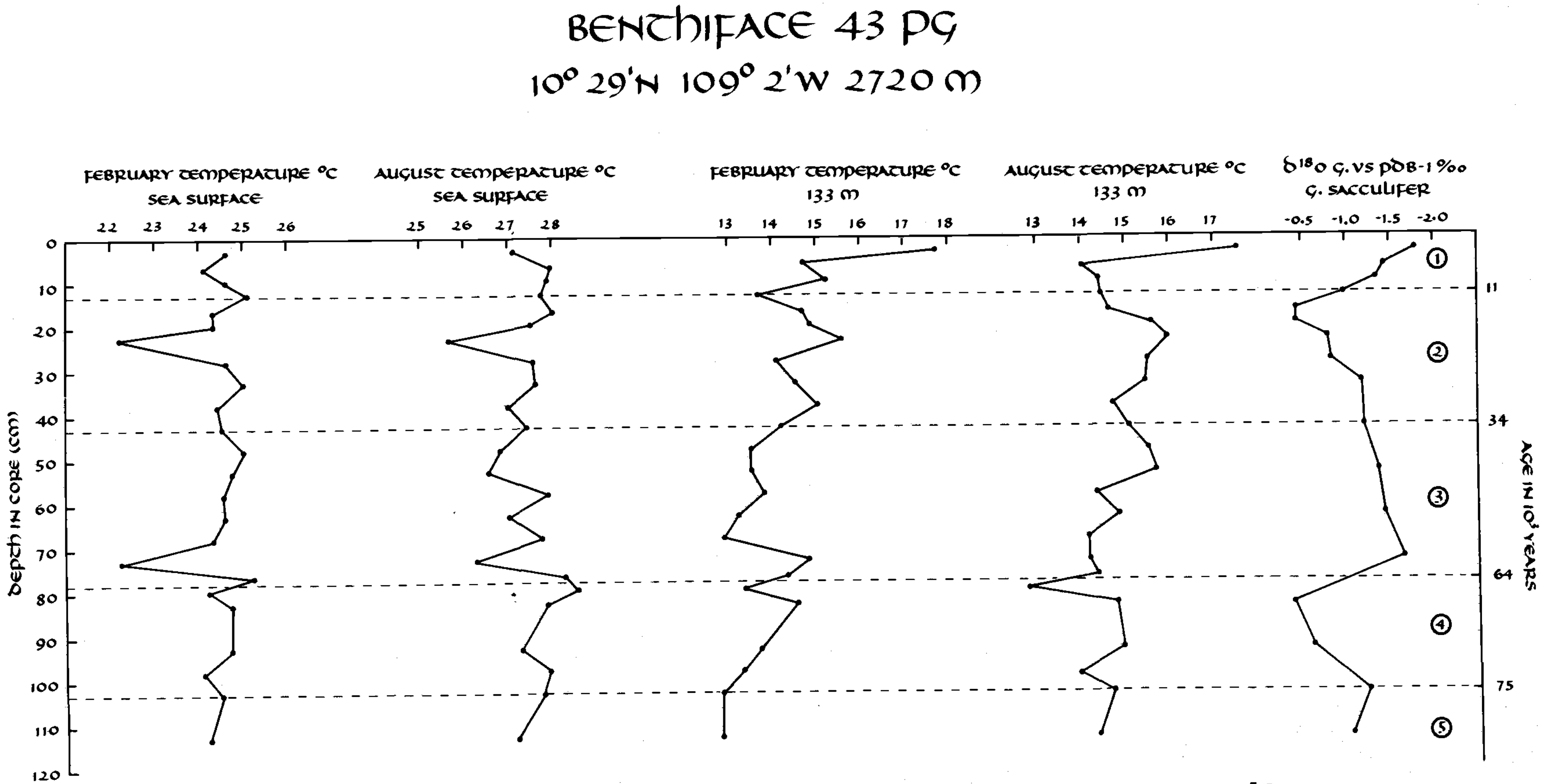



Figure 19. Estimated paleotemperatures for BNFC 43 PG, plotted against $\delta^{18}O$. Circled numbers are isotope stages of Emiliani (1966).

## LAPD 1G

LAPD 1G was taken at 22°53'N, 110°51'W in 2322 m of water. The temperature ranges from a February minimum of 21.5°C to an August maximum of 27.8°C (Wyrtki, 1965b; Robinson and Bauer, 1971). There is a small salinity change of 34.4 o/oo to 34.5 o/oo from February to August. According to Wyrtki (1965b) the station is characterized by a shallow permanent thermocline, the center of which varies from 60 m to 90 m below the sea surface and a thin mixed layer which averages 45 m in thickness.

This station is under the influence of the low salinity, cool California Current which has mixed with warmer, more saline water from the tropics and the Equatorial Countercurrent, to form water of the North Equatorial Current. This site is also affected by the very warm saline water emerging from the Gulf of California, as the station is situated very close to its mouth. The NE tradewinds also play a role in determining the oceanography of this area, as the strength of the North Equatorial Current and the Equatorial Countercurrent are a function of the position of the tradewinds (Wyrtki, 1974).

From February to April this station is dominated by the California Current which provides most of the water to the NEC (Figure 2a). The region feels only minor influence of tropical (warmer, more saline) waters and during this time there is no Equatorial Countercurrent this far to the east. From May to July, the Countercurrent is present but weak, and the California Current is still the major water supply of the NEC. From August to December (Figure 2b), the California Current does not extend as far south, the Equatorial Countercurrent is fully developed and both supply water to the NEC.

The age levels in this core were determined from the correlation between the downcore variation of three tropical radiolarian species in this core and BNFC 43 PG as stated in the Methods section and shown in Figures 8a and 8b.

## Analysis of Radiolarian Fauna

The present day assemblage is dominated by radiolarian species of factor assemblage three, that is associated with the NEC and the mixing of California current water and tropical waters. It accounts for 77% of the sample variance. Assemblages one and two account for 12% and 7% of the sample variance, respectively.

Warm water Assemblage One is less dominant in this region during isotope stages three and two than it is today (Figure 20; Appendix XI). This indicates less water of this type and less influence of this water on the fauna. It may be that there was less tropical water available for transport into the area. This factor grows in importance during isotope stage one and peaks at a level that could represent the hypsithermal (7,000 yrs BP) when climatic conditions were thought to be warmer than today (Flint, 1971). It is possible that at this time there was a large pool of warm saline water available for transport into this area.

Factor two (Figure 20) shows the increasing influence of the water of the California current on the fauna at this station. This factor grows in importance through isotope stages four and three,

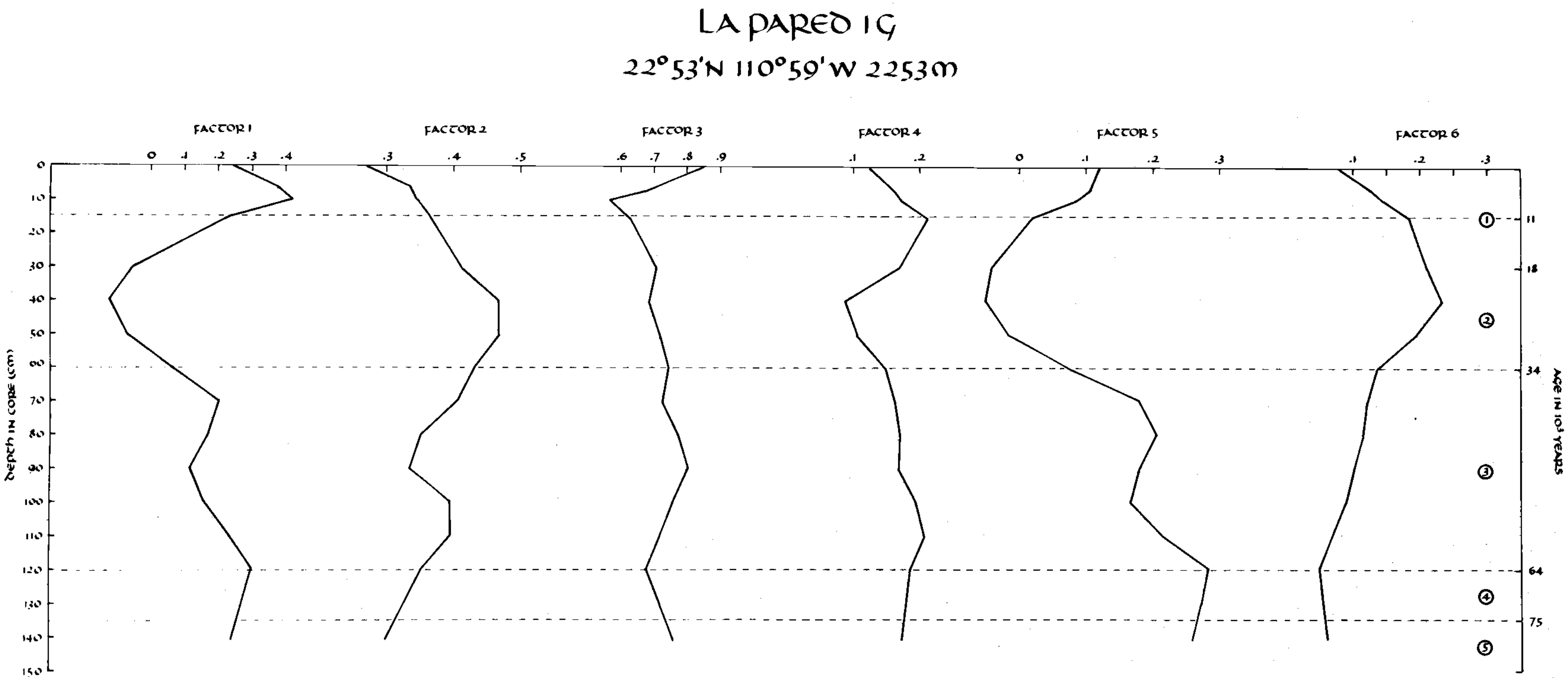



Figure 20. Downcore variation of factors for LAPD 1G. Circled numbers are isotope stages of Emiliani (1966).

reaches its maximum expression before the time of maximum ice cover (18,000 yrs BP) and then gradually drops to present day levels. This implies that during glacial times the influence of the California Current was stronger in this region, and that a coherent California Current extended further south than today.

Factor assemblage three (Figure 20) dominates the present day fauna and also dominates the area during glacial times. The factor is only weak during isotope stage one, after Termination I (11,000 yrs BP), probably during the hypsithermal. This constancy suggests that NEC has not varied much through glacial times and that there has continually been mixing of California Current water with tropical waters to form the NEC. The sharp drop in this factor during the hypsithermal implies less mixing of water types especially in conjunction with the drop in factor two (Curve B) which suggests less influence of the California Current. It is also possible that the tradewinds occupied a more southerly position during this time.

During isotope stages four and three, factor four (which is associated with the oxygen minimum layer) was more important than it is today. Since this factor varies inversely with $O_2$ content, higher factor loadings indicate lower $O_2$ in the water column, and therefore slower subsurface mixing and replenishment and/or greater $O_2$ utilization as organic debris is oxidized. Higher factor loadings result from greater numbers of radiolarian species comprising this assemblage, which suggests increased fertility of this layer (water) during stages four and three, as well as other favorable conditions like optimum temperature and salinity. During stage 2 there is a decrease in this factor suggesting higher $O_2$ content, increased subsurface circulation, and decreased fertility. Factor four increases toward Termination I (11,000 yrs BP), peaks near the hypsithermal and then decreases toward the present.

There is a slow decrease in the importance of factor four (associated with Tropical Surface Water) through glacial times which reaches a minimum in isotope stage two just before the 18,000 yrs BP glacial maximum. This indicates that during stage two, Tropical Surface Water was restricted to areas further south, and that the fauna in this assemblage were not being carried in large numbers into the waters at this station. The higher factor loading during stages four and three indicate the presence/influence of Tropical Surface Water at this site, perhaps remnant from the previous interglacial. After the 18,000 yrs BP this factor becomes more important, but it never attains the significance it had previous to the glacial maximum.

Factor six, representing dissolution, explains little of the sample variance and its maximum factor loading is 0.29. There does appear to be an increase in factor six during glacial times, thus implying an increase in dissolution of silica during glacial times. This increased is pronounced during stage two just before 18,000 yrs BP.

## Estimated Paleotemperatures

At this station estimated February sea surface temperatures (Figure 21; Appendix X) were generally higher than present during isotope stages four, three and two, while estimated August sea surface temperatures are somewhat lower than at present. It is possible that

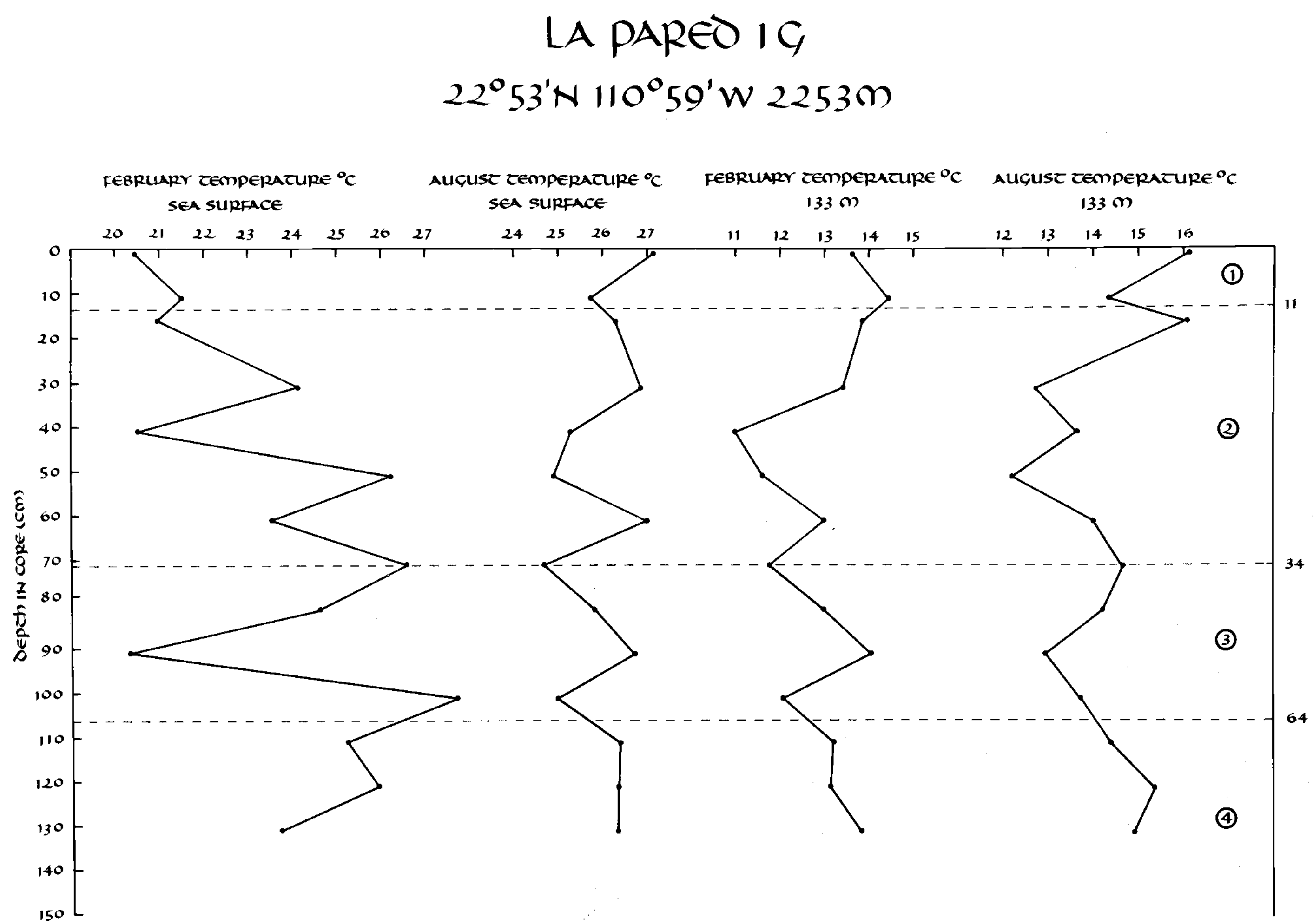



Figure 21. Estimated paleotemperatures for LAPD 1G. Circled numbers are isotope stages of Emiliani (1966).

the high February temperatures reflect warm water from the Gulf of California mixing with or overriding denser California Current water, as there is no other source of warm water available, and increased insolation seems unlikely. Today, warm saline surface water is transported out of the Gulf when northerly winds prevail from November to April (Roden, 1958, 1971). Colinvaux (1972) and Newell and others (1975) have postulated decreased cloud cover and increased aridity at low latitudes during the last glacial maximum, which might logically result in higher surface water temperatures in the Gulf during stages four, three and two.

Today from May through November occasional winds from the south (hurricanes, in September and October) transport tropical water into the Gulf at the surface. The low August paleotemperatures (Figure 21) imply colder open ocean tropical water during glacial times.

At this site there was no large decrease in temperature at the glacial maximum. There was a decrease in temperature just before 18,000 yrs BP, an increase at 18,000 yrs BP and then the progression to present day temperatures. There is no sea surface temperature indication of the hypsithermal.

There is a definite decrease in February and August subsurface temperatures during stages three and four (Figure 21), then an increase up through stage one to the present. Colder temperatures at depth suggest a steeper thermal gradient or a rising of the thermocline. It may also represent an increase in upwelling of cooler water from below.

# SUMMARY AND CONCLUSIONS

In the waters overlying BNFC 43 PG at 10°27'N, 109°2'W during isotope stages four, three and two the faunal evidence indicates that there was less warm, saline Equatorial Surface Water, an increase in Tropical Surface Water, a strong Equatorial Countercurrent, an increase in the North Equatorial Current, and a decrease in the $O_2$ content of the subsurface layer. There is also evidence for an increase in the thermal gradient of the thermocline, a thicker mixed layer, an increased upwelling, a small decrease in surface water temperature, and a large temperature change between seasons.

In the waters overlying LAPD 1G at 22°53'N, 110°W, there is faunal evidence for a decrease in Equatorial Surface Water, a decrease in Tropical Surface Water, a stronger Equatorial Countercurrent, a strong North Equatorial Current, an increased southward extension of the California Current and a change in the $O_2$ minimum layer. There is also evidence for an increase in the thermal gradient of the thermocline, a thicker mixed layer, warmer winter temperatures, similar summer temperatures and a smaller temperature change between seasons.

Though it is difficult to create a regional picture of the paleo-oceanography of the northeastern tropical Pacific from only two cores, an attempt is valid because these stations (1) presently share the same thermal structure of a thin mixed layer and shallow permanent thermocline; (2) the present overlying water are closely related as they are influenced by the same current system.

During the last 75,000 yrs BP it appears that the areal extent of warm saline Equatorial Surface Water was diminished, as temperatures decreased in the Pacific Ocean (the isotherms were shifted south). Warm, less saline Tropical Surface water did not extend as far north as it does today. This surface water mass was probably somewhat thicker due to an increase in the thickness of the mixed layer. There was a sharp thermocline with a large thermal gradient creating a well stratified, stable ocean. The $O_2$ minimum layer decreased near 22°N and increased near 10°N implying stronger gyre margin circulation, and more sluggish circulation south of the gyre. The California Current, North Equatorial Current, and Equatorial Countercurrent appear to have been stronger. The California Current and the Equatorial Countercurrent exhibit smaller seasonal shifts in position. The NE trades and the ITC also experience smaller seasonal fluctuations in position and were probably located somewhat further south of their present average position.

These conclusions are in agreement with those of other workers in the eastern tropical Pacific. For example, Luz (1973), Dinkelman (1974), and Molina-Cruz (1975) all find evidence of increased gyre margin circulation. Luz (1973) postulates a breakdown of the $O_2$ minimum near the gyre margin. Molina-Cruz (1975) suggests increased vigor and a more northerly mean position of the SE tradewinds. This together with a more stationary mean NE trade wind implies a shrinking of the "tropical" region between the two gyres of the Pacific, which is a reasonable model of the oceanography of the eastern tropical Pacific during a period of marked global cooling.

This study demonstrates the validity of the assumption that radiolarian skeletal assemblages in the sediment accurately reflect the oceanography of the overlying surface waters. Even without good statistical correlation, the assemblages can be clearly shown to be associated with distinct oceanographic features. By studying these assemblages downcore one can model ancient oceanography.

In modern sediments six radiolarian assemblages or factors have been determined which are associated with Pacific Equatorial Water, the California Current, the North Equatorial Current, Tropical Surface Water, an oxygen minimum layer, and silica dissolution. In the two cores studied there are major downcore changes in the importance of the different factors and in estimated paleotemperatures. Each station records a significant change (decrease or increase) in factors near the isotope stage boundaries. It appears that with the onset of glaciation near the stage five - stage four boundary, sea surface temperatures were lower than at present or were dropping. Oceanographic conditions were more stable until the middle of stage three, when changes occur in the surface waters. Large changes occur at the stage three - stage two boundary, which is considered the onset of the last period of large scale ice accumulation. From these changes it appears that the transition from "warmer" to "cooler" conditions and the accompanying changes in surface oceanography is fairly rapid (on the order of five to ten thousand years). However, the magnitude of the change (ie. how much cooler the earth becomes) affects the rate at which oceanographic conditions respond. There is evidence for large warm water masses developed during the previous interglacial being maintained after the onset of early Wisconsin glaciation (75,000 yrs BP). As the maximum ice accumulation 18,000 yrs BP is approached, the warm water "signals" essentially disappear and become important again only after Termination I 11,000 yrs BP.

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# APPENDICES

# APPENDIX I

## Surface Sample Identification

| Core | Water Depth (m) | Type of Core | Sample Depth in Core (m) | | Latitude | Longitude | Accession Number<br>S = SIO<br>L = Lamont-Doherty<br>O = OSU |
|---|---|---|---|---|---|---|---|
| IDEN V20-29 | 4116 | PC | 0 | | 8.09 | 117.05 | ML03423 |
| IDEN V20-57 | 5106 | PC | 0 | | 17.21 | 153.52 | ML03426 |
| IDEN V20-90 | 5991 | PC | 0 | | 38.48 | 155.37 | ML03433 |
| IDEN V24-64 | 3933 | PG | 0 | | 4.10 | 159.04 | ML03986 |
| IDEN V24-65 | 4726 | PG | 0 | | 6.40 | 157.32 | ML03987 |
| IDEN LFGS-48G | 4617 | GC | 3 | 5 | 38.35 | 127.45 | MS05229 |
| IDEN LFGS-68G | 3922 | GC | 2 | 4 | 35.33 | 124.05 | MS05232 |
| IDEN SCAN-5PG | 3268 | GC | 0 | 2 | 41.03 | 130.04 | MS05242 |
| IDEN SCAN-6PG | 4544 | GC | 0 | 4 | 41.04 | 140.35 | MS05243 |
| IDEN RIS-3G | 3935 | GC | 0 | 4 | 24.15 | 117.21 | MS05246 |
| IDEN TRI-10GO | 4121 | GC | 2 | 4 | 22.27 | 119.10 | MS05256 |
| IDEN ZAP-G2 | 3640 | GC | 0 | 4 | 17.52 | 109.31 | MS05267 |
| IDEN TRI 7G | 3697 | G | 0 | 2 | 17.30 | 113.00 | MS06653 |
| IDEN TRI 11G | 4025 | G | 0 | 2 | 23.19 | 119.00 | MS06679 |
| IDEN TRI 12G | 4180 | G | 0 | 2 | 25.28 | 118.25 | MS06697 |
| IDEN TRI 5G | 4039 | G | 0 | 2 | 12.38 | 96.21 | MS06702 |
| IDEN V28 165 | 4155 | TW | 2 | 3 | 14.46 | 116.56 | ML05713 |
| IDEN RC10 90 | 4261 | TW | 2 | 3 | 13.46 | 116.38 | ML05714 |
| IDEN V28-168 | 545 | TW | 0 | 1 | 13.30 | 119.42 | ML06715 |
| IDEN RC 10 91 | 4471 | TW | 0 | 1 | 12.16 | 120.99 | ML05716 |
| IDEN V28 167 | 4208 | TW | 2 | 3 | 13.27 | 118.25 | ML06717 |
| IDEN ZTS 7 44G | 4569 | G | 4 | 6 | 31.18 | 133.00 | MS06718 |
| IDEN ZTS 7 43 | 4569 | G | 2 | 3 | 31.06 | 134.58 | MS06726 |
| IDEN ZTS 7 46 | 4526 | G | 5 | 7 | 31.23 | 131.03 | MS06734 |
| IDEN MSN 157 | 4414 | G | | | 24.18 | 126.30 | MS06742 |
| IDEN ZTS 7 42 | 4672 | G | 2 | 4 | 31.10 | 135.57 | MS06743 |
| IDEN FAN HMS 1 | 3690 | G | 0 | 2 | 28.12 | 117.15 | MS05782 |
| IDEN FAN HMS 2 | 2970 | G | 0 | 2 | 30.17 | 118.14 | MS06790 |
| IDEN FAN HMS 3 | 3535 | G | 0 | 2 | 30.06 | 118.42 | MS06806 |
| IDEN RC10-240TW | 3598 | TW | 0 | 2 | 16.37 | 114.31 | ML08053 |
| IDEN RC12-46 TW | 4072 | TW | 0 | 2 | 20.32 | 118.48 | ML08054 |
| IDEN RC10-242 TW | 3835 | TW | 0 | 3 | 14.21 | 107.53 | ML08055 |
| IDEN RC12-52 TW | 4909 | TW | 0 | 2 | 13.49 | 129.56 | ML08056 |
| IDEN RC12-51 TW | 4660 | TW | 0 | 2 | 15.08 | 127.41 | ML08057 |
| IDEN RC10-249 TW | 3233 | TW | 0 | 2 | 7.19 | 87.03 | ML08058 |
| IDEN RC10-80 TW | 3288 | TW | 0 | 2 | 11.54 | 109.17 | ML08059 |
| IDEN RC15-13 TW | 5009 | TW | 0 | 2 | 17.25 | 134.07 | ML08060 |
| IDEN RC10-248 TW | 3493 | TW | 0 | 2 | 8.27 | 91.33 | ML08061 |
| IDEN RC12-47 TW | 4226 | TW | 0 | 2 | 19.52 | 119.52 | ML08062 |
| IDEN RC10-246 TW | 3884 | TW | 0 | 2 | 9.41 | 95.20 | ML08063 |
| IDEN RC13-123 TW | 5535 | TW | 0 | 3 | 28.34 | 162.56 | ML08064 |
| IDEN Y73-2-5MG | 3395 | MG | 0 | 1 | 14.15 | 104.50 | MO08932 |
| IDEN Y73-2-4MG4 | 4138 | MG | 0 | 2 | 24.35 | 114.35 | MO08939 |
| IDEN Y73-2-3MG1 | 3957 | MG | 0 | 1 | 29.13 | 116.50 | MO08946 |
| IDEN LAPD-1G | 2322 | GC | 0 | 2 | 22.53 | 110.59 | MS08956 |
| IDEN BNFC-43 | 2720 | PG | 2 | 4 | 10.29 | 109.01 | MS09061 |
| IDEN RC12-43 | 3336 | TW | 0 | 2 | 20.59 | 111.59 | ML09234 |
| IDEN Y74-2-22 MG 2 | 3054 | MG | 0 | 2 | 23.44 | 112.26 | MO09761 |
| IDEN Y74-2-18MG | 2795 | MC | 0 | 2 | 24.42 | 116.06 | MO09773 |
| IDEN Y74-2-16MG | 3670 | MC | 0 | 2 | 25.24 | 119.02 | MO09778 |
| IDEN Y74-2-31MG1 | 3590 | MG | 0 | 2 | 20.15 | 113.57 | MO09788 |
| IDEN Y74-2-34MG4 | 3910 | MG | 0 | 2 | 22.34 | 124.28 | MO09789 |
| IDEN Y74-2-39GCTW | 5320 | TW | 0 | 2 | 20.11 | 145.06 | MO09790 |
| IDEN Y74-2-31MG1 | 3590 | MG | 0 | 2 | 20.15 | 113.57 | MO09788 |
| IDEN AHF-10614 | 1275 | PG | 5 | 7 | 32.52 | 119.49 | MO09908 |
| IDEN Y73-2-4MGI | 4138 | MG | 0 | 2 | 24.35 | 114.35 | MO10128 |
| IDEN MSN-155G | 4992 | PG | 0 | 1 | 15.09 | 137.06 | MS10129 |
| IDEN MEN-4G | 4640 | PG | 0 | 1 | 34.02 | 125.15 | MS10130 |

# APPENDIX II

## Downcore Sample Identification

| Core | Water Depth (meters) | Type of Core | Sample Depth in Core (cm) | | Latitude | Longitude | OSU Accession No.* |
|---|---|---|---|---|---|---|---|
| IDEN LAPD-1G | 2322 | GC | 0 | 2 | 22.53 | 110.59 | MS08956 |
| IDEN LAPD-1G | 2322 | GC | 5 | 7 | 22.53 | 110.59 | MS08957 |
| IDEN LAPD-1G | 2322 | GC | 10 | 12 | 22.53 | 110.59 | MS08958 |
| IDEN LAPD-1G | 2322 | GC | 15 | 17 | 22.53 | 110.59 | MS08959 |
| IDEN LAPD-1G | 2322 | GC | 20 | 22 | 22.53 | 110.59 | MS08960 |
| IDEN LAPD-1G | 2322 | GC | 25 | 27 | 22.53 | 110.59 | MS08961 |
| IDEN LAPD-1G | 2322 | GC | 30 | 32 | 22.53 | 110.59 | MS08962 |
| IDEN LAPD-1G | 2322 | GC | 35 | 37 | 22.53 | 110.59 | MS08963 |
| IDEN LAPD-1G | 2322 | GC | 40 | 42 | 22.53 | 110.59 | MS08964 |
| IDEN LAPD-1G | 2322 | GC | 45 | 47 | 22.53 | 110.59 | MS08965 |
| IDEN LAPD 1G | 2322 | GC | 50 | 52 | 22.53 | 110.59 | MS08966 |
| IDEN LAPD 1G | 2322 | GC | 55 | 57 | 22.53 | 110.59 | MS08967 |
| IDEN LAPD 1G | 2322 | GC | 60 | 62 | 22.53 | 110.59 | MS08968 |
| IDEN LAPD 1G | 2322 | GC | 65 | 67 | 22.53 | 110.59 | MS08969 |
| IDEN LAPD 1G | 2322 | GC | 70 | 72 | 22.53 | 110.59 | MS08970 |
| IDEN LAPD 1G | 2322 | GC | 75 | 77 | 22.53 | 110.59 | MS08971 |
| IDEN LAPD 1G | 2322 | GC | 80 | 82 | 22.53 | 110.59 | MS08972 |
| IDEN LAPD 1G | 2322 | GC | 85 | 87 | 22.53 | 110.59 | MS08973 |
| IDEN LAPD 1G | 2322 | GC | 90 | 92 | 22.53 | 110.59 | MS08974 |
| IDEN LAPD 1G | 2322 | GC | 95 | 97 | 22.53 | 110.59 | MS08975 |
| IDEN LAPD 1G | 2322 | GC | 100 | 102 | 22.53 | 110.59 | MS08976 |
| IDEN LAPD 1G | 2322 | GC | 105 | 107 | 22.53 | 110.59 | MS08977 |
| IDEN LAPD 1G | 2322 | GC | 110 | 112 | 22.53 | 110.59 | MS08978 |
| IDEN LAPD 1G | 2322 | GC | 115 | 117 | 22.53 | 110.59 | MS08979 |
| IDEN LAPD 1G | 2322 | GC | 120 | 122 | 22.53 | 110.59 | MS08980 |
| IDEN LAPD 1G | 2322 | GC | 125 | 127 | 22.53 | 110.59 | MS08981 |
| IDEN LAPD 1G | 2322 | GC | 136 | 138 | 22.53 | 110.59 | MS08982 |
| IDEN LAPD 1G | 2322 | GC | 141 | 143 | 22.53 | 110.59 | MS08983 |
| IDEN BNFC-43 | 2720 | PG | 2 | 4 | 10.29 | 109.01 | MS09051 |
| IDEN BNFC 43 PG 3 | 2720 | PG | 5 | 7 | 10.29 | 109.01 | MS09854 |
| IDEN BNFC 43 PG 3 | 2720 | PG | 9 | 10 | 10.29 | 109.01 | MS09855 |
| IDEN BNFC-43 | 2720 | PG | 12 | 14 | 10.29 | 109.01 | MS09052 |
| IDEN BNFC 43 PG 3 | 2720 | PG | 16 | 17 | 10.29 | 109.01 | MS09856 |
| IDEN BNFC 43 PG 3 | 2720 | PG | 19 | 20 | 10.29 | 109.01 | MS09857 |
| IDEN BNFC-43 | 2720 | PG | 22 | 24 | 10.29 | 109.01 | MS09053 |
| IDEN BNFC 43 PG 3 | 2720 | PG | 27 | 29 | 10.29 | 109.01 | MS09858 |
| IDEN BNFC-43 | 2720 | PG | 32 | 34 | 10.29 | 109.01 | MS09054 |
| IDEN BNFC 43 PG 3 | 2720 | PG | 37 | 39 | 10.29 | 109.01 | MS09859 |
| IDEN BNFC-43 | 2720 | PG | 42 | 44 | 10.29 | 109.01 | MS09055 |
| IDEN BNFC 43 PG 3 | 2720 | PG | 47 | 49 | 10.29 | 109.01 | MS09870 |
| IDEN BNFC-43 | 2720 | PG | 52 | 54 | 10.29 | 109.01 | MS09056 |
| IDEN BNFC 43PG3 | 2720 | PG | 57 | 59 | 10.29 | 109.01 | MS09871 |
| IDEN BNFC-43 | 2720 | PG | 62 | 64 | 10.29 | 109.01 | MS09057 |
| IDEN BNFC 43PG3 | 2720 | PG | 67 | 69 | 10.29 | 109.01 | MS09872 |
| IDEN BNFC-43 | 2720 | PG | 72 | 74 | 10.29 | 109.01 | MS09058 |
| IDEN BNFC 43PG3 | 2720 | PG | 76 | 77 | 10.29 | 109.01 | MS09873 |
| IDEN BNFC 43PG3 | 2720 | PG | 79 | 80 | 10.29 | 109.01 | MS09874 |
| IDEN BNFC-43 | 2720 | PG | 82 | 84 | 10.29 | 109.01 | MS09059 |
| IDEN BNFC 43PG3 | 2720 | PG | 87 | 89 | 10.29 | 109.01 | MS09875 |
| IDEN BNFC-43 | 2720 | PG | 92 | 94 | 10.29 | 109.01 | MS09070 |
| IDEN BNFC 43PG3 | 2720 | PG | 97 | 99 | 10.29 | 109.01 | MS09876 |
| IDEN BNFC-43 | 2720 | PG | 102 | 104 | 10.29 | 109.01 | MS09071 |
| IDEN BNFC 43PG3 | 2720 | PG | 107 | 109 | 10.29 | 109.01 | MS09877 |
| IDEN BNFC-43 | 2720 | PG | 112 | 114 | 10.29 | 109.01 | MS09072 |
| IDEN BNFC 43PG3 | 2720 | PG | 117 | 119 | 10.29 | 109.01 | MS09878 |

*Code letters indicate core source

MS = Scripps Institution of Oceanography
ML = Lamont-Doherty Geological Observatory
MO = Oregon State University

# APPENDIX III

## Opal and Quartz Determinations

| Sample Identification | wt % Opal | wt % Quartz |
|---|---|---|
| MS06663 | 9.84 | 7.87 |
| MS06679 | 3.20 | 15.72 |
| MS06687 | 3.42 | 19.90 |
| MS06702 | 19.88 | 6.25 |
| ML06713 | 5.95 | 10.84 |
| ML06714 | 5.74 | 12.31 |
| ML06715 | 0.70 | 3.81 |
| ML06716 | 7.60 | 11.73 |
| ML06717 | 1.44 | 9.39 |
| MS06718 | 2.25 | 15.39 |
| MS06726 | 1.25 | 34.70 |
| MS06734 | 2.20 | 14.11 |
| MS06742 | 2.36 | 13.44 |
| MS06743 | 1.43 | 14.56 |
| MS06782 | 4.65 | 13.08 |
| MS06790 | 4.93 | 16.93 |
| MS06806 | 8.27 | 8.36 |
| ML08053 | 14.52 | 5.89 |
| ML08054 | 3.67 | 14.53 |
| ML08055 | 6.51 | 5.73 |
| ML08056 | 2.30 | 10.94 |
| ML08058 | 21.62 | 5.30 |
| ML08059 | 17.84 | 5.72 |
| ML08060 | 5.34 | 14.50 |
| ML08061 | 29.05 | 3.12 |
| ML08062 | 1.73 | 13.90 |
| ML08063 | 28.67 | 4.24 |
| ML08064 | 17.60 | 2.83 |
| MO08932 | 11.26 | 6.80 |
| MO08939 | 4.92 | 10.72 |
| MO08946 | 6.54 | 11.43 |
| MS08956 | 2.25 | 10.48 |
| MS09061 | 35.86 | 3.75 |
| ML09234 | 5.88 | 9.51 |
| MO09761 | 7.80 | 7.51 |
| MO09773 | 5.91 | 11.75 |
| MO09778 | 1.84 | 14.98 |
| MO09788 | 6.43 | 10.05 |
| MO09789 | 1.45 | 13.53 |
| MO09790 | 2.26 | 12.26 |
| MC09908 | 3.73 | 11.86 |
| MO10128 | 5.41 | 10.64 |
| MS10129 | 3.61 | 13.17 |
| MS10130 | 5.98 | 13.11 |

# APPENDIX IV

## Taxonomic Notes

Numerical listing of species used in this study. The numbering system on the percentage data corresponds to this listing.

| | |
|---|---|
| S2 | Polysolenia lappacea |
| S3 | Polysolenia murrayana |
| S9 | Actinomma medianum |
| S11 | Axoprunum stauraxonium |
| S12 | Cenosphaera sp. |
| S15 | Druppatractus pyriformis |
| S16 | Echinomma delicatum |
| S17 | Echinomma leptodermum |
| S22 | Hexacontium sp. B |
| S25 | Ommatartus tetrathalamus |
| S30 | Stylatractus sp. A |
| S32 | Thecosphaera sp. |
| S33 | Heliodiscus astericus |
| S38 | Euchitonia furcata |
| S39 | Euchitonia triangulum |
| S43 | Ommatodiscus sp. A |
| S44 | Ommatodiscus sp. B |
| S47 | Spongaster tetras |
| S48 | Spongopyle osculosa |
| S50 | Stylochiamidium astericus |
| S53 | Spongodiscus setosus |
| S54 | Tetrapyle octacantha plus Octopyle stenozoa |
| S55 | Larcopyle butschlii |
| S56 | Larcospira guadrangula |
| S58 | Lithelius minor |
| S59 | Tholospira sp. |
| S62 | Hexapyle dodecantha |
| S65 | Chromuechinus antarctica |
| S69 | Haliomma group |
| | |
| N2 | Lithomelissa sp. |
| N4 | Giraffospyris angulata |
| N11 | Dictyophymus infabricatus |
| N19 | Peripyramis circumtexta |
| N28 | Theocalyptra bicornis |
| N29 | Cycladophora davisiana |
| N30 | Carpocanium sp. A |
| N31 | Carpocanium sp. B |
| N38 | Lamprocyrtis haysi |
| N41 | Theoconus minythorax |
| N42 | Theoconus zancieus |
| N48 | Siphocampe aquilonius |

# TAXONOMIC NOTES

Subclass Radiolaria Muller 1858

Order Polycystina Ehrenberg 1838, emend. Riedel 1967

Suborder Spumellaria Ehrenberg 1875

Family Collosphaeridae Muller 1858

Genus Collosphaera Haeckel

Collosphaera tuberosa Haeckel
S1

Nigrini, 1971, p. 446, Pl. 34.1, fig. 1

Genus Polysolenia Ehrenberg, emend. Nigrini, 1967

Polysolenia lappacea (Haeckel)
S2*

Nigrini, 1967, p. 14, Pl. 1, fig. 1

1970, Pl. 1, fig. 3

Polysolenia murrayana (Haeckel)
S3*

Nigrini, 1968, p. 52, Pl. 1, figs. 1a, 1b

Polysolenia spinosa (Haeckel)
S4

Nigrini, 1967, p. 14, Pl. 1, fig. 1

1970, Pl. 1, fig. 2

Siphonosphaera polysiphonia Haeckel
S5

Nigrini, 1967, p. 18, Pl. 1, figs. 4a, b

Genus Buccinosphaera Haeckel 1887

<u>Bucinosphaera invaginata</u> Haeckel
S6

Nigrini, 1967, p. 446, Pl. 34.1, fig. 2

Genus <u>Disolenia</u> Ehrenberg, 1860

<u>Disolenia zanguebarica</u> (Ehrenberg)
S7

Nigrini, 1967, p. 20, Pl. 1, fig. 6

Family <u>Actinommidae</u> Haeckel, emend. Riedel, 1967

Genus <u>Actinomma</u> Haeckel, emend. Nigrini, 1967

<u>Actinomma arcadophorum</u> Haeckel
S8

Nigrini, 1967, p. 29, Pl. 2, fig. 3

<u>Actinomma medianum</u> Nigrini
S9*

Nigrini, 1967, p. 27, Pl. 2, figs 2a, 2b

<u>Actinomma sp.</u>
S10

Benson, 1966, p. 164, Pl. 5, fig. 6

Sachs, 1973, p. 137, Pl. 2.1, fig. g

Genus <u>Axoprunum</u> Haeckel 1887

<u>Axoprunum stauraxonium</u>
S11*

Genus <u>Cenosphaera</u> Ehrenberg

<u>Cenosphaera sp.</u>
S12*

Genus Heteracantha

Heteracantha dentata Mast
S13

Anomalacantha dentata (Mast.) in Benson, 1966, p. 170, Pl. 5, figs. 10, 11

Genus Druppatractus Haeckel

Druppatractus irrgularis Popofsky
S14

Benson, 1966, p. 180, Pl. 7, figs. 9-11

Druppatractus cf. pyriformis (Bailey)
S15*

Benson, 1966, Pl. 7, figs. 2-5

Genus Echinomma Haeckel

Echinomma delicatum (Dogiel)
S16*

Petrushevskaya, 1968, p. 18, fig. 11

Ling et al., 1971, p. 710, Pl. 1, fig. 4

Echinomma delicatum Jorgensen
S16*

Hays, 1965, p. 169, Pl. 1, fig. 2

Genus Hexacontium Haeckel

Hexacontium entacanthum Jorgensen
S17

Benson, 1966, p. 149, Pl. 3, figs. 13, 14

Hexacontium laevigatum Haeckel
S18

Benson, 1966, p. 154, Pl. 4, figs. 4, 5

Hexacontium sp. A
S19

6 spines, irregular pores, thin test

Hexacontium sp. B
S52*

6 spines, large, somewhat "square" test

Hexacontium cf. heteracantha
S23

Benson, Pl. 4, fig. 6

Genus Haliomma Ehrenberg

Haliomma erinaceum Haeckel
S69*

Renz, 1973, p. 152, Pl. 2, figs. 4a, b

Haliomma glisifra Renz
S69*

Renz, 1973, p. 153, Pl. 2, fig. 10

Genus Heliosphaera Haeckel, 1862 emend. Haeckel, 1

Heliosphaera radiata Popofsky
S69*

Popofsky, 1913, p. 198, text fig. 10

Genus Hexastylus Haeckel 1881

Hexastylus triaxonius
S69*

Haeckel, 1887, p. 175, Pl. 21, fig. 2

Subfamily Artiscinae Haeckel 1881 emend. Riedel, 1967

Genus Ommatartus Haeckel 1881 emend. Riedel, 1971

Ommatartus tetrathalamus tetrathalamus (Haeckel)
S25*

Panartus tetrathalamus Haeckel, Nigrini, 1967, p. 30, Pl. 2, figs. 4a-4d

Ommatartus tetrathalamus (Haeckel), Renz, 1973, p. 158, Pl. 1, fig. 6

Ommatartus tetrathalamus coronatus (Haeckel)
S25*

Panartus tetrathalamus coronatus Haeckel

Nigrini, 1970, p. 168, Pl. 1, figs. 13, 14

Genus Spongurus Haeckel 1860

Spongurus pylomaticus Riedel
S26

Riedel, 1958, p. 225, Pl. 1, figs. 10, 11

Spongurus cf. elliptica (Ehrenberg)
S27

Benson, 1966, p. 189, Pl. 8, figs. 4, 5

Spongurus sp.
S28

Spongurus (?) sp. Petrushevskaya, 1968, p. 30, figs. 16.III, and 26.I

Genus Styposphaera Haeckel 1881

Styposphaera spumacea Haeckel
S29

Nigrini, 1970, p. 167, Pl. 1, figs. 7, 8

Genus Stylatractus Haeckel 1887

Stylactrus sp. A
S30*

Xiphafractus chronus (Haeckel) Benson, 1966, p. 182, Pl. 7, figs. 12, 13

Xiphatractus pluto (Haeckel) Benson, 1966, p. 184, Pl. 7, figs. 14-17

Stylatractus sp., Petrushevskaya, 1968, p. 27, fig. 15 I-IV.

Stylactrus sp. B
S31

slightly elliptical cortical shell with long, thin polar spines, 8 hexagonally-framed pores on half-equator. Spherical medullary shell about 1/3 diameter of outer shell and connected to it by 6 thin spines radiating from equator and 2 from the polar region.

Genus Thecosphaera Haeckel

Thecosphaera sp.
S32*

simple Spumellarian spherical, with irregularly arranged sub-rounded pores - "pore-frames" have knuckles.

Family Phacodiscidae Haeckel 1881

Genus Heliodiscus Haeckel 1862, emend. Nigrini, 1967

Heliodiscus astericus Haeckel
S33*

Nigrini, 1967, p. 32, Pl. 3, figs. 1a, b

Heliodiscus echiniscus Haeckel
S34

Nigrini, 1967, p. 34, Pl. 3, figs. 2a, b

Family Spongodiscidae Haeckel 1881, emend. Riedel, 1967

Genus Amphiropalum Haeckel 1881, emend. Nigrini, 1967

Amphiropalum ypsilon Haeckel
S35

Nigrini, 1967, p. 35, Pl. 3, figs. 3a-3d

Genus Dictyocorne Ehrenberg 1860

Dictyocorne profunda Ehrenberg
S36

Genus Euchitonig Ehrenberg 1860, emend. Nigrini, 1967

Euchitonia elegans (Ehrenberg)
S37

Nigrini, 1967, p. 39, Pl. 4, figs. 2a, b

Euchitonia furcata Ehrenberg
S38*

Euchitonia mullen Nigrini, 1967, p. 37, Pl. 4, figs. la, b

Euchitonia triangulum (Ehrenberg)
S39*

Ling and Anikouchine, 1967, p. 1488, Pl. 191, fig. 3

Genus Hymeniastrum Ehrenberg 1847

Hymeniastrum euclides Haeckel
S40

Benson, 1966, p. 222, Pl. 12, figs. 1-3

Hymeniastrum koellikeri Haeckel
S41

Benson, 1966, p. 225, Pl. 12, figs. 4-6

Genus Ommatodiscus Stohr 1880

Ommatodiscus pantanellii Carnevale
S42

Benson, 1966, p. 207, Pl. 10, fig. 1

Ommatodiscus sp. A
S43*

in part Benson, 1966, p. 207, Pl. 10, figs. 3 & 6

Ommatodiscus sp. B
S44*

in part Benson, 1966, Pl. 10, fig. 4

Genus Spongocore

Spongocore puella Haeckel
S46

Benson, 1966, p. 187, Pl. 8, figs. 1-3

Genus Spongaster Ehrenberg 1860

Spongaster tetras tetras Ehrenberg
S47*

Nigrini, 1967, p. 41, Pl. 5, figs. 1a, b

Genus Spongopyle Dreyer 1889

Spongopyle osculosa Dreyer
S48*

Riedel, 1958, p. 226, Pl. 1, fig. 12

Genus Spongotrochus Haeckel 1860

Spongotrochus glacialis Popofsky
S49

Riedel, 1958, p. 227, Pl. 2, figs. 1, 2

Genus Stylochlamidium Haeckel 1887

Stylochlamidium astericus Haeckel
S50

Stylochlamidium venustum (Bailey)
S51

Sachs, 1973c, p. 152, Pl. 2.3, fig. i, j

Genus Stylodictya Ehrenberg 1847

Stylodictya validispina Jorgensen
S52

Petrushevskaya, 1968, p. 30, fig. 17 IV, V

Genus Spongodiscus Ehrenberg 1854

Spongodiscus (?) Setosus (Dreyer)
S53*

Petrushevskaya, 1968, p. 36, fig. 20 III-V

Family Pyloniidae Haeckel 1881

Genus Octopyle Haeckel 1881

Octopyle stenozoa Haeckel
S54*

Benson, 1966, p. 251, Pl. 16, figs. 3, 4

Genus Phorticium Haeckel 1882

Phorticium pylonium (Haeckel)
S57

Benson, 1966, p. 252, Pl. 17, figs. 1-3

Genus Tetrapyle Muller 1858

Tetrapyle octacantha Muller
S54*

Benson, 1966, p. 245, Pl. 15, figs. 3-10, Pl. 16, fig. 1

Family Litheliidae Haeckel 1862

Genus Larcopyle Dreyer 1889

Larcopyle butschlii Dreyer
S55*

Benson, 1966, p. 280, Pl. 19, fig. 3-5

Genus Larcospira Heackel 1887

Larcospira quadrangula Haeckel
S56*

Benson, 1966, p. 266, Pl. 18, figs. 7, 8

Genus Lithelius Haeckel 1862

Lithelius minor Jorgensen
S58*

Benson, 1966, p. 262, Pl. 17, figs. 9-10, Pl. 18, figs. 1-4

Genus Tholospira Haeckel 1887

Tholospira sp.
S59*

Petrushevskaya, 1968, p. 54, fig. 31

Family Pylodiscidae Haeckel

Genus Hexapyle Haeckel

Hexapyle dodicantha Haeckel
S62*

Benson, 1966, p. 275, Pl. 18, figs. 14-16

Suborder Nassellaria Ehrenberg 1875

Family Plagoniidae Haeckel 1881 emend. Riedel 1967

Genus Helotholus Jorgensen

Helotholus histricosa
N1

Benson, 1966, p. 459, Pl. 31, figs. 4-8

Genus Lithomelissa Ehrenberg 1847

Lithomelissa spp.
N2*

Benson, 1966, Pl. 24, figs. 6-13

Genus Acanthocorys

Acanthocorys variablis Popofsky emend. Benson 1966
N3

Benson, 1966, Pl. 24, fig. 19

Family Trissocyclidae Haeckel 1881 emend. Goll 1968

Genus Giraffospyris Haeckel 1881 emend. Goll 1968

Giraffospyris angulata (Haeckel
N4

Goll, 1969, p. 331, Pl. 59, figs. 4, 6, 7, 9

Genus Dendrospyris Haeckel 1881 emend. Goll 1968

Dendrospyris cf. D. anthocyrtoides (Butschlii)
N5

Desmospyris anthocyrtoides (Butschlii); Benson, 1966, p. 332, Pl. 23, figs. 6-8

Dendrospyris stabilis Goll; Goll, 1968, p. 1422, Pl. 173, figs. 16-18, 20

Genus Liriospyris Haeckel 1881 emend. Goll 1968

Liriospyris reticulata Goll
N4

Goll, 1968, p. 1429, Pl. 176, figs. 9, 11, 13

Genus Tholospyris Haeckel 1881 emend. Goll 1968

Tholospyris scaphipes (Haeckel)
N7

Goll, 1968, p. 328, Pl. 58, figs. 1-8, 13, 14

Tholospyris subquadrata (Haeckel)
N4

T. procera, Goll, 1969, p. 328, Pl. 59, figs. 8, 10-12

Genus Rhrodospyris Haeckel, 1882

Rhrodospyris sp.
N8

Benson, 1966, p. 239, Pl. 23, figs. 3-5

Family Theoperidae Haeckel 1881 emend. Riedel 1967

Genus Dictyophymus Ehrenberg 1847, emend. Nigrini, 1968

Dictyophymus crisiae Ehrenberg
N9

Nigrini, 1967, p. 66, Pl. 6, fig. 7

Dictyophymus gracilipes Bailey
N10

Petrushevskaya, 1968, p. 65, figs. 38, 39

Dictyophymus infabricatus Nigrini
N11

Nigrini, 1968, p. 56, Pl. 1, fig. 6

Dictyophymus mawsoni Riedel
N12*

Riedel, 1958, p. 234, Pl. 3, figs. 6, 7

Genus Eucyrtidium Ehrenberg 1847 emend. Nigrini 1967

Eucyrtidium acuminatum (Ehrenberg)
N13

Nigrini, 1967, p. 81, Pl. 8, figs. 3a, b

Eucyrtidium calvertense Martin
N14

Hays, 1965, p. 181, Pl. 3, fig. 4

Eucyrtidium hexagonatum Haeckel
N15

Nigrini, 1967, p. 83, Pl. 8, figs. 4a, b

Genus Peripyramis Haeckel 1881 emend. Riedel 1958

Peripyramis cirumtexta Haeckel
N19*

Riedel, 1958, p. 231, Pl. 2, figs. 8, 9

Genus Pletopyramis Haeckel 1881

Plectopyramis dodecomma Haeckel
N20

Benson, 1966, p. 424, Pl. 29, fig. 3

Genus Cornutella Ehrenberg 1838 emend. Nigrini 1967

Cornutella profunda Ehrenberg
N21

Riedel, 1958, p. 232, Pl. 3, figs. 1. 2

Genus Lithopera Ehrenberg 1847 emend. Nigrini 1967

Lithopera bacca Ehrenberg
N22

Nigrini, 1967, p. 54, Pl. 6, fig. 2

Genus Pterocanium Ehrenberg 1847

Pterocanium grandiporus Nigrini
N23

Nigrini, 1968, p. 57, Pl. 1, fig. 7

*Pterocanium korotnevi* (Dogiel)
N24

*Pterocorys korotnevi* Dogiel, Dogiel and Reshetnyak, p. 17, fig. 11

*Pterocanium praetextum praetextum* (Ehrenberg)
N25

Nigrini, 1967, p. 68, Pl. 7, fig. 1

*Pterocanium praetextum euculpum* Haeckel
N26

Nigrini, 1967, p. 70, Pl. 7, fig. 2

*Pterocanium trilobum* Haeckel
N27

Nigrini, 1967, p. 71, Pl. 7, figs. 3a, b

Genus *Theocalyptra* Haeckel 1887

*Theocalyptra* (?) *bicornis* (Popofsky)
N28*

Riedel, 1958, p. 240, Pl. 4, fig. 4

Genus *Cycladophora* Ehrenberg 1847

*Cycladophora davisiana cornutoides* (Ehrenberg)
N29*

Petrushevskaya, 1968, p. 124, fig. 70 I-III

*Cycladophora davisiana* Ehrenberg
N29*

Petrushevskaya, 1968, p. 120, fig. 69

including *C. davisiana semeloides* (Ehrenberg)

Family Carpocanidae Haeckel 1881 emend. Riedel 1971

Genus *Carpocanium* Ehrenberg 1847

*Carpocanium* sp. A
N30*

Nigrini, 1968, p. 55, Pl. 1, fig. 4

Carpocanium sp. B
N31*

C. petalospyris in Benson, 1966, p. 434, Pl. 29, figs. 9, 10

Family Pterocoryidae Haeckel 1881 emend. Riedel 1967

Genus Anthocyrtidium Haeckel 1881

Anthocyrtidium ophirense (Ehrenberg)
N32

Nigrini, 1967, p. 56, Pl. 6, fig. 3

Anthocyrtidium zanguebaricum (Ehrenberg)
N33

Nigrini, 1967, p. 58, Pl. 6, fig. 4

Genus Lamprocyclas Haeckel 1881

Lamprocyclas junonis (Haeckel)
N34

Theoconus junonis, Haeckel, 1887, p. 1401, Pl. 69, fig. 7

Lamprocyclas maritalis maritalis Haeckel
N35

Nigrini, 1967, p. 74, Pl. 7, fig. 5

Lamprocyclas maritalis polypora Nigrini
N36

Nigrini, 1967, p. 76, Pl. 7, fig. 6

Lamprocyclas maritalis ventricosa Nigrini
N37

Nigrini, 1968, p. 57, Pl. 1, fig. 9

Genus Lamprocyrtis Kling 1973

Lamprocyrtis haysi Kling
N38*

Kling, 1973, p. 639, Pl. 5, figs. 15, 16, Pl. 15, figs. 1-3

Genus Conarachnium Haeckel 1881

Conarachnium ? sp.
N39

Nigrini, 1968, p. 56, Pl. 1, figs. 5a, b

Genus Pterocorys Haeckel 1881

Pterocorys hirundo Haeckel
N40

Haeckel, 1887, p. 1318, Pl. 71, fig. 4, p. 114, fig. 67, I-V

Genus Theoconus Haeckel 1887

Theoconus minythorax Nigrini
N41*

Nigrini, 1968, p. 57, Pl. 1, fig. 8

Theoconus zancleus (Muller)
N42*

Benson, 1966, p. 482, Pl. 33, fig. 4 only

Genus Theocorythium Haeckel 1887

Theocorythium trachelium (Ehrenberg) dianae (Haeckel)
N43

Nigrini, 1967, p. 77, Pl. 8, figs. 1a, b

Theocorythium trachelium trachelium (Ehrenberg)
N44

Nigrini, 1967, p. 79, Pl. 8, fig. 2

Family Artostrobiidae Riedel 1967a

Genus Dictyocryphalus Haeckel 1887

Dictyocryphalus papillosus (Ehrenberg)
N45

Nigrini, 1967, Pl. 6, fig. 6

Genus Lithostrobus Butschlii 1882

Lithostrobus (?) botryocyrtis Haeckel
N46

Petrushevskaya, 1968, p. 141, fig. 80 VI, fig. 81 I-IV

Lithostrobus (?) seriatus Haeckel
N47

Petrushevskaya, 1968, p. 143, fig. 82 I-III

Genus Siphocampe Haeckel 1881

Siphocampe aquilonius (Bailey)
N48

Ling et al., 1971, p. 716, Pl. 2, fig. 12

Family Cannobotryidae Haeckel 1881 emend. Riedel 1967

Genus Botryocyrtis Ehrenberg 1960

Botryocyrtis scutum (Harting)
N50

Nigrini, 1967, p. 52, Pl. 6, figs. 1a-c

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# APPENDIX V

## Varimax Factor Matrix (B) and Scaled Varimax Factor Scores (F)

VARIMAX FACTOR MATRIX

| | | COMM. | F1 | F2 | F6 | F3 | F5 | F4 |
|---|---|---|---|---|---|---|---|---|
| 1 | 13423 | .937 | .766 | .076 | .249 | .134 | .489 | -.159 |
| 2 | 23426 | .708 | .721 | .174 | .119 | .157 | .252 | -.236 |
| 3 | 33433 | .845 | .712 | .319 | .459 | -.045 | .016 | -.152 |
| 4 | 43813 | .938 | .926 | .144 | .183 | .128 | .072 | -.067 |
| 5 | 53986 | .959 | .948 | .085 | .208 | .081 | -.017 | -.053 |
| 6 | 63987 | .889 | .893 | .099 | .196 | .178 | .088 | -.054 |
| 7 | 71234 | .889 | .633 | .183 | .509 | .260 | -.035 | -.357 |
| 8 | 85229 | .931 | .423 | .175 | .789 | .148 | .213 | -.178 |
| 9 | 95232 | .861 | .067 | .047 | .833 | .363 | .106 | -.132 |
| 10 | 105242 | .942 | .323 | .065 | .803 | -.071 | .406 | -.139 |
| 11 | 115243 | .892 | .383 | .130 | .629 | -.044 | .555 | -.152 |
| 12 | 125246 | .915 | .208 | .894 | .215 | .120 | .010 | -.109 |
| 13 | 135256 | .969 | .108 | .969 | .111 | .037 | .018 | -.075 |
| 14 | 145267 | .941 | .837 | .032 | .232 | .236 | .331 | -.140 |
| 15 | 156663 | .932 | .869 | .052 | .230 | .178 | .260 | -.148 |
| 16 | 166687 | .939 | .069 | .956 | .094 | .035 | .090 | -.044 |
| 17 | 176713 | .854 | .396 | .066 | .274 | .698 | .268 | -.242 |
| 18 | 186714 | .955 | .435 | .074 | .320 | .651 | .166 | -.455 |
| 19 | 196716 | .870 | .399 | .183 | .334 | .718 | .031 | -.220 |
| 20 | 206717 | .931 | .692 | .112 | .234 | .601 | .006 | -.155 |
| 21 | 216782 | .882 | .526 | .286 | .588 | .376 | -.003 | -.190 |
| 22 | 226806 | .841 | .454 | .344 | .617 | .321 | -.055 | -.175 |
| 23 | 238053 | .932 | .709 | .090 | .299 | .154 | .526 | -.178 |
| 24 | 248055 | .882 | .581 | -.006 | .227 | .346 | .584 | -.175 |
| 25 | 258056 | .940 | .736 | .235 | .292 | .238 | .360 | -.268 |
| 26 | 268059 | .909 | .709 | .062 | .180 | .162 | .550 | -.205 |
| 27 | 278062 | .930 | .289 | .101 | .242 | .271 | .491 | -.680 |
| 28 | 288939 | .930 | .496 | .479 | .343 | .212 | -.016 | -.539 |
| 29 | 298956 | .939 | .351 | .073 | .243 | .193 | .127 | -.835 |
| 30 | 309061 | .946 | .896 | .119 | .222 | .243 | -.004 | -.143 |
| 31 | 319234 | .897 | -.023 | .510 | .306 | .400 | .042 | -.618 |
| 32 | 329908 | .869 | .174 | .159 | .840 | .262 | .007 | -.198 |
| 33 | 330129 | .963 | .883 | .097 | .270 | .188 | .176 | -.188 |
| 34 | 340130 | .933 | .494 | .334 | .706 | .095 | .170 | -.203 |
| | | VARIANCE | 35.826 | 11.492 | 18.164 | 9.347 | 7.364 | 8.661 |
| | | CUM. VAR | 35.826 | 47.318 | 65.482 | 74.829 | 82.193 | 90.854 |

VARIMAX FACTOR SCORE MATRIX

| VAR. | F1 | F2 | F6 | F3 | F5 | F4 |
|---|---|---|---|---|---|---|
| S2 | .022 | .006 | -.016 | -.008 | .007 | -.010 |
| S3 | -.008 | .002 | .023 | .081 | .152 | -.028 |
| S9 | -.021 | -.005 | .291 | -.204 | .041 | -.163 |
| S11 | -.038 | .454 | -.051 | -.027 | .063 | .015 |
| S12 | -.020 | .124 | -.026 | .023 | .027 | -.037 |
| S15 | -.052 | -.058 | -.140 | .077 | .026 | -.840 |
| S16 | -.082 | .152 | .298 | .024 | -.104 | -.247 |
| S17 | -.028 | .004 | .097 | .030 | -.014 | -.001 |
| S22 | .014 | -.036 | -.015 | -.059 | -.033 | -.204 |
| S25 | .229 | .031 | -.173 | .012 | .116 | -.287 |
| S28 | .003 | -.013 | .036 | .034 | -.039 | -.036 |
| S30 | -.068 | .803 | -.035 | .004 | .078 | .028 |
| S32 | -.005 | .014 | .083 | -.112 | .045 | -.070 |
| S33 | .063 | .054 | -.032 | -.028 | .035 | -.011 |
| S38 | .043 | -.005 | -.031 | .104 | .029 | -.010 |
| S39 | -.003 | -.001 | -.048 | .197 | .060 | .025 |
| S43 | .021 | -.010 | .123 | .460 | .088 | -.049 |
| S44 | -.020 | -.040 | .043 | .325 | .151 | .054 |
| S47 | .050 | -.005 | -.038 | .103 | .014 | .037 |
| S48 | -.039 | .045 | .203 | .381 | -.120 | .063 |
| S49 | .047 | .015 | .165 | -.166 | .517 | -.048 |
| S50 | .131 | -.004 | .045 | -.061 | -.073 | .055 |
| S53 | -.027 | .013 | .063 | .350 | -.038 | -.025 |
| S54 | .830 | .000 | .236 | .058 | -.075 | -.015 |
| S55 | -.024 | -.030 | .145 | .035 | .027 | -.058 |
| S56 | .050 | -.010 | .074 | -.013 | .056 | .023 |
| S58 | -.018 | .215 | .319 | -.020 | -.151 | -.163 |
| S59 | .097 | -.031 | .024 | -.027 | .717 | .037 |
| S62 | .065 | -.009 | .015 | .015 | .045 | .012 |
| S65 | -.048 | -.005 | .141 | .002 | -.001 | -.047 |
| S67 | -.017 | -.008 | -.011 | .129 | .009 | .018 |
| S68 | -.014 | -.017 | .116 | -.047 | .012 | .013 |
| S69 | -.027 | -.029 | .281 | -.132 | .048 | .059 |
| N4 | .416 | .179 | -.120 | -.010 | -.149 | .019 |
| N11 | -.021 | .009 | -.007 | .155 | .067 | .067 |
| N19 | .002 | .068 | .006 | -.016 | .034 | .021 |
| N28 | -.019 | -.023 | .154 | -.018 | .049 | .041 |
| N29 | -.084 | -.057 | .345 | .091 | -.033 | -.052 |
| N30 | -.034 | .053 | -.062 | .312 | .041 | .016 |
| N31 | .010 | .056 | .122 | -.025 | .007 | -.039 |
| N38 | -.024 | -.016 | .090 | .009 | .001 | .023 |
| N41 | .024 | -.006 | -.078 | .267 | .145 | -.006 |
| N42 | -.023 | -.017 | .104 | .046 | .062 | .050 |
| N48 | -.080 | -.025 | .399 | -.040 | -.012 | .055 |

# APPENDIX VI

## Surface Sample Radiolarian Percentages

RAW DATA

| NO. | SAMPLE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | S2 | S3 | S9 | S11 | S12 | S15 | S16 | S17 | S22 | S25 |
| 1 | 13423 | .100 | .800 | 1.400 | .100 | 0.000 | .300 | 1.100 | .100 | .400 | 5.400 |
| 2 | 23426 | 3.500 | .200 | .400 | .400 | 0.000 | .400 | 1.300 | 0.000 | 0.000 | 12.000 |
| 3 | 33433 | .100 | 0.000 | 4.800 | 3.100 | 0.000 | .900 | 4.500 | 0.000 | 0.000 | .100 |
| 4 | 43813 | .400 | .100 | 0.000 | .100 | 0.000 | .200 | .400 | 0.000 | .400 | 5.000 |
| 5 | 53986 | 0.000 | 0.000 | .500 | 0.000 | 0.000 | 0.000 | .600 | 0.000 | .300 | 4.300 |
| 6 | 63987 | .500 | 0.000 | .500 | .200 | 0.000 | 0.000 | .400 | 0.000 | .100 | 6.500 |
| 7 | 71234 | 0.000 | 0.000 | 1.300 | .100 | .200 | 2.200 | 1.700 | .400 | 1.000 | 2.600 |
| 8 | 85229 | 0.000 | 1.600 | 2.000 | .500 | .100 | .300 | 4.700 | 2.200 | 0.000 | .500 |
| 9 | 95232 | 0.000 | 1.200 | 2.900 | .100 | .100 | .200 | 3.800 | 2.000 | 0.000 | .200 |
| 10 | 105242 | 0.000 | .700 | 4.800 | .200 | 0.000 | 0.000 | 2.000 | 0.000 | 0.000 | .100 |
| 11 | 115243 | 0.000 | 0.000 | 3.600 | .200 | .100 | .800 | 1.900 | 0.000 | .100 | .300 |
| 12 | 125246 | .100 | 0.000 | 2.700 | 5.000 | 2.700 | 0.000 | 5.000 | 0.000 | 0.000 | .400 |
| 13 | 135256 | 0.000 | .600 | .300 | 13.400 | 3.500 | 0.000 | 3.800 | .400 | 0.000 | 1.900 |
| 14 | 145267 | .300 | .500 | .600 | 0.000 | 0.000 | 1.700 | .300 | 0.000 | .400 | 2.800 |
| 15 | 156663 | 0.000 | .900 | .200 | 0.000 | .100 | .600 | .300 | .300 | .100 | 3.200 |
| 16 | 166687 | 0.000 | .400 | 0.000 | 9.900 | 1.600 | 0.000 | .800 | .400 | 0.000 | 1.200 |
| 17 | 176713 | 0.000 | 1.200 | .100 | 0.000 | .700 | 3.300 | 1.600 | .100 | .200 | 1.500 |
| 18 | 186714 | .100 | 1.300 | .900 | .200 | .200 | 6.000 | 2.100 | .300 | .200 | 1.900 |
| 19 | 196716 | 0.000 | .400 | .100 | .600 | .600 | 1.700 | 2.500 | 0.000 | .300 | 2.200 |
| 20 | 206717 | 0.000 | 1.100 | 0.000 | .200 | .100 | 1.900 | .400 | 0.000 | .100 | 2.400 |
| 21 | 216782 | .100 | .200 | 1.300 | .300 | 0.000 | .600 | 3.500 | 1.700 | .200 | 1.400 |
| 22 | 226806 | .100 | .300 | 1.000 | .400 | .200 | 0.000 | 1.800 | .700 | .100 | .800 |
| 23 | 238053 | 0.000 | 1.100 | .600 | .400 | .100 | .800 | .400 | .400 | .100 | 3.400 |
| 24 | 248055 | .100 | 2.400 | .400 | 0.000 | 0.000 | 1.800 | .900 | .600 | .400 | 3.300 |
| 25 | 258056 | 0.000 | 1.800 | .600 | .500 | .600 | 1.200 | 1.300 | 0.000 | 0.000 | 3.000 |
| 26 | 268059 | 0.000 | 2.100 | 1.000 | 0.000 | 0.000 | 1.900 | 0.000 | .100 | .400 | 1.400 |
| 27 | 278062 | .100 | 1.900 | 1.600 | .500 | .900 | 7.900 | 1.200 | .100 | .800 | 4.100 |
| 28 | 288939 | 0.000 | .200 | 2.300 | 2.000 | .700 | 4.100 | 4.200 | 0.000 | .300 | 4.500 |
| 29 | 298956 | 0.000 | .600 | 3.200 | .500 | .700 | 10.100 | 3.000 | .400 | 4.300 | 3.800 |
| 30 | 309061 | 0.000 | 1.900 | .600 | 0.000 | .200 | 1.700 | .300 | 0.000 | .200 | 1.600 |
| 31 | 319234 | 0.000 | .900 | .200 | 1.800 | .700 | 5.600 | 5.500 | 1.000 | 0.000 | .500 |
| 32 | 329908 | 0.000 | 1.600 | 4.900 | .400 | 0.000 | .600 | 6.400 | 1.000 | .100 | .400 |
| 33 | 330129 | .100 | .400 | 1.100 | .300 | .200 | 2.500 | 1.200 | 0.000 | .100 | 3.900 |
| 34 | 340130 | .200 | 1.500 | 1.500 | 1.700 | .900 | .900 | 3.900 | .700 | .500 | .900 |

| NO. | SAMPLE | 11 S28 | 12 S30 | 13 S32 | 14 S33 | 15 S38 | 16 S39 | 17 S43 | 18 S44 | 19 S47 | 20 S48 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 13423 | 0.000 | .400 | .200 | 1.400 | 1.100 | 1.100 | 4.100 | 1.700 | .600 | 0.000 |
| 2 | 23426 | .200 | 2.000 | .100 | .400 | 1.400 | 1.000 | 5.600 | .100 | .300 | .600 |
| 3 | 33433 | 0.000 | 4.500 | 3.100 | .700 | 0.000 | 0.000 | .300 | 0.000 | 0.000 | 0.000 |
| 4 | 43813 | 0.000 | .700 | .300 | 2.700 | 1.400 | .900 | 4.300 | 1.300 | 2.300 | 1.400 |
| 5 | 53986 | 0.000 | 0.000 | 0.000 | 0.000 | 1.300 | .500 | 2.400 | .900 | 1.900 | 1.000 |
| 6 | 63987 | 0.000 | .200 | .100 | 3.000 | .600 | 1.500 | 5.200 | 2.400 | 2.500 | 3.000 |
| 7 | 71234 | 1.000 | .900 | .300 | .100 | .700 | .200 | 1.500 | .900 | .600 | 2.600 |
| 8 | 85229 | .600 | 1.000 | .800 | .300 | .400 | 0.000 | 1.900 | 1.400 | 0.000 | 2.300 |
| 9 | 95232 | .300 | .400 | .300 | 0.000 | .100 | 0.000 | 6.400 | 3.600 | 0.000 | 4.300 |
| 10 | 105242 | .200 | .400 | 2.000 | .200 | 0.000 | 0.000 | 2.100 | 0.000 | 0.000 | .900 |
| 11 | 115243 | .100 | 1.800 | 2.200 | 0.000 | .100 | 0.000 | 2.500 | 1.100 | 0.000 | .400 |
| 12 | 125246 | 0.000 | 12.000 | 0.000 | 1.600 | .200 | .100 | .700 | .300 | 0.000 | 2.600 |
| 13 | 135256 | .100 | 19.600 | 0.000 | 1.000 | 0.000 | 0.000 | .100 | 0.000 | 0.000 | 2.900 |
| 14 | 145267 | .100 | 0.000 | .100 | .300 | .100 | .200 | 2.100 | 2.700 | .100 | .400 |
| 15 | 156663 | .400 | .200 | 0.000 | 1.300 | 1.000 | .100 | 2.000 | .100 | .800 | .600 |
| 16 | 166687 | 0.000 | 16.500 | 1.200 | .400 | 0.000 | 0.000 | 1.200 | 0.000 | 0.000 | .400 |
| 17 | 176713 | .100 | .600 | 0.000 | 0.000 | 1.600 | 2.900 | 7.100 | 3.300 | 1.800 | 3.300 |
| 18 | 186714 | .600 | .500 | 0.000 | 0.000 | .300 | 1.300 | 5.900 | 3.300 | .400 | 4.000 |
| 19 | 196716 | 1.000 | .800 | 0.000 | .100 | 1.500 | 2.200 | 3.900 | 2.400 | .900 | 5.800 |
| 20 | 206717 | 1.000 | .700 | 0.000 | .200 | 2.100 | 1.200 | 4.900 | 4.300 | 1.800 | 2.900 |
| 21 | 216782 | .100 | 2.700 | 0.000 | .100 | .500 | .100 | 3.500 | .400 | .100 | 3.800 |
| 22 | 226806 | .900 | 3.200 | .100 | .400 | .200 | 0.000 | 4.300 | .700 | 0.000 | 1.400 |
| 23 | 238053 | .100 | .200 | .500 | .900 | .600 | .100 | 1.800 | 1.100 | .500 | .600 |
| 24 | 248055 | .200 | 0.000 | 0.000 | .600 | 1.000 | 1.500 | 1.700 | 4.800 | .500 | .200 |
| 25 | 258056 | .100 | 1.300 | .100 | .400 | .900 | .600 | 1.500 | .700 | 1.000 | .700 |
| 26 | 268059 | 0.000 | .300 | 0.000 | 1.100 | 1.000 | .200 | 1.000 | .800 | .500 | .600 |
| 27 | 278062 | .300 | 1.000 | .600 | .600 | .400 | .400 | 3.700 | 1.800 | .200 | .600 |
| 28 | 288939 | .500 | 3.800 | .500 | 1.500 | .500 | 0.000 | 1.700 | .100 | 0.000 | 1.600 |
| 29 | 298956 | .800 | .400 | .900 | 0.000 | 1.000 | .500 | 1.800 | 1.300 | .100 | .900 |
| 30 | 309061 | 0.000 | .600 | .100 | .800 | .600 | .200 | 3.100 | .400 | .400 | 1.700 |
| 31 | 319234 | 0.000 | 4.400 | .800 | .200 | .300 | .600 | 4.000 | .700 | .200 | 1.400 |
| 32 | 329908 | .900 | 1.200 | .200 | 0.000 | .500 | .100 | 2.900 | 2.100 | 0.000 | 5.800 |
| 33 | 330129 | .400 | .800 | 1.000 | .500 | 1.100 | .200 | 5.200 | 1.800 | 0.000 | .300 |
| 34 | 340130 | .400 | 2.500 | .300 | .200 | .100 | 0.000 | 1.600 | 1.500 | 0.000 | 2.100 |

| NO. | SAMPLE | 21<br>S49 | 22<br>S50 | 23<br>S53 | 24<br>S54 | 25<br>S55 | 26<br>S56 | 27<br>S58 | 28<br>S59 | 29<br>S62 | 30<br>S65 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 13423 | 7.600 | 1.600 | .200 | 10.700 | 1.200 | .200 | .100 | 5.600 | 1.800 | .500 |
| 2 | 23426 | 3.900 | 2.900 | .400 | 9.500 | .700 | .400 | .200 | 3.100 | 1.000 | .300 |
| 3 | 33433 | .900 | 0.000 | 0.000 | 18.300 | 0.000 | .900 | 4.400 | 2.100 | 1.200 | .700 |
| 4 | 43813 | 4.300 | 4.400 | .400 | 18.900 | .100 | 1.700 | 1.100 | 2.900 | 1.700 | .200 |
| 5 | 53986 | 4.900 | 6.000 | .300 | 24.300 | .200 | 1.100 | .400 | .200 | 1.900 | .300 |
| 6 | 63987 | 2.900 | 10.300 | .600 | 18.700 | .200 | 2.100 | .600 | 4.200 | 1.400 | 0.000 |
| 7 | 71234 | 1.200 | 0.000 | 1.300 | 8.900 | 2.100 | .800 | 5.400 | .200 | .200 | .100 |
| 8 | 85229 | 3.000 | 2.400 | .600 | 7.400 | 2.100 | 1.400 | 4.600 | 3.500 | .300 | .800 |
| 9 | 95232 | 1.900 | 1.000 | 2.600 | 3.600 | 4.200 | .500 | 3.600 | 1.300 | .600 | 3.900 |
| 10 | 105242 | 4.800 | .300 | 0.000 | 5.100 | 1.300 | .800 | 2.000 | 3.400 | .900 | .800 |
| 11 | 115243 | 7.300 | .200 | 0.000 | 6.100 | .500 | 3.000 | 1.300 | 4.800 | .800 | 1.100 |
| 12 | 125246 | 1.000 | .700 | .400 | 3.500 | .100 | .400 | 3.300 | .300 | 0.000 | .700 |
| 13 | 135256 | .700 | 0.000 | .100 | 3.500 | 0.000 | .100 | 6.700 | 0.000 | 0.000 | 1.900 |
| 14 | 145267 | 1.800 | 0.000 | 1.300 | 13.000 | .900 | 1.400 | .100 | 6.400 | 1.600 | 0.000 |
| 15 | 156663 | 1.700 | .200 | 0.000 | 9.700 | .300 | 1.700 | .400 | 2.900 | 1.300 | 0.000 |
| 16 | 166687 | 1.600 | 0.000 | 1.600 | 2.000 | 0.000 | 0.000 | 4.900 | 0.000 | .800 | 0.000 |
| 17 | 176713 | 1.300 | 0.000 | 1.400 | 5.900 | .100 | .700 | .600 | 2.400 | 1.100 | .500 |
| 18 | 186714 | .900 | 0.000 | 3.200 | 7.400 | .800 | .600 | 1.700 | 2.000 | .600 | .600 |
| 19 | 196716 | .400 | 0.000 | 2.800 | 6.300 | 1.200 | 0.000 | 3.000 | .100 | .700 | .500 |
| 20 | 206717 | .100 | 0.000 | 6.400 | 11.800 | .400 | 1.600 | 1.700 | .100 | .500 | .300 |
| 21 | 216782 | .900 | .700 | 1.400 | 7.400 | .600 | 1.000 | 1.300 | .700 | .100 | .300 |
| 22 | 226806 | 1.000 | 0.000 | 3.600 | 7.600 | 1.500 | .900 | 7.100 | .300 | .200 | 0.000 |
| 23 | 238053 | 3.600 | 0.000 | 0.000 | 8.700 | .800 | .600 | 2.600 | 7.200 | .300 | 0.000 |
| 24 | 248055 | 3.600 | 0.000 | 4.600 | 9.200 | .900 | .400 | .300 | 9.000 | 1.600 | 0.000 |
| 25 | 258056 | 2.600 | 0.000 | .400 | 6.900 | .900 | .400 | 2.300 | 3.200 | .100 | 0.000 |
| 26 | 268059 | 2.700 | 0.000 | .700 | 6.400 | 1.000 | .800 | .200 | 6.200 | .400 | 0.000 |
| 27 | 278062 | 6.100 | 0.000 | 1.500 | 3.600 | 1.300 | .900 | 1.700 | 3.300 | .100 | .400 |
| 28 | 288939 | .200 | 0.000 | 2.000 | 6.200 | .900 | .400 | 4.400 | .400 | .300 | 0.000 |
| 29 | 298956 | .800 | 0.000 | 1.100 | 5.600 | 1.000 | .100 | 2.500 | 2.100 | .900 | 2.300 |
| 30 | 309061 | .800 | 0.000 | 1.500 | 13.900 | .700 | .500 | .700 | 1.100 | 1.300 | 0.000 |
| 31 | 319234 | .700 | 0.000 | 2.200 | .900 | .900 | 0.000 | 2.400 | 0.000 | .100 | .200 |
| 32 | 329908 | 2.000 | .400 | 4.100 | 5.800 | 1.700 | .800 | 4.400 | .500 | .800 | 2.900 |
| 33 | 330129 | 3.100 | 1.700 | 1.600 | 17.200 | .200 | 1.700 | .600 | 4.000 | 2.700 | 0.000 |
| 34 | 340130 | 3.200 | 1.200 | .300 | 8.100 | .800 | .500 | 5.700 | 3.000 | .700 | 1.600 |

| NO. | SAMPLE | 31<br>S67 | 32<br>S68 | 33<br>S69 | 34<br>N4 | 35<br>N11 | 36<br>N19 | 37<br>N28 | 38<br>N29 | 39<br>N30 | 40<br>N31 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 13423 | 0.000 | .600 | .400 | 4.100 | 0.000 | .300 | 0.000 | .100 | .300 | .600 |
| 2 | 23426 | .100 | 1.500 | 0.000 | 5.000 | 0.000 | .300 | .400 | .100 | 0.000 | 1.800 |
| 3 | 33433 | 0.000 | .400 | 4.400 | 2.800 | 0.000 | .400 | 0.000 | 0.000 | 0.000 | 0.000 |
| 4 | 43813 | 0.000 | 0.000 | .700 | 13.900 | 0.000 | 2.100 | .400 | .100 | 0.000 | 1.400 |
| 5 | 53986 | 0.000 | .200 | .200 | 12.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | .600 |
| 6 | 63987 | 0.000 | 0.000 | 1.000 | 11.300 | 0.000 | .200 | .100 | .400 | 0.000 | .800 |
| 7 | 71234 | 0.000 | 0.000 | 0.000 | 1.600 | .400 | .200 | 1.100 | 2.300 | 0.000 | .900 |
| 8 | 85229 | 0.000 | .900 | 1.300 | .700 | .300 | .200 | 1.700 | 3.500 | 0.000 | 1.300 |
| 9 | 95232 | 0.000 | 0.000 | 4.600 | .100 | .500 | .600 | 2.900 | 8.200 | 0.000 | .600 |
| 10 | 105242 | 0.000 | 1.700 | 3.300 | 0.000 | 0.000 | .400 | 1.400 | 2.200 | 0.000 | 1.400 |
| 11 | 115243 | 0.000 | .600 | 3.300 | .200 | 0.000 | .400 | 2.300 | 1.700 | 0.000 | 2.500 |
| 12 | 125246 | 0.000 | 0.000 | 0.000 | 4.900 | 0.000 | .100 | .200 | .100 | 3.300 | 0.000 |
| 13 | 135256 | 0.000 | 0.000 | 0.000 | 4.700 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | .400 |
| 14 | 145267 | 0.000 | 0.000 | 0.000 | 4.400 | 1.300 | 0.000 | 1.300 | .800 | 1.100 | .500 |
| 15 | 156663 | 0.000 | 0.000 | 0.000 | 1.600 | .100 | 0.000 | .500 | .100 | .100 | .100 |
| 16 | 166687 | 0.000 | 0.000 | 0.000 | 2.300 | .800 | 4.100 | 0.000 | 0.000 | 0.000 | 2.400 |
| 17 | 176713 | 1.800 | 0.000 | 0.000 | 1.200 | 4.900 | 0.000 | .200 | 1.400 | 2.000 | .500 |
| 18 | 186714 | 2.500 | 0.000 | 0.000 | 1.200 | 0.000 | 0.000 | .100 | 1.700 | 2.700 | .400 |
| 19 | 196716 | .600 | 0.000 | 0.000 | 1.200 | .100 | 0.000 | .500 | .500 | 5.100 | 1.000 |
| 20 | 206717 | .400 | 0.000 | 0.000 | 4.900 | .200 | 0.000 | .100 | .900 | 2.900 | .200 |
| 21 | 216782 | .700 | 0.000 | 0.000 | 2.300 | .100 | 0.000 | .400 | 3.900 | .400 | 2.900 |
| 22 | 226806 | 0.000 | 0.000 | 0.000 | 2.300 | .300 | .100 | .100 | 4.300 | .300 | 2.500 |
| 23 | 238053 | 0.000 | 0.000 | 0.000 | 1.900 | .600 | .100 | .100 | 1.000 | .500 | 1.200 |
| 24 | 248055 | 0.000 | 0.000 | 0.000 | .900 | .300 | .100 | .200 | 1.400 | .300 | .300 |
| 25 | 258056 | 0.000 | 0.000 | 0.000 | 2.600 | .100 | 0.000 | .400 | .500 | .600 | .500 |
| 26 | 268059 | 0.000 | 0.000 | 0.000 | 3.400 | 0.000 | .300 | .400 | 0.000 | .100 | .200 |
| 27 | 278062 | 0.000 | 0.000 | 0.000 | .800 | 0.000 | 0.000 | 0.000 | 1.800 | 1.900 | .600 |
| 28 | 288939 | 0.000 | 0.000 | 0.000 | 3.300 | .200 | .100 | .200 | 1.000 | .200 | 2.700 |
| 29 | 298956 | 0.000 | 0.000 | 0.000 | 1.600 | 0.000 | .200 | .100 | 2.300 | .400 | .600 |
| 30 | 309061 | 0.000 | 0.000 | 0.000 | 7.300 | 0.000 | 0.000 | .200 | .400 | .600 | .400 |
| 31 | 319234 | 0.000 | 0.000 | 0.000 | .600 | 0.000 | .200 | 0.000 | 1.100 | .900 | .600 |
| 32 | 329908 | 0.000 | 4.100 | 2.400 | .200 | 0.000 | .100 | 1.600 | 2.600 | 0.000 | .600 |
| 33 | 330129 | 0.000 | .400 | 1.500 | 6.600 | .100 | .200 | .500 | .300 | .200 | .400 |
| 34 | 340130 | 0.000 | .500 | 3.300 | 3.000 | .400 | .200 | 1.100 | 2.400 | 0.000 | 2.200 |

| NO. | SAMPLE | 41 N38 | 42 N41 | 43 N42 | 44 N48 |
|---|---|---|---|---|---|
| 1 | 13423 | .100 | 1.600 | .200 | .100 |
| 2 | 23426 | 0.000 | 0.000 | 0.000 | .100 |
| 3 | 33433 | 0.000 | 0.000 | 0.000 | 1.000 |
| 4 | 43813 | 0.000 | .100 | 0.000 | .300 |
| 5 | 53986 | 0.000 | 0.000 | .400 | .300 |
| 6 | 63987 | 0.000 | .400 | 0.000 | .100 |
| 7 | 71234 | .100 | .800 | 1.100 | .300 |
| 8 | 85229 | 1.000 | .300 | 1.600 | 3.500 |
| 9 | 95232 | 3.000 | 0.000 | 1.700 | 4.100 |
| 10 | 105242 | .700 | 0.000 | 1.400 | 3.800 |
| 11 | 115243 | .200 | 0.000 | 2.300 | 1.600 |
| 12 | 125246 | 0.000 | 0.000 | .100 | .100 |
| 13 | 135256 | 0.000 | 0.000 | 0.000 | 0.000 |
| 14 | 145267 | 0.000 | 1.700 | .700 | .200 |
| 15 | 156663 | 0.000 | 1.300 | .100 | .100 |
| 16 | 166687 | 0.000 | 0.000 | 0.000 | .800 |
| 17 | 176713 | 0.000 | 1.500 | .900 | .600 |
| 18 | 186714 | 0.000 | 2.600 | .500 | .400 |
| 19 | 196716 | .200 | 4.100 | 1.600 | .400 |
| 20 | 206717 | 0.000 | 3.200 | .400 | .200 |
| 21 | 216782 | .400 | 1.200 | 0.000 | 2.100 |
| 22 | 226806 | 0.000 | .200 | .600 | 2.300 |
| 23 | 238053 | .100 | 2.000 | .300 | .200 |
| 24 | 248055 | 0.000 | 3.400 | .300 | 0.000 |
| 25 | 258056 | 0.000 | 2.200 | .200 | .200 |
| 26 | 268059 | 0.000 | 2.000 | .300 | 0.000 |
| 27 | 278062 | 0.000 | 1.200 | .100 | 1.000 |
| 28 | 288939 | .300 | 1.500 | .100 | .600 |
| 29 | 298956 | .100 | 1.100 | 0.000 | 0.000 |
| 30 | 309061 | .200 | .800 | .500 | .100 |
| 31 | 319234 | 0.000 | .400 | 0.000 | .500 |
| 32 | 329908 | .400 | .100 | .200 | 7.300 |
| 33 | 330129 | 0.000 | .500 | 0.000 | .400 |
| 34 | 340130 | .300 | .200 | .200 | 4.300 |

# APPENDIX VII

## Downcore Factor Matrix (B') for BNFC 43 PG

| | | COMUNAL | F1 | F2 | F6 | F3 | F5 | F4 |
|---|---|---|---|---|---|---|---|---|
| 1 | 489864 | .9008 | .7734 | .1345 | .3707 | .2056 | .0577 | -.3188 |
| 2 | 499865 | .8706 | .4209 | .2018 | .2960 | .2650 | .0200 | -.7032 |
| 3 | 509062 | .7614 | -.0381 | .1640 | .4273 | .2792 | -.0245 | -.6869 |
| 4 | 519866 | .7137 | .0561 | .2860 | .4425 | .0279 | -.0497 | -.6555 |
| 5 | 529867 | .7801 | .0547 | .1713 | .5071 | .1887 | .0143 | -.6744 |
| 6 | 539063 | .8182 | .1645 | .1132 | .3551 | .2139 | .0306 | -.7781 |
| 7 | 549868 | .8690 | .4844 | .1076 | .4025 | .2227 | .1984 | -.6099 |
| 8 | 559064 | .8796 | .3134 | .1144 | .3216 | .2780 | .1667 | -.7482 |
| 9 | 569869 | .8475 | .2097 | .0825 | .2190 | .2044 | .1687 | -.8237 |
| 10 | 579065 | .8637 | .3652 | .0827 | .4480 | .2834 | .1191 | -.6545 |
| 11 | 589870 | .8782 | .3218 | .0649 | .3334 | .2850 | .1548 | -.7444 |
| 12 | 599066 | .8421 | .5599 | .0203 | .3211 | .2557 | .2695 | -.5357 |
| 13 | 609871 | .8439 | .3995 | .0489 | .2558 | .2568 | .2126 | -.7108 |
| 14 | 619067 | .3678 | .3798 | .1724 | .3743 | .1073 | .1959 | .0626 |
| 15 | 629872 | .5108 | .3541 | .2112 | .3887 | .0742 | .1804 | .3894 |
| 16 | 639068 | .5456 | .3343 | .2182 | .4362 | .0357 | .1763 | .4045 |
| 17 | 649873 | .5223 | .3448 | .1046 | .4581 | .0467 | .1820 | .3839 |
| 18 | 659874 | .5192 | .3278 | .1805 | .4525 | .0196 | .1732 | .3795 |
| 19 | 669069 | .5717 | .3251 | .1968 | .4082 | .0312 | .1532 | .4861 |
| 20 | 679070 | .4126 | .3028 | .2077 | .3754 | .0284 | .1584 | .3330 |
| 21 | 689876 | .5130 | .2933 | .2335 | .3639 | .0262 | .1487 | .4660 |
| 22 | 699071 | .5841 | .2944 | .2084 | .3492 | .0352 | .1308 | .5600 |
| 23 | 709072 | .4425 | .2754 | .2258 | .3805 | -.0054 | .1461 | .3866 |

# APPENDIX VIII

Downcore Radiolarian Percentages
for BNFC 43 PG

BNFC DOWNCORE

RAW DATA

| NO. | SAMPLE NAME | 1<br>S2 | 2<br>S3 | 3<br>S9 | 4<br>S11 | 5<br>S12 | 6<br>S15 | 7<br>S16 | 8<br>S17 | 9<br>S22 | 10<br>S25 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 489864 | .773 | .135 | .371 | .206 | .058 | -.319 | .260 | .005 | 0.000 | .162 |
| 2 | 499865 | .421 | .202 | .296 | .265 | .020 | -.703 | .260 | .005 | 0.000 | .162 |
| 3 | 509062 | -.038 | .164 | .427 | .279 | -.024 | -.687 | .260 | .005 | 0.000 | .162 |
| 4 | 519866 | .056 | .286 | .442 | .028 | -.050 | -.656 | .260 | .005 | 0.000 | .162 |
| 5 | 529867 | .055 | .171 | .507 | .189 | .014 | -.674 | .260 | .005 | 0.000 | .162 |
| 6 | 539063 | .164 | .113 | .355 | .214 | .031 | -.778 | .260 | .005 | 0.000 | .162 |
| 7 | 549868 | .484 | .108 | .402 | .223 | .198 | -.610 | .260 | .005 | 0.000 | .162 |
| 8 | 559064 | .313 | .114 | .322 | .278 | .167 | -.748 | .260 | .005 | 0.000 | .162 |
| 9 | 569869 | .210 | .082 | .219 | .204 | .169 | -.824 | .260 | .005 | 0.000 | .162 |
| 10 | 579065 | .365 | .083 | .448 | .283 | .119 | -.654 | .260 | .005 | 0.000 | .162 |
| 11 | 589870 | .322 | .065 | .333 | .285 | .155 | -.744 | .260 | .005 | 0.000 | .162 |
| 12 | 599066 | .560 | .020 | .321 | .256 | .270 | -.536 | .260 | .005 | 0.000 | .162 |
| 13 | 609871 | .400 | .049 | .256 | .257 | .213 | -.711 | .260 | .005 | 0.000 | .162 |
| 14 | 619067 | 0.000 | .100 | .100 | 0.000 | 0.000 | .100 | 0.000 | 0.000 | 0.000 | .200 |
| 15 | 629872 | 0.000 | .100 | .100 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | .200 |
| 16 | 639068 | 0.000 | .400 | 0.000 | 0.000 | 0.000 | .200 | 0.000 | 0.000 | 0.000 | .400 |
| 17 | 649873 | 0.000 | .200 | .100 | 0.000 | 0.000 | .200 | 0.000 | 0.000 | .100 | .400 |
| 18 | 659874 | .100 | 2.700 | .800 | .200 | 0.000 | 4.500 | 2.000 | 0.000 | .100 | 4.200 |
| 19 | 669069 | 0.000 | .400 | .100 | 0.000 | .100 | .600 | .100 | 0.000 | 0.000 | .700 |
| 20 | 679070 | 0.000 | .100 | .100 | 0.000 | 0.000 | .400 | 0.000 | 0.000 | 0.000 | .400 |
| 21 | 689876 | 0.000 | .100 | 0.000 | 0.000 | 0.000 | .300 | 0.000 | 0.000 | 0.000 | .600 |
| 22 | 699071 | 0.000 | .100 | 0.000 | 0.000 | .100 | .500 | 0.000 | 0.000 | 0.000 | .200 |
| 23 | 709072 | 0.000 | .100 | .100 | 0.000 | 0.000 | .300 | 0.000 | 0.000 | 0.000 | .400 |

| NO. | SAMPLE NAME | 11<br>S28 | 12<br>S30 | 13<br>S32 | 14<br>S33 | 15<br>S38 | 16<br>S39 | 17<br>S43 | 18<br>S44 | 19<br>S47 | 20<br>S48 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 489864 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | .400 | .100 | 0.000 | .100 |
| 2 | 499865 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | .400 | .100 | 0.000 | .100 |
| 3 | 509062 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | .400 | .100 | 0.000 | .100 |
| 4 | 519866 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | .400 | .100 | 0.000 | .100 |
| 5 | 529867 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | .400 | .100 | 0.000 | .100 |
| 6 | 539063 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | .400 | .100 | 0.000 | .100 |
| 7 | 549868 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | .400 | .100 | 0.000 | .100 |
| 8 | 559064 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | .400 | .100 | 0.000 | .100 |
| 9 | 569869 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | .400 | .100 | 0.000 | .100 |
| 10 | 579065 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | .400 | .100 | 0.000 | .100 |
| 11 | 589870 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | .400 | .100 | 0.000 | .100 |
| 12 | 599066 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | .400 | .100 | 0.000 | .100 |
| 13 | 609871 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | .400 | .100 | 0.000 | .100 |
| 14 | 619067 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | .200 | .200 | 0.000 | .100 |
| 15 | 629872 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | .300 | .300 | 0.000 | .200 |
| 16 | 639068 | 0.000 | 0.000 | 0.000 | 0.000 | .100 | 0.000 | .300 | .200 | 0.000 | .200 |
| 17 | 649873 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | .300 | 0.000 | 0.000 | 0.000 |
| 18 | 659874 | .100 | .500 | .200 | .100 | .800 | .800 | 2.000 | 2.000 | .100 | .600 |
| 19 | 669069 | 0.000 | 0.000 | 0.000 | 0.000 | .100 | 0.000 | .200 | .100 | 0.000 | .100 |
| 20 | 679070 | 0.000 | 0.000 | 0.000 | 0.000 | .100 | 0.000 | .300 | .100 | 0.000 | .100 |
| 21 | 689876 | 0.000 | 0.000 | 0.000 | 0.000 | .200 | 0.000 | .500 | .100 | 0.000 | .300 |
| 22 | 699071 | 0.000 | 0.000 | .200 | 0.000 | .300 | 0.000 | .600 | .300 | 0.000 | .300 |
| 23 | 709072 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | .400 | .100 | 0.000 | .100 |

| NO. | SAMPLE NAME | 21 S49 | 22 S50 | 23 S53 | 24 S54 | 25 S55 | 26 S56 | 27 S58 | 28 S59 | 29 S62 | 30 S65 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 489864 | .100 | 0.000 | 0.000 | 1.200 | 0.000 | 0.000 | 0.000 | .300 | .200 | 0.000 |
| 2 | 499865 | .100 | 0.000 | 0.000 | 1.200 | 0.000 | 0.000 | 0.000 | .300 | .200 | 0.000 |
| 3 | 509062 | .100 | 0.000 | 0.000 | 1.200 | 0.000 | 0.000 | 0.000 | .300 | .200 | 0.000 |
| 4 | 519866 | .100 | 0.000 | 0.000 | 1.200 | 0.000 | 0.000 | 0.000 | .300 | .200 | 0.000 |
| 5 | 529867 | .100 | 0.000 | 0.000 | 1.200 | 0.000 | 0.000 | 0.000 | .300 | .200 | 0.000 |
| 6 | 539063 | .100 | 0.000 | 0.000 | 1.200 | 0.000 | 0.000 | 0.000 | .300 | .200 | 0.000 |
| 7 | 549868 | .100 | 0.000 | 0.000 | 1.200 | 0.000 | 0.000 | 0.000 | .300 | .200 | 0.000 |
| 8 | 559064 | .100 | 0.000 | 0.000 | 1.200 | 0.000 | 0.000 | 0.000 | .300 | .200 | 0.000 |
| 9 | 569869 | .100 | 0.000 | 0.000 | 1.200 | 0.000 | 0.000 | 0.000 | .300 | .200 | 0.000 |
| 10 | 579065 | .100 | 0.000 | 0.000 | 1.200 | 0.000 | 0.000 | 0.000 | .300 | .200 | 0.000 |
| 11 | 589870 | .100 | 0.000 | 0.000 | 1.200 | 0.000 | 0.000 | 0.000 | .300 | .200 | 0.000 |
| 12 | 599066 | .100 | 0.000 | 0.000 | 1.200 | 0.000 | 0.000 | 0.000 | .300 | .200 | 0.000 |
| 13 | 609871 | .100 | 0.000 | 0.000 | 1.200 | 0.000 | 0.000 | 0.000 | .300 | .200 | 0.000 |
| 14 | 619067 | .100 | .100 | 0.000 | 1.400 | 0.000 | .100 | 0.000 | .400 | .300 | 0.000 |
| 15 | 629872 | .100 | 0.000 | 0.000 | 1.600 | 0.000 | 0.000 | 0.000 | .400 | .100 | 0.000 |
| 16 | 639068 | 0.000 | 0.000 | 0.000 | 1.400 | 0.000 | .100 | 0.000 | .500 | .100 | 0.000 |
| 17 | 649873 | 0.000 | 0.000 | 0.000 | 1.700 | 0.000 | 0.000 | 0.000 | .500 | .200 | 0.000 |
| 18 | 659874 | .100 | 0.000 | 0.000 | 15.400 | .200 | .500 | .300 | 4.400 | 1.100 | .100 |
| 19 | 669069 | 0.000 | 0.000 | 0.000 | .700 | 0.000 | 0.000 | 0.000 | .400 | 0.000 | 0.000 |
| 20 | 679070 | .100 | 0.000 | 0.000 | 1.200 | 0.000 | 0.000 | .100 | .400 | 0.000 | 0.000 |
| 21 | 689876 | .100 | 0.000 | 0.000 | 1.300 | 0.000 | 0.000 | 0.000 | .300 | .200 | 0.000 |
| 22 | 699071 | 0.000 | 0.000 | .100 | .600 | 0.000 | 0.000 | .100 | .200 | 0.000 | 0.000 |
| 23 | 709072 | .100 | 0.000 | 0.000 | 1.200 | 0.000 | 0.000 | 0.000 | .300 | .200 | 0.000 |

| NO. | SAMPLE NAME | 31<br>S67 | 32<br>S68 | 33<br>S69 | 34<br>N4 | 35<br>N11 | 36<br>N19 | 37<br>N28 | 38<br>N29 | 39<br>N30 | 40<br>N31 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 489864 | 0.000 | 0.000 | 0.000 | .300 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2 | 499865 | 0.000 | 0.000 | 0.000 | .300 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 3 | 509062 | 0.000 | 0.000 | 0.000 | .300 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 4 | 519866 | 0.000 | 0.000 | 0.000 | .300 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5 | 529867 | 0.000 | 0.000 | 0.000 | .300 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 6 | 539063 | 0.000 | 0.000 | 0.000 | .300 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 7 | 549868 | 0.000 | 0.000 | 0.000 | .300 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 8 | 559064 | 0.000 | 0.000 | 0.000 | .300 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 9 | 569869 | 0.000 | 0.000 | 0.000 | .300 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 10 | 579065 | 0.000 | 0.000 | 0.000 | .300 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 11 | 589870 | 0.000 | 0.000 | 0.000 | .300 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 12 | 599066 | 0.000 | 0.000 | 0.000 | .300 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 13 | 609871 | 0.000 | 0.000 | 0.000 | .300 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 14 | 619067 | 0.000 | 0.000 | 0.000 | .500 | 0.000 | 0.000 | 0.000 | .100 | 0.000 | 0.000 |
| 15 | 629872 | 0.000 | 0.000 | 0.000 | .800 | 0.000 | 0.000 | 0.000 | .100 | 0.000 | 0.000 |
| 16 | 639068 | 0.000 | 0.000 | .100 | .300 | 0.000 | 0.000 | 0.000 | 0.000 | .100 | 0.000 |
| 17 | 649873 | 0.000 | 0.000 | .100 | .300 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 18 | 659874 | 0.000 | 0.000 | .200 | 2.900 | 0.000 | 0.000 | .500 | .600 | .700 | .600 |
| 19 | 669069 | 0.000 | 0.000 | 0.000 | .200 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 20 | 679070 | 0.000 | 0.000 | 0.000 | .300 | 0.000 | 0.000 | 0.000 | .100 | 0.000 | 0.000 |
| 21 | 689876 | 0.000 | 0.000 | 0.000 | .300 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 22 | 699071 | 0.000 | 0.000 | 0.000 | .200 | 0.000 | 0.000 | 0.000 | 0.000 | .100 | 0.000 |
| 23 | 709072 | 0.000 | 0.000 | 0.000 | .300 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

| NO. | SAMPLE NAME | 41 | 42 | 43 | 44 |
|---|---|---|---|---|---|
| | | N38 | N41 | N42 | N48 |
| 1 | 489864 | 0.000 | .400 | .100 | 0.000 |
| 2 | 499865 | 0.000 | .400 | .100 | 0.000 |
| 3 | 509062 | 0.000 | .400 | .100 | 0.000 |
| 4 | 519866 | 0.000 | .400 | .100 | 0.000 |
| 5 | 529867 | 0.000 | .400 | .100 | 0.000 |
| 6 | 539063 | 0.000 | .400 | .100 | 0.000 |
| 7 | 549868 | 0.000 | .400 | .100 | 0.000 |
| 8 | 559064 | 0.000 | .400 | .100 | 0.000 |
| 9 | 569869 | 0.000 | .400 | .100 | 0.000 |
| 10 | 579065 | 0.000 | .400 | .100 | 0.000 |
| 11 | 589870 | 0.000 | .400 | .100 | 0.000 |
| 12 | 599066 | 0.000 | .400 | .100 | 0.000 |
| 13 | 609871 | 0.000 | .400 | .100 | 0.000 |
| 14 | 619067 | 0.000 | .200 | .100 | 0.000 |
| 15 | 629872 | 0.000 | .200 | 0.000 | 0.000 |
| 16 | 639068 | 0.000 | .400 | 0.000 | 0.000 |
| 17 | 649873 | 0.000 | .300 | .100 | 0.000 |
| 18 | 659874 | 0.000 | 3.500 | 1.200 | 0.000 |
| 19 | 669069 | 0.000 | .300 | .100 | 0.000 |
| 20 | 679070 | 0.000 | .400 | .100 | 0.000 |
| 21 | 689876 | 0.000 | .400 | .200 | 0.000 |
| 22 | 699071 | 0.000 | .100 | 0.000 | 0.000 |
| 23 | 709072 | 0.000 | .400 | .100 | 0.000 |

# APPENDIX IX

## Results of Regression Analysis

SURFACE TEMPERATURE REGRESSIONS
CORRELATION MATRIX

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ROW 1. | TFEB | | | | | | | | | | |
| | | 1.000 | .935 | .743 | .736 | .603 | -.204 | -.833 | .310 | .095 | .042 |
| | | -.156 | -.341 | .651 | .321 | -.294 | -.654 | .028 | -.125 | .131 | -.062 |
| | | -.352 | .485 | .459 | -.273 | -.139 | .571 | -.291 | -.836 | .403 | .109 |
| | | -.039 | | | | | | | | | |
| ROW 2. | TAUG | | | | | | | | | | |
| | | .935 | 1.000 | .683 | .670 | .558 | -.223 | -.881 | .294 | .158 | .194 |
| | | -.194 | -.324 | .563 | .354 | -.375 | -.680 | -.017 | -.107 | .068 | -.191 |
| | | -.264 | .402 | .454 | -.326 | -.212 | .537 | -.307 | -.859 | .336 | .175 |
| | | -.178 | | | | | | | | | |
| ROW 3. | T133F | | | | | | | | | | |
| | | .743 | .683 | 1.000 | .970 | .641 | -.110 | -.687 | .003 | -.072 | -.020 |
| | | -.004 | -.249 | .276 | .088 | -.121 | -.518 | -.130 | -.091 | .152 | -.256 |
| | | -.363 | .520 | .179 | -.013 | -.046 | .571 | -.176 | -.716 | .046 | -.057 |
| | | .086 | | | | | | | | | |
| ROW 4. | T133A | | | | | | | | | | |
| | | .736 | .670 | .970 | 1.000 | .657 | -.104 | -.684 | -.082 | -.074 | .031 |
| | | .019 | -.250 | .212 | .088 | -.126 | -.513 | -.150 | -.072 | .133 | -.322 |
| | | -.337 | .497 | .147 | .019 | -.065 | .579 | -.166 | -.717 | -.031 | -.050 |
| | | .058 | | | | | | | | | |
| ROW 5. | F1SQ | | | | | | | | | | |
| | | .603 | .558 | .641 | .657 | 1.000 | -.378 | -.472 | -.252 | -.029 | -.355 |
| | | .215 | .322 | .322 | .273 | -.172 | -.459 | -.393 | -.167 | .376 | -.386 |
| | | -.211 | .640 | -.014 | .399 | .173 | .965 | -.398 | -.473 | -.200 | -.010 |
| | | .400 | | | | | | | | | |
| ROW 6. | F2SQ | | | | | | | | | | |
| | | -.204 | -.223 | -.110 | -.104 | -.378 | 1.000 | -.169 | -.181 | -.259 | -.051 |
| | | .274 | -.401 | -.344 | -.321 | .335 | .446 | .340 | .250 | -.346 | -.182 |
| | | -.260 | .152 | -.254 | .120 | .249 | -.459 | .954 | -.211 | -.215 | -.293 |
| | | .109 | | | | | | | | | |
| ROW 7. | F3SQ | | | | | | | | | | |
| | | -.833 | -.881 | -.687 | -.684 | -.472 | -.169 | 1.000 | -.125 | -.065 | -.193 |
| | | -.094 | .407 | -.403 | -.224 | .359 | .450 | -.073 | -.016 | .085 | .335 |
| | | .405 | -.473 | -.332 | .219 | .171 | -.443 | -.096 | .985 | -.166 | -.058 |
| | | .157 | | | | | | | | | |
| ROW 8. | F4SQ | | | | | | | | | | |
| | | .310 | .294 | .003 | -.082 | -.252 | -.181 | -.125 | 1.000 | -.175 | .053 |
| | | -.258 | -.228 | .706 | -.201 | -.033 | -.167 | .415 | -.268 | .005 | .673 |
| | | -.200 | -.097 | .364 | -.687 | .035 | -.193 | -.182 | -.075 | .935 | -.158 |
| | | -.154 | | | | | | | | | |
| ROW 9. | F5SQ | | | | | | | | | | |
| | | .095 | .158 | -.072 | -.074 | -.029 | -.259 | -.065 | -.175 | 1.000 | -.014 |
| | | -.371 | .008 | -.088 | .348 | -.138 | -.368 | -.416 | .409 | .251 | -.332 |
| | | .713 | .084 | .525 | .114 | -.673 | .059 | -.363 | -.060 | -.200 | .953 |
| | | -.028 | | | | | | | | | |
| ROW 10. | F6SQ | | | | | | | | | | |
| | | .042 | .194 | -.020 | .031 | -.355 | -.051 | -.193 | .053 | -.014 | 1.000 |
| | | -.195 | -.381 | -.124 | -.131 | -.560 | -.031 | .232 | -.011 | -.515 | .025 |
| | | -.089 | -.699 | .137 | -.668 | -.502 | -.348 | -.009 | -.158 | .139 | .009 |
| | | -.970 | | | | | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ROW 11. | F1*F2 | | | | | | | | |
| -.156 | -.194 | -.004 | .019 | .215 | .274 | -.084 | -.258 | -.371 | -.195 |
| 1.000 | .432 | -.062 | -.293 | -.211 | .566 | .169 | -.049 | -.237 | -.194 |
| -.353 | .099 | -.409 | .317 | .369 | .290 | .450 | -.027 | -.274 | -.433 |
| .165 | | | | | | | | | |
| ROW 12. | F1*F3 | | | | | | | | |
| -.341 | -.324 | -.249 | -.250 | .322 | -.401 | .407 | -.228 | .008 | -.381 |
| .432 | 1.000 | .015 | .069 | -.090 | .316 | -.280 | -.053 | .276 | -.124 |
| .260 | -.026 | -.269 | .432 | .208 | .453 | -.270 | .481 | -.297 | .002 |
| .337 | | | | | | | | | |
| ROW 13. | F1*F4 | | | | | | | | |
| .651 | .563 | .276 | .212 | .322 | -.344 | -.403 | .706 | -.088 | -.124 |
| -.062 | .015 | 1.000 | .073 | -.309 | -.391 | .157 | -.326 | .263 | .423 |
| -.317 | .261 | .381 | -.364 | .050 | .408 | -.374 | -.366 | .768 | -.080 |
| .050 | | | | | | | | | |
| ROW 14. | F1*F5 | | | | | | | | |
| .321 | .354 | .088 | .088 | .273 | -.321 | -.224 | -.201 | .848 | -.131 |
| -.293 | .069 | .073 | 1.000 | -.256 | -.481 | -.464 | .411 | .331 | -.348 |
| .539 | .269 | .580 | .181 | -.517 | .345 | -.430 | -.231 | -.174 | .902 |
| .078 | | | | | | | | | |
| ROW 15. | F1*F6 | | | | | | | | |
| -.294 | -.375 | -.121 | -.126 | -.172 | .335 | .359 | -.033 | -.138 | -.560 |
| -.211 | -.090 | -.309 | -.256 | 1.000 | .243 | .149 | .001 | .084 | .101 |
| .068 | .298 | -.238 | .345 | .425 | -.314 | .298 | .305 | -.107 | -.189 |
| .610 | | | | | | | | | |
| ROW 16. | F2*F3 | | | | | | | | |
| -.654 | -.680 | -.518 | -.513 | -.459 | .446 | .450 | -.167 | -.368 | -.031 |
| .566 | .316 | -.391 | -.481 | .243 | 1.000 | .526 | -.019 | -.534 | .158 |
| -.157 | -.422 | -.480 | .073 | .365 | -.428 | .648 | .505 | -.165 | -.449 |
| -.021 | | | | | | | | | |
| ROW 17, | F2*F4 | | | | | | | | |
| .028 | -.017 | -.130 | -.150 | -.393 | .340 | -.073 | .415 | -.416 | .232 |
| .169 | -.280 | .157 | -.464 | .149 | .526 | 1.000 | -.214 | -.739 | .477 |
| -.448 | -.339 | -.189 | -.528 | .266 | -.431 | .497 | -.015 | .502 | -.492 |
| -.314 | | | | | | | | | |
| ROW 18. | F2*F5 | | | | | | | | |
| -.125 | -.107 | -.091 | -.072 | -.167 | .250 | -.016 | -.268 | .409 | -.011 |
| -.049 | -.053 | -.326 | .411 | .001 | -.019 | -.214 | 1.000 | .039 | -.390 |
| .513 | .039 | .102 | .151 | -.419 | -.166 | .220 | -.051 | -.356 | .526 |
| .000 | | | | | | | | | |
| ROW 19. | F2*F6 | | | | | | | | |
| .131 | .068 | .152 | .133 | .376 | -.346 | .085 | .005 | .251 | -.515 |
| -.237 | .276 | .263 | .331 | .084 | -.534 | -.739 | .039 | 1.000 | -.060 |
| .251 | .559 | .191 | .457 | -.077 | .430 | -.521 | .031 | -.073 | .303 |
| .582 | | | | | | | | | |
| ROW 20. | F3*F4 | | | | | | | | |
| -.062 | -.191 | -.256 | -.322 | -.386 | -.182 | .335 | .673 | -.332 | .025 |
| -.194 | -.124 | .423 | -.348 | .101 | .158 | .477 | -.390 | -.060 | 1.000 |
| -.337 | -.351 | .177 | -.512 | .167 | -.373 | -.126 | .361 | .793 | -.348 |
| -.120 | | | | | | | | | |
| ROW 21. | F3*F5 | | | | | | | | |
| -.352 | -.264 | -.363 | -.337 | -.211 | -.260 | .405 | -.200 | .713 | -.089 |
| -.353 | .260 | -.317 | .539 | .068 | -.157 | -.448 | .513 | .251 | -.337 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.000 | -.129 | .128 | .218 | -.428 | -.136 | -.325 | .405 | -.353 | .770 |
| .062 | | | | | | | | | |
| ROW 22. | F3*F6 | | | | | | | | |
| .485 | .402 | .520 | .497 | .640 | .152 | -.473 | -.097 | .084 | -.699 |
| .099 | -.026 | .261 | .269 | .298 | -.422 | -.339 | .039 | .559 | -.351 |
| -.129 | 1.000 | .058 | .566 | .255 | .588 | .007 | -.529 | -.149 | .076 |
| .768 | | | | | | | | | |
| ROW 23. | F4*F5 | | | | | | | | |
| .459 | .454 | .179 | .147 | -.014 | -.254 | -.332 | .364 | .525 | .137 |
| -.409 | -.269 | .381 | .580 | -.288 | -.480 | -.189 | .102 | .191 | .177 |
| .128 | .058 | 1.000 | -.399 | -.596 | .049 | -.374 | -.327 | .438 | .591 |
| -.214 | | | | | | | | | |
| ROW 24. | F4*F6 | | | | | | | | |
| -.273 | -.326 | -.013 | .019 | .399 | .120 | .219 | -.687 | .114 | -.668 |
| .317 | .432 | -.364 | .181 | .345 | .073 | -.528 | .151 | .457 | -.512 |
| .218 | .566 | -.399 | 1.000 | .325 | .382 | .075 | .160 | -.742 | .082 |
| .759 | | | | | | | | | |
| ROW 25. | F5*F6 | | | | | | | | |
| -.139 | -.212 | -.046 | -.065 | .173 | .249 | .171 | .035 | -.673 | -.502 |
| .369 | .208 | .050 | -.517 | .425 | .365 | .266 | -.419 | -.077 | .167 |
| -.428 | .255 | -.596 | .325 | 1.000 | .107 | .319 | .166 | -.001 | -.717 |
| .524 | | | | | | | | | |
| ROW 26. | F1 | | | | | | | | |
| .571 | .537 | .571 | .579 | .965 | -.459 | -.443 | -.193 | .059 | -.348 |
| .290 | .453 | .408 | .345 | -.314 | -.428 | -.431 | -.166 | .430 | -.373 |
| -.136 | .588 | .049 | .382 | .107 | 1.000 | -.464 | -.424 | -.162 | .072 |
| .367 | | | | | | | | | |
| ROW 27. | F2 | | | | | | | | |
| -.291 | -.307 | -.176 | -.166 | -.398 | .954 | -.096 | -.182 | -.363 | -.009 |
| .450 | -.270 | -.374 | -.430 | .298 | .648 | .497 | .220 | -.521 | -.126 |
| -.325 | .007 | -.374 | .075 | .319 | -.464 | 1.000 | -.109 | -.207 | -.415 |
| .036 | | | | | | | | | |
| ROW 28. | F3 | | | | | | | | |
| -.836 | -.859 | -.716 | -.717 | -.473 | -.211 | .985 | -.075 | -.060 | -.158 |
| -.027 | .481 | -.366 | -.231 | .305 | .505 | -.015 | -.051 | .031 | .361 |
| .405 | -.529 | -.327 | .160 | .166 | -.424 | -.109 | 1.000 | -.122 | -.067 |
| .106 | | | | | | | | | |
| ROW 29. | F4 | | | | | | | | |
| .403 | .336 | .046 | -.031 | -.200 | -.215 | -.166 | .935 | -.200 | .139 |
| -.274 | -.297 | .768 | -.174 | -.107 | -.165 | .502 | -.356 | -.073 | .793 |
| -.353 | -.149 | .438 | -.742 | -.001 | -.162 | -.207 | -.122 | 1.000 | -.193 |
| -.244 | | | | | | | | | |
| ROW 30. | F5 | | | | | | | | |
| .109 | .175 | -.057 | -.050 | -.010 | -.293 | -.058 | -.158 | .953 | .009 |
| -.433 | .002 | -.080 | .902 | -.189 | -.449 | -.492 | .525 | .303 | -.348 |
| .770 | .076 | .591 | .082 | -.717 | .072 | -.415 | -.067 | -.193 | 1.000 |
| -.053 | | | | | | | | | |
| ROW 31. | F6 | | | | | | | | |
| -.039 | -.178 | .086 | .058 | .400 | .109 | .157 | -.154 | -.028 | -.970 |
| .165 | .337 | .050 | .078 | .610 | -.021 | -.314 | .000 | .582 | -.120 |
| .062 | .768 | -.214 | .759 | .524 | .367 | .036 | .106 | -.244 | -.053 |
| 1.000 | | | | | | | | | |

STEP 7

VARIABLE ENTERED..... 23 , F4*F5
(FORCED VARIABLE)

SUM OF SQUARES REDUCED IN THIS STEP.... .793

PROPORTION REDUCED IN THIS STEP........ .001

CUMULATIVE SUM OF SQUARES REDUCED...... 928.707

CUMULATIVE PROPORTION REDUCED.......... .930 OF 998.582

FOR 7 VARIABLES ENTERED
MULTIPLE CORRELATION COEFFICIENT... .964
(ADJUSTED FOR D.F.) .955
F-VALUE FOR ANALYSIS OF VARIANCE... 43.671
STANDARD ERROR OF ESTIMATE......... 1.743
(ADJUSTED FOR D.F.) 1.949

| VARIABLE NUMBER | VARIABLE NAME | REGRESSION COEFFICIENT | STD.ERROR OF REG. COEFF. | COMPUTED T-VALUE |
|---|---|---|---|---|
| 28 | F3 | -19.24143 | 1.90526 | -10.099 |
| 6 | F2SQ | .79996 | 7.31726 | .109 |
| 29 | F4 | 1.69844 | 3.01854 | .563 |
| 22 | F3*F6 | 18.75814 | 7.44516 | 2.520 |
| 17 | F2*F4 | 37.30034 | 15.61495 | 2.389 |
| 27 | F2 | -13.39708 | 7.93154 | -1.689 |
| 23 | F4*F5 | 4.14743 | 8.13399 | .510 |
| INTERCEPT | | 29.89828 | | |

SURFACE TEMPERATURE REGRESSIONS
SELECTION..... 1, TFEB

TABLE OF RESIDUALS

| CASE NO. | SAMPLE | Y VALUE | Y ESTIMATE | RESIDUAL | 80% C.I. HIGH | LOW | STD. ERROR |
|---|---|---|---|---|---|---|---|
| 1 | 3 42 6 | 24.39000 | 26.21611 | -1.82611 | 28.88804 | 23.54418 | 2.05533 |
| 2 | 3 43 3 | 11.72000 | 14.93532 | -3.21532 | 17.91385 | 11.95680 | 2.29117 |
| 3 | 3 81 3 | 27.22000 | 25.18528 | 2.03472 | 27.84601 | 22.52454 | 2.04672 |
| 4 | 3 98 6 | 26.67000 | 24.95428 | 1.71572 | 27.63880 | 22.26976 | 2.06502 |
| 5 | 3 98 7 | 26.39000 | 25.62181 | .76819 | 28.26069 | 22.98293 | 2.02991 |
| 6 | 5 22 9 | 11.11000 | 11.10967 | .00033 | 13.80618 | 8.41316 | 2.07424 |
| 7 | 5 23 2 | 11.67000 | 12.60105 | -.93105 | 15.45568 | 9.74641 | 2.19587 |
| 8 | 5 24 2 | 10.78000 | 11.07647 | -.29647 | 13.99072 | 8.16222 | 2.24173 |
| 9 | 5 24 3 | 11.67000 | 13.86971 | -2.19971 | 16.55013 | 11.18928 | 2.06186 |
| 10 | 5 24 6 | 18.28000 | 18.17119 | .10881 | 21.19942 | 15.14295 | 2.32941 |
| 11 | 5 26 7 | 24.83000 | 25.40323 | -.57323 | 28.02770 | 22.77876 | 2.01882 |
| 12 | 6 66 3 | 23.94000 | 24.98217 | -1.04217 | 27.59965 | 22.36468 | 2.01345 |
| 13 | 6 68 7 | 17.28000 | 17.24819 | .03181 | 20.47520 | 14.02118 | 2.48232 |
| 14 | 6 71 3 | 25.06000 | 26.17222 | -1.11222 | 29.10092 | 23.24351 | 2.25285 |
| 15 | 6 71 4 | 25.72000 | 23.36691 | 2.35309 | 26.23387 | 20.49994 | 2.20536 |
| 16 | 6 71 6 | 25.39000 | 25.89331 | -.50331 | 28.75481 | 23.03182 | 2.20115 |
| 17 | 6 71 7 | 25.56000 | 26.78143 | -1.22143 | 29.66453 | 23.89833 | 2.21777 |
| 18 | 6 78 2 | 16.06000 | 17.36773 | -1.30773 | 20.04552 | 14.68995 | 2.05984 |
| 19 | 6 80 6 | 15.06000 | 16.08271 | -1.02271 | 18.79989 | 13.36553 | 2.09014 |
| 20 | 8 05 3 | 25.00000 | 23.05203 | 1.94797 | 25.66704 | 20.43701 | 2.01155 |
| 21 | 8 05 5 | 25.72000 | 26.20932 | -.48932 | 29.14517 | 23.27347 | 2.25834 |
| 22 | 8 05 6 | 24.72000 | 22.55986 | 2.16014 | 25.26371 | 19.85601 | 2.07989 |
| 23 | 8 05 9 | 26.33000 | 25.92711 | .40289 | 28.57877 | 23.27546 | 2.03974 |
| 24 | 8 06 2 | 21.17000 | 22.85813 | -1.68813 | 25.67231 | 20.04396 | 2.16475 |
| 25 | 8 93 9 | 18.28000 | 17.72553 | .55447 | 20.55006 | 14.90099 | 2.17272 |
| 26 | 8 95 6 | 20.62000 | 21.39186 | -.77186 | 24.51558 | 18.26814 | 2.40286 |
| 27 | 9 06 1 | 26.67000 | 24.92824 | 1.74176 | 27.57163 | 22.28484 | 2.03338 |
| 28 | 9 23 4 | 21.67000 | 22.18056 | -.51056 | 25.33464 | 19.02649 | 2.42621 |
| 29 | 9 90 8 | 13.06000 | 10.51306 | 2.54694 | 13.24812 | 7.77799 | 2.10390 |
| 30 | 10 12 9 | 23.22000 | 23.61074 | -.39074 | 26.18248 | 21.03899 | 1.97827 |
| 31 | 10 13 0 | 13.39000 | 10.65479 | 2.73521 | 13.45825 | 7.85133 | 2.15651 |

STATISTICS FOR RESIDUALS

EAN ABSOLUTE VALUE OF RESIDUALS = 1.2324 STANDARD DEVIATION OF ABSOLUTE VALUE OF RESIDUALS = .8716

MAXIMUM ABSOLUTE VALUE = 3.2153 MINIMUM ABSOLUTE VALUE = .0003

STEP 6

VARIABLE ENTERED..... 27 , F2
(FORCED VARIABLE)

SUM OF SQUARES REDUCED IN THIS STEP.... .005

PROPORTION REDUCED IN THIS STEP........ .000

CUMULATIVE SUM OF SQUARES REDUCED...... 492.758

CUMULATIVE PROPORTION REDUCED.......... .915 OF 538.517

FOR 6 VARIABLES ENTERED
MULTIPLE CORRELATION COEFFICIENT... .957
(ADJUSTED FOR D.F.) .948
F-VALUE FOR ANALYSIS OF VARIANCE... 43.075
STANDARD ERROR OF ESTIMATE......... 1.381
(ADJUSTED FOR D.F.) 1.513

| VARIABLE NUMBER | VARIABLE NAME | REGRESSION COEFFICIENT | STD.ERROR OF REG. COEFF. | COMPUTED T-VALUE |
|---|---|---|---|---|
| 28 | F3 | -16.99472 | 1.31589 | -12.915 |
| 6 | F2SQ | -7.74770 | 4.71852 | -1.642 |
| 18 | F2*F5 | -9.48241 | 9.99878 | -.948 |
| 23 | F4*F5 | 3.53541 | 5.58862 | .633 |
| 12 | F1*F3 | -1.59496 | 3.57782 | -.446 |
| 27 | F2 | -.22738 | 4.31342 | -.053 |
| INTERCEPT | | 31.64530 | | |

SURFACE TEMPERATURE REGRESSIONS
SELECTION..... 2, TAUG

TABLE OF RESIDUALS

| CASE NO. | SAMPLE | Y VALUE | Y ESTIMATE | RESIDUAL | 80% C.I. HIGH | LOW | STD. ERROR |
|---|---|---|---|---|---|---|---|
| 1 | 3 42 6 | 25.83000 | 28.92876 | -3.09876 | 31.05531 | 26.80222 | 1.63580 |
| 2 | 3 43 3 | 22.44000 | 22.40954 | .03046 | 24.53136 | 20.28772 | 1.63217 |
| 3 | 3 81 3 | 26.67000 | 28.01018 | -1.34018 | 30.04611 | 25.97425 | 1.56610 |
| 4 | 3 98 6 | 27.78000 | 27.73501 | .04499 | 29.81439 | 25.65562 | 1.59953 |
| 5 | 3 98 7 | 27.79000 | 27.90039 | -.11039 | 29.93407 | 25.86670 | 1.56437 |
| 6 | 5 22 9 | 17.39000 | 17.18650 | .20350 | 19.32852 | 15.04448 | 1.64771 |
| 7 | 5 23 2 | 16.11000 | 17.46076 | -1.35076 | 19.80131 | 15.12021 | 1.80042 |
| 8 | 5 24 2 | 18.11000 | 17.18535 | .92465 | 19.38145 | 14.98924 | 1.68931 |
| 9 | 5 24 3 | 19.94000 | 19.63238 | .30762 | 21.84026 | 17.42451 | 1.69837 |
| 10 | 5 24 6 | 21.89000 | 21.43566 | .45434 | 23.79383 | 19.07749 | 1.81398 |
| 11 | 5 26 7 | 28.56000 | 27.55396 | 1.00604 | 29.60406 | 25.50386 | 1.57700 |
| 12 | 6 66 3 | 27.17000 | 27.42201 | -.25201 | 29.45748 | 25.38654 | 1.56574 |
| 13 | 6 68 7 | 21.33000 | 21.93968 | -.60968 | 24.44789 | 19.43148 | 1.92939 |
| 14 | 6 71 3 | 27.44000 | 27.25256 | .18744 | 29.45173 | 25.05339 | 1.69167 |
| 15 | 6 71 4 | 27.67000 | 26.19394 | 1.47606 | 28.21678 | 24.17109 | 1.55603 |
| 16 | 6 71 6 | 27.89000 | 25.48292 | 2.40708 | 27.49659 | 23.46925 | 1.54898 |
| 17 | 6 71 7 | 27.83000 | 27.30095 | .52905 | 29.34095 | 25.26094 | 1.56923 |
| 18 | 6 78 2 | 19.94000 | 20.46917 | -.52917 | 22.56005 | 18.37828 | 1.60837 |
| 19 | 6 80 6 | 18.84000 | 19.83754 | -.99754 | 21.98401 | 17.69106 | 1.65114 |
| 20 | 8 05 3 | 27.17000 | 25.97474 | 1.19526 | 28.00987 | 23.93961 | 1.56549 |
| 21 | 8 05 5 | 28.11000 | 28.32295 | -.21295 | 30.63156 | 26.01435 | 1.77585 |
| 22 | 8 05 6 | 26.94000 | 25.35955 | 1.58045 | 27.59895 | 23.12015 | 1.72262 |
| 23 | 8 05 9 | 28.06000 | 28.32625 | -.26625 | 30.34951 | 26.30298 | 1.55636 |
| 24 | 8 06 2 | 24.94000 | 27.32750 | -2.38750 | 29.45137 | 25.20362 | 1.63375 |
| 25 | 8 93 9 | 22.28000 | 23.71491 | -1.43491 | 25.86897 | 21.56086 | 1.65697 |
| 26 | 8 95 6 | 27.78000 | 27.31758 | .46242 | 29.37947 | 25.25570 | 1.58607 |
| 27 | 9 06 1 | 27.83000 | 27.41291 | .41709 | 29.46500 | 25.36081 | 1.57854 |
| 28 | 9 23 4 | 26.89000 | 24.17596 | 2.71404 | 26.51014 | 21.84178 | 1.79552 |
| 29 | 9 90 8 | 16.72000 | 16.90538 | -.18538 | 19.08798 | 14.72279 | 1.67892 |
| 30 | 10 12 9 | 26.11000 | 26.54470 | -.43470 | 28.56775 | 24.52165 | 1.55619 |
| 31 | 10 13 0 | 16.94000 | 17.67031 | -.73031 | 19.87250 | 15.46812 | 1.69399 |

STATISTICS FOR RESIDUALS

EAN ABSOLUTE VALUE OF RESIDUALS = .8994 STANDARD DEVIATION OF ABSOLUTE VALUE OF RESIDUALS = .8476

MAXIMUM ABSOLUTE VALUE = 3.0988 MINIMUM ABSOLUTE VALUE = .0305

STEP 8

VARIABLE ENTERED..... 9 , F5SQ
(FORCED VARIABLE)

SUM OF SQUARES REDUCED IN THIS STEP.... .018

PROPORTION REDUCED IN THIS STEP........ .000

CUMULATIVE SUM OF SQUARES REDUCED...... 285.788

CUMULATIVE PROPORTION REDUCED.......... .722 OF 395.743

FOR 8 VARIABLES ENTERED
MULTIPLE CORRELATION COEFFICIENT... .850
(ADJUSTED FOR D.F.) .798
F-VALUE FOR ANALYSIS OF VARIANCE... 7.148
STANDARD ERROR OF ESTIMATE......... 2.236
(ADJUSTED FOR D.F.) 2.553

| VARIABLE NUMBER | VARIABLE NAME | REGRESSION COEFFICIENT | STD.ERROR OF REG. COEFF. | COMPUTED T-VALUE |
|---|---|---|---|---|
| 28 | F3 | -12.47460 | 3.49512 | -3.569 |
| 5 | F1SQ | 2.79768 | 3.52698 | .793 |
| 14 | F1*F5 | -7.84864 | 7.78092 | -1.009 |
| 27 | F2 | -6.17370 | 3.68943 | -1.673 |
| 15 | F1*F6 | 11.65062 | 7.26284 | 1.604 |
| 8 | F4SQ | -4.94844 | 4.54495 | -1.089 |
| 24 | F4*F6 | -5.39319 | 10.55404 | -.511 |
| 9 | F5SQ | -.56547 | 9.44500 | -.060 |
| INTERCEPT | | 20.99716 | | |

SURFACE TEMPERATURE REGRESSIONS
SELECTION..... 3,     T133F

TABLE OF RESIDUALS

| CASE NO. | SAMPLE | | | Y VALUE | Y ESTIMATE | RESIDUAL | 80% C.I. HIGH | LOW | STD. ERROR |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | 42 | 6 | 20.00000 | 16.52068 | 3.47932 | 20.13682 | 12.90455 | 2.78164 |
| 2 | 3 | 43 | 3 | 11.61000 | 13.31780 | -1.70780 | 16.79976 | 9.83583 | 2.67844 |
| 3 | 3 | 81 | 3 | 16.44000 | 18.93958 | -2.49958 | 22.50301 | 15.37615 | 2.74110 |
| 4 | 3 | 98 | 6 | 25.44000 | 19.93209 | 5.50791 | 23.74050 | 16.12369 | 2.92954 |
| 5 | 3 | 98 | 7 | 21.67000 | 18.87688 | 2.79312 | 22.45027 | 15.30350 | 2.74875 |
| 6 | 5 | 22 | 9 | 8.89000 | 8.99762 | -.10762 | 12.54891 | 5.44633 | 2.73176 |
| 7 | 5 | 23 | 2 | 9.78000 | 9.76638 | .01362 | 13.54668 | 5.98607 | 2.90793 |
| 8 | 5 | 24 | 2 | 8.67000 | 9.14803 | -.47803 | 12.76740 | 5.52867 | 2.74413 |
| 9 | 5 | 24 | 3 | 10.00000 | 10.18556 | -.18556 | 14.00679 | 6.36434 | 2.93940 |
| 10 | 5 | 24 | 6 | 13.33000 | 12.63173 | .69827 | 16.46585 | 8.79760 | 2.94933 |
| 11 | 5 | 26 | 7 | 14.17000 | 16.16530 | -1.99530 | 19.75248 | 12.57812 | 2.75937 |
| 12 | 6 | 66 | 3 | 13.89000 | 16.59750 | -2.70750 | 20.14215 | 13.05286 | 2.72665 |
| 13 | 6 | 68 | 7 | 13.17000 | 13.85130 | -.68130 | 17.90418 | 9.79842 | 3.11760 |
| 14 | 6 | 71 | 3 | 14.50000 | 14.11449 | .38551 | 17.89345 | 10.33553 | 2.90689 |
| 15 | 6 | 71 | 4 | 15.00000 | 13.69626 | 1.30374 | 17.57792 | 9.81461 | 2.98589 |
| 16 | 6 | 71 | 6 | 13.89000 | 13.32361 | .56639 | 17.15576 | 9.49145 | 2.94781 |
| 17 | 6 | 71 | 7 | 14.44000 | 16.16527 | -1.72527 | 19.83453 | 12.49600 | 2.82251 |
| 18 | 6 | 78 | 2 | 11.33000 | 11.20606 | .12394 | 14.67237 | 7.73976 | 2.66639 |
| 19 | 6 | 80 | 6 | 10.61000 | 10.81702 | -.20702 | 14.28813 | 7.34592 | 2.67008 |
| 20 | 8 | 05 | 3 | 14.06000 | 13.59006 | .46994 | 17.19697 | 9.98315 | 2.77455 |
| 21 | 8 | 05 | 5 | 14.61000 | 14.83232 | -.22232 | 18.54395 | 11.12069 | 2.85510 |
| 22 | 8 | 05 | 6 | 14.06000 | 13.03491 | 1.02509 | 16.69090 | 9.37891 | 2.81230 |
| 23 | 8 | 05 | 9 | 14.50000 | 14.89783 | -.39783 | 18.52143 | 11.27423 | 2.78738 |
| 24 | 8 | 06 | 2 | 15.22000 | 14.68309 | .53691 | 18.60290 | 10.76329 | 3.01523 |
| 25 | 8 | 93 | 9 | 12.28000 | 11.78722 | .49278 | 15.68506 | 7.88937 | 2.99834 |
| 26 | 8 | 95 | 6 | 13.44000 | 14.77138 | -1.33138 | 18.99526 | 10.54750 | 3.24913 |
| 27 | 9 | 06 | 1 | 13.33000 | 18.15745 | -4.82745 | 21.78440 | 14.53050 | 2.78996 |
| 28 | 9 | 23 | 4 | 13.39000 | 14.74016 | -1.35016 | 19.06411 | 10.41620 | 3.32612 |
| 29 | 9 | 90 | 8 | 9.44000 | 9.15564 | .28436 | 12.79018 | 5.52111 | 2.79580 |
| 30 | 10 | 12 | 9 | 17.28000 | 16.06786 | 1.21214 | 19.56665 | 12.56907 | 2.69138 |
| 31 | 10 | 13 | 0 | 10.56000 | 9.02891 | 1.53109 | 12.60579 | 5.45203 | 2.75145 |

STATISTICS FOR RESIDUALS

EAN ABSOLUTE VALUE OF RESIDUALS =      1.3177   STANDARD DEVIATION OF ABSOLUTE VALUE OF RESIDUALS =      1.3781

MAXIMUM ABSOLUTE VALUE =      5.5079   MINIMUM ABSOLUTE VALUE =      .0136

STEP 13

VARIABLE ENTERED..... 11 , F1*F2
(FORCED VARIABLE)

SUM OF SQUARES REDUCED IN THIS STEP.... .123

PROPORTION REDUCED IN THIS STEP........ .000

CUMULATIVE SUM OF SQUARES REDUCED...... 343.041

CUMULATIVE PROPORTION REDUCED.......... .768 OF 446.721

FOR 13 VARIABLES ENTERED
MULTIPLE CORRELATION COEFFICIENT... .876
(ADJUSTED FOR D.F.) .783
F-VALUE FOR ANALYSIS OF VARIANCE... 4.327
STANDARD ERROR OF ESTIMATE......... 2.470
(ADJUSTED FOR D.F.) 3.188

| VARIABLE NUMBER | VARIABLE NAME | REGRESSION COEFFICIENT | STD.ERROR OF REG. COEFF. | COMPUTED T-VALUE |
|---|---|---|---|---|
| 5 | F1SQ | -2.99466 | 11.85566 | -.253 |
| 12 | F1*F3 | -28.65259 | 10.85620 | -2.639 |
| 14 | F1*F5 | -8.16590 | 27.53153 | -.297 |
| 25 | F5*F6 | -21.77966 | 23.28055 | -.936 |
| 26 | F1 | 19.97654 | 14.35845 | 1.391 |
| 15 | F1*F6 | 11.51259 | 11.64462 | .989 |
| 18 | F2*F5 | 13.64996 | 32.75055 | .417 |
| 9 | F5SQ | -2.34037 | 22.99400 | -.102 |
| 30 | F5 | -6.38545 | 41.23992 | -.155 |
| 27 | F2 | 1.84843 | 4.93528 | .375 |
| 23 | F4*F5 | 6.38932 | 19.47553 | .328 |
| 21 | F3*F5 | 9.29099 | 30.84144 | .301 |
| 11 | F1*F2 | -2.28498 | 16.07819 | -.142 |
| INTERCEPT | | 10.06930 | | |

SURFACE TEMPERATURE REGRESSIONS
SELECTION..... 4, T133A

TABLE OF RESIDUALS

| CASE NO. | SAMPLE | Y VALUE | Y ESTIMATE | RESIDUAL | 80% C.I. HIGH | LOW | STD. ERROR |
|---|---|---|---|---|---|---|---|
| 1 | 3 42 6 | 19.44000 | 17.70953 | 1.73047 | 22.81542 | 12.60365 | 3.92760 |
| 2 | 3 43 3 | 10.56000 | 12.22373 | -1.66373 | 17.00326 | 7.44420 | 3.67656 |
| 3 | 3 81 3 | 19.78000 | 19.80300 | -.02300 | 24.40088 | 15.20512 | 3.53683 |
| 4 | 3 98 6 | 24.67000 | 20.23130 | 4.43870 | 25.08698 | 15.37561 | 3.73514 |
| 5 | 3 98 7 | 22.94000 | 19.17917 | 3.76083 | 23.66901 | 14.68933 | 3.45372 |
| 6 | 5 22 9 | 8.67000 | 8.60200 | .06800 | 13.30053 | 3.90346 | 3.61426 |
| 7 | 5 23 2 | 8.67000 | 10.44648 | -1.77648 | 15.63470 | 5.25827 | 3.99093 |
| 8 | 5 24 2 | 8.89000 | 8.72323 | .16677 | 13.86234 | 3.58411 | 3.95317 |
| 9 | 5 24 3 | 9.78000 | 9.74889 | .03111 | 14.94902 | 4.54876 | 4.00010 |
| 10 | 5 24 6 | 13.33000 | 13.87363 | -.54363 | 19.39036 | 8.35690 | 4.24364 |
| 11 | 5 26 7 | 14.00000 | 15.51078 | -1.51078 | 20.17878 | 10.84277 | 3.59077 |
| 12 | 6 66 3 | 14.17000 | 16.16251 | -1.99251 | 20.77157 | 11.55344 | 3.54543 |
| 13 | 6 68 7 | 12.78000 | 13.54770 | -.76770 | 19.14930 | 7.94610 | 4.30892 |
| 14 | 6 71 3 | 14.44000 | 14.14258 | .29742 | 19.25552 | 9.02964 | 3.93303 |
| 15 | 6 71 4 | 13.89000 | 13.26680 | .62320 | 17.92884 | 8.60476 | 3.58618 |
| 16 | 6 71 6 | 12.50000 | 13.07206 | -.57206 | 17.71161 | 8.43250 | 3.56889 |
| 17 | 6 71 7 | 13.00000 | 16.62038 | -3.62038 | 21.35916 | 11.88161 | 3.64521 |
| 18 | 6 78 2 | 10.56000 | 9.90659 | .65341 | 14.48735 | 5.32582 | 3.52367 |
| 19 | 6 80 6 | 10.50000 | 9.52103 | .97897 | 14.27089 | 4.77117 | 3.65374 |
| 20 | 8 05 3 | 14.44000 | 12.83488 | 1.60512 | 17.57621 | 8.09355 | 3.64718 |
| 21 | 8 05 5 | 13.72000 | 13.11330 | .60670 | 18.36867 | 7.85794 | 4.04259 |
| 22 | 8 05 6 | 14.33000 | 14.78730 | -.45730 | 20.02927 | 9.54533 | 4.03228 |
| 23 | 8 05 9 | 13.33000 | 14.41277 | -1.08277 | 19.25529 | 9.57024 | 3.72502 |
| 24 | 8 06 2 | 15.61000 | 16.49660 | -.88660 | 22.20535 | 10.78784 | 4.39135 |
| 25 | 8 93 9 | 12.50000 | 11.42210 | 1.07790 | 16.69917 | 6.14504 | 4.05928 |
| 26 | 8 95 6 | 14.44000 | 12.63095 | 1.80905 | 17.69494 | 7.56695 | 3.89538 |
| 27 | 9 06 1 | 13.22000 | 18.37456 | -5.15456 | 23.03295 | 13.71618 | 3.58337 |
| 28 | 9 23 4 | 13.17000 | 11.77274 | 1.39726 | 16.76937 | 6.77611 | 3.84356 |
| 29 | 9 90 8 | 9.17000 | 9.16390 | .00610 | 13.90848 | 4.41932 | 3.64968 |
| 30 | 10 12 9 | 16.00000 | 15.77085 | .22915 | 20.35808 | 11.18361 | 3.52864 |
| 31 | 10 13 0 | 9.78000 | 9.20870 | .57130 | 13.90240 | 4.51500 | 3.61054 |

STATISTICS FOR RESIDUALS

EAN ABSOLUTE VALUE OF RESIDUALS = 1.2936 STANDARD DEVIATION OF ABSOLUTE VALUE OF RESIDUALS = 1.3314

MAXIMUM ABSOLUTE VALUE = 5.1546 MINIMUM ABSOLUTE VALUE = .0061

# APPENDIX X

## Estimated Temperatures For BNFC 43 PG and LAPD 1G

BNFC 43 PG

| OSU ACCNO | $T^oC$ Sea Surface | Sea Surface $T^oC$ | $T^oC$ at 133 m | $T^oC$ at 133 m |
|---|---|---|---|---|
| | TFEB | TAUG | T133F | T133A |
| 9864 | 20.1911 | 24.6857 | 14.1355 | 12.7261 |
| 9865 | 20.0942 | 26.0352 | 13.6973 | 11.4015 |
| 9062 | 16.1488 | 24.1777 | 15.6042 | 9.9741 |
| 9866 | 12.5161 | 23.5167 | 13.4071 | 9.7555 |
| 9867 | 12.9918 | 22.7031 | 13.6962 | 10.4587 |
| 9063 | 17.6700 | 25.3826 | 15.0842 | 10.7637 |
| 9868 | 17.5718 | 24.3336 | 12.2369 | 11.9427 |
| 9064 | 19.5251 | 25.8746 | 14.1355 | 12.7928 |
| 9869 | 22.3200 | 27.7687 | 16.2740 | 13.2825 |
| 9065 | 16.1710 | 23.7249 | 12.7399 | 11.0043 |
| 9870 | 19.3186 | 25.8215 | 14.2740 | 12.3849 |
| 9066 | 21.1353 | 26.0855 | 13.4386 | 13.0629 |
| 9871 | 22.0435 | 27.1999 | 14.6083 | 13.5509 |
| 9067 | 21.8093 | 24.5420 | 15.2453 | 12.6551 |
| 9872 | 23.2307 | 24.1124 | 16.0988 | 12.6081 |
| 9068 | 22.3071 | 23.2386 | 15.5324 | 12.0749 |
| 9873 | 23.2869 | 23.3491 | 15.8928 | 11.5252 |
| 9874 | 22.2000 | 23.1407 | 15.4834 | 11.7816 |
| 9069 | 23.4623 | 23.8826 | 16.3361 | 12.4430 |
| 9070 | 22.5588 | 24.4067 | 16.0176 | 12.4073 |
| 9876 | 23.2815 | 24.4997 | 16.4251 | 12.5963 |
| 9071 | 24.4427 | 24.9207 | 17.0933 | 12.9291 |
| 9072 | 22.2941 | 24.2497 | 15.9924 | 12.2624 |

LAPD 1G

| | | | | |
|---|---|---|---|---|
| 8958 | 20.1911 | 24.6857 | 14.1355 | 12.7261 |
| 8959 | 20.0942 | 26.0352 | 13.6973 | 11.4015 |
| 8962 | 16.1488 | 24.1777 | 15.6042 | 9.9741 |
| 8964 | 12.5161 | 23.5167 | 13.4071 | 9.7555 |
| 9866 | 12.9918 | 22.7031 | 13.6962 | 10.4587 |
| 8968 | 17.6700 | 25.3826 | 15.0842 | 10.7637 |
| 8970 | 17.5718 | 24.3336 | 12.2369 | 11.9427 |
| 9872 | 19.5251 | 25.8746 | 14.1355 | 12.7928 |
| 8974 | 22.3200 | 27.7687 | 16.2740 | 13.2825 |
| 8976 | 16.1710 | 23.7249 | 12.7399 | 11.0043 |
| 8978 | 19.3186 | 25.8215 | 14.2740 | 12.3849 |
| 8980 | 21.1353 | 26.0855 | 13.4386 | 13.0629 |
| 8983 | 22.0435 | 27.1999 | 14.6083 | 13.5509 |

APPENDIX XI

Downcore Factor Matrix (B') for LAPD 1G

LAPD DOWNCORE

B-HAT MATRIX

| | | COMUNAL | WARM F1 | CALIF F2 | SOLUTION F6 | NEC F3 | TROPICAL F5 | $O_2$ MIN F4 |
|---|---|---|---|---|---|---|---|---|
| 1 | 358958 | .9008 | .7734 | .1345 | .3707 | .2056 | .0577 | -.3188 |
| 2 | 368959 | .8706 | .4209 | .2018 | .2960 | .2650 | .0200 | -.7032 |
| 3 | 378962 | .7614 | -.0381 | .1640 | .4273 | .2792 | -.0245 | -.6869 |
| 4 | 388964 | .7137 | .0561 | .2860 | .4425 | .0279 | -.0497 | -.6555 |
| 5 | 399866 | .7801 | .0547 | .1713 | .5071 | .1887 | .0143 | -.6744 |
| 6 | 408968 | .8182 | .1645 | .1132 | .3551 | .2139 | .0306 | -.7781 |
| 7 | 418970 | .8690 | .4844 | .1076 | .4025 | .2227 | .1984 | -.6099 |
| 8 | 429872 | .8796 | .3134 | .1144 | .3216 | .2780 | .1667 | -.7482 |
| 9 | 438974 | .8475 | .2097 | .0825 | .2190 | .2044 | .1687 | -.8237 |
| 10 | 448976 | .8637 | .3652 | .0827 | .4480 | .2834 | .1191 | -.6545 |
| 11 | 458978 | .8782 | .3218 | .0649 | .3334 | .2850 | .1548 | -.7444 |
| 12 | 468980 | .8421 | .5599 | .0203 | .3211 | .2557 | .2695 | -.5357 |
| 13 | 478983 | .8438 | .3995 | .0489 | .2558 | .2568 | .2126 | -.7108 |

# APPENDIX XII

## Downcore Radiolarian Percentages for LAPD 1G

LAPD DOWNCORE

RAW DATA

| NO. | SAMPLE NAME | 1<br>S2 | 2<br>S3 | 3<br>S9 | 4<br>S11 | 5<br>S12 | 6<br>S15 | 7<br>S16 | 8<br>S17 | 9<br>S22 | 10<br>S25 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 358958 | 0.000 | 1.700 | 1.300 | .300 | 0.000 | 4.100 | 1.600 | 1.700 | .100 | 2.800 |
| 2 | 368959 | 0.000 | .900 | .700 | .800 | 0.000 | 12.700 | 4.700 | .600 | 0.000 | 2.600 |
| 3 | 378962 | .100 | .700 | 1.800 | 1.900 | .200 | 11.000 | 7.300 | 1.100 | 0.000 | .900 |
| 4 | 388964 | 0.000 | .500 | 1.500 | 2.000 | 1.100 | 9.500 | 7.100 | 6.000 | 0.000 | 1.700 |
| 5 | 399866 | 0.000 | .600 | 1.600 | 1.200 | .500 | 8.800 | 5.800 | 2.200 | 0.000 | 1.900 |
| 6 | 408968 | 0.000 | .900 | 2.100 | .900 | 0.000 | 12.100 | 3.800 | 2.300 | .100 | 2.600 |
| 7 | 418970 | .100 | .500 | 2.700 | .300 | .100 | 7.000 | 3.200 | 1.100 | 0.000 | 3.400 |
| 8 | 429872 | .100 | .600 | 2.000 | .600 | .100 | 9.800 | 4.100 | 1.100 | 0.000 | 3.200 |
| 9 | 438974 | 0.000 | .200 | 2.200 | .400 | .300 | 13.700 | 3.100 | .400 | 0.000 | 3.100 |
| 10 | 448976 | .100 | 0.000 | 3.600 | .500 | .200 | 9.000 | 4.300 | .700 | .100 | 1.800 |
| 11 | 458978 | 0.000 | .200 | 2.100 | .300 | 0.000 | 11.300 | 5.000 | .300 | 0.000 | 5.500 |
| 12 | 468980 | 0.000 | .200 | 1.800 | 0.000 | .100 | 8.100 | 2.800 | 1.100 | 0.000 | 3.100 |
| 13 | 478983 | 0.000 | .400 | 2.400 | .200 | 0.000 | 13.800 | 5.300 | .100 | 0.000 | 3.300 |

| NO. | SAMPLE NAME | 11<br>S28 | 12<br>S30 | 13<br>S32 | 14<br>S33 | 15<br>S38 | 16<br>S39 | 17<br>S43 | 18<br>S44 | 19<br>S47 | 20<br>S48 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 358958 | .600 | 1.600 | 1.500 | 0.000 | 1.800 | 0.000 | 1.800 | 1.600 | .200 | 1.000 |
| 2 | 368959 | .800 | 3.100 | 1.600 | 0.000 | 2.300 | .100 | 1.900 | 1.300 | .200 | 3.500 |
| 3 | 378962 | .400 | 1.200 | .400 | .500 | 1.000 | 0.000 | 3.100 | 1.800 | .100 | 5.000 |
| 4 | 388964 | .600 | 2.400 | 2.000 | .700 | .500 | 0.000 | .200 | .200 | 0.000 | .800 |
| 5 | 399866 | 1.300 | 1.200 | 1.500 | .200 | 1.000 | .500 | 1.700 | 1.900 | .100 | 2.000 |
| 6 | 408968 | 2.300 | 1.000 | 1.700 | .200 | 1.000 | .100 | 1.300 | 2.000 | 0.000 | 2.300 |
| 7 | 418970 | 1.900 | 1.100 | .800 | .300 | 1.000 | 0.000 | 2.500 | 2.300 | 0.000 | .400 |
| 8 | 429872 | 1.000 | .900 | 1.000 | .300 | 1.800 | 0.000 | 1.800 | 2.500 | 0.000 | 2.500 |
| 9 | 438974 | .500 | 1.400 | .700 | .400 | 1.500 | .100 | 1.500 | 2.000 | .200 | 1.400 |
| 10 | 448976 | 1.200 | .600 | 1.000 | .700 | 1.200 | .100 | 2.300 | 1.600 | .100 | 3.200 |
| 11 | 458978 | 1.300 | .400 | .300 | .900 | .700 | .200 | 2.700 | 2.700 | 0.000 | 3.300 |
| 12 | 468980 | .600 | .300 | 0.000 | .200 | .700 | 0.000 | 2.800 | 1.800 | 0.000 | 1.700 |
| 13 | 478983 | 1.500 | .900 | .800 | .500 | 2.100 | .100 | 3.700 | 1.100 | .200 | 2.700 |

| NO. | SAMPLE NAME | 21 S49 | 22 S50 | 23 S53 | 24 S54 | 25 S55 | 26 S56 | 27 S58 | 28 S59 | 29 S62 | 30 S65 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 358958 | 1.200 | .500 | .800 | 15.700 | .500 | .300 | 3.100 | 1.700 | 1.100 | .200 |
| 2 | 368959 | .700 | .600 | .600 | 9.800 | .600 | .400 | 2.900 | .900 | .800 | .200 |
| 3 | 378962 | .200 | 0.000 | .400 | 1.500 | .900 | 0.000 | 2.000 | 0.000 | .100 | .600 |
| 4 | 388964 | 0.000 | 0.000 | .400 | 2.800 | .300 | 0.000 | 5.900 | 0.000 | 0.000 | 0.000 |
| 5 | 399866 | .500 | .300 | .300 | 2.500 | .600 | .100 | 3.000 | .200 | .100 | .800 |
| 6 | 408968 | .100 | 0.000 | .300 | 4.000 | .600 | .100 | 3.000 | 1.000 | .100 | .300 |
| 7 | 418970 | .100 | 0.000 | .200 | 7.500 | 1.000 | .100 | 2.300 | 3.800 | .600 | 0.000 |
| 8 | 429872 | .200 | .100 | .200 | 5.400 | 1.700 | .300 | 2.700 | 3.200 | .200 | 0.000 |
| 9 | 438974 | .100 | 0.000 | .100 | 4.400 | 1.800 | .300 | 2.500 | 3.600 | .700 | .600 |
| 10 | 448976 | .200 | 0.000 | .200 | 7.300 | 1.400 | 0.000 | 1.900 | 2.800 | 1.000 | .900 |
| 11 | 458978 | .200 | .100 | .200 | 6.700 | .600 | .100 | 3.300 | 3.800 | .500 | .700 |
| 12 | 468980 | 0.000 | .200 | 0.000 | 10.200 | 1.000 | .300 | 1.300 | 6.500 | .600 | .600 |
| 13 | 478983 | 0.000 | .500 | .100 | 9.400 | 1.000 | .200 | 1.100 | 6.300 | .800 | 1.000 |

| NO. | SAMPLE NAME | 31<br>S67 | 32<br>S68 | 33<br>S69 | 34<br>N4 | 35<br>N11 | 36<br>N19 | 37<br>N28 | 38<br>N29 | 39<br>N30 | 40<br>N31 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 358958 | 0.000 | .100 | .200 | 2.400 | 0.000 | .100 | .100 | 3.200 | .900 | 1.600 |
| 2 | 368959 | 0.000 | 1.300 | .100 | 1.800 | 0.000 | .400 | .100 | 3.100 | .600 | 1.600 |
| 3 | 378962 | 0.000 | 2.300 | 0.000 | .400 | 0.000 | .400 | 0.000 | 1.700 | .100 | .800 |
| 4 | 388964 | 0.000 | .700 | 5.400 | .900 | 0.000 | .500 | 0.000 | .700 | 0.000 | .400 |
| 5 | 399866 | 0.000 | .500 | 2.600 | .600 | .100 | .300 | .300 | 1.700 | .600 | .700 |
| 6 | 408968 | 0.000 | .400 | .300 | 1.500 | 0.000 | .400 | 0.000 | 3.200 | .800 | .900 |
| 7 | 418970 | 0.000 | 1.300 | .100 | 1.700 | 0.000 | .400 | .600 | 3.800 | .200 | .500 |
| 8 | 429872 | 0.000 | .400 | 0.000 | 1.000 | 0.000 | .600 | .300 | 2.200 | .400 | .300 |
| 9 | 438974 | 0.000 | .400 | 0.000 | 1.100 | 0.000 | .300 | .300 | 4.100 | .200 | .100 |
| 10 | 448976 | 0.000 | .300 | 0.000 | 1.000 | 0.000 | .300 | .300 | 3.000 | .900 | .900 |
| 11 | 458978 | 0.000 | 1.300 | 0.000 | .400 | 0.000 | .300 | .500 | 4.000 | .400 | .100 |
| 12 | 468980 | 0.000 | 1.500 | 0.000 | 1.500 | 0.000 | .300 | .500 | 3.900 | .200 | .300 |
| 13 | 478983 | 0.000 | 1.200 | 0.000 | 1.200 | 0.000 | .300 | .200 | 3.200 | .800 | .100 |

| NO. | SAMPLE NAME | 41<br>N38 | 42<br>N41 | 43<br>N42 | 44<br>N48 |
|---|---|---|---|---|---|
| 1 | 358958 | .200 | 1.200 | 0.000 | .400 |
| 2 | 368959 | .300 | 1.200 | .200 | 1.100 |
| 3 | 378962 | .100 | 0.000 | .200 | 6.300 |
| 4 | 388964 | 0.000 | .100 | 0.000 | 3.600 |
| 5 | 399866 | 0.000 | .300 | 0.000 | 6.400 |
| 6 | 408968 | 0.000 | .400 | .100 | 4.800 |
| 7 | 418970 | 0.000 | .800 | .600 | 1.600 |
| 8 | 429872 | 0.000 | 1.200 | .200 | 1.600 |
| 9 | 438974 | .700 | .500 | .700 | .700 |
| 10 | 448976 | .500 | 2.300 | .300 | 3.300 |
| 11 | 458978 | .600 | 1.000 | .200 | 1.600 |
| 12 | 468980 | .500 | 1.800 | .700 | .300 |
| 13 | 478983 | .900 | 1.000 | .900 | .300 |