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Sangamonian Interglacial (Middle Pleistocene) Environments of Deposition of Artifacts at the Valsequillo Archeological Site, Puebla, Mexico

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Abstract

Human artifacts (including the "Schaedel Dorenberg" or Dorenberg Skull, an "early human") from the region of Valsequillo (Puebla), Mexico, have been found within a complex sequence of volcanic, volcano-sedimentary, lacustrine, and fluviatile deposits. These deposits contain many important marker fossils from two major groups of organisms (Phylum Protista and Division Bacillariophyta) which indicate an age corresponding to Sangamonian Interglacial time (ca. 80,000-330,000 yr BP). The depositional environments of four samples from deposits in intimate association with the artifacts from the Valsequillo (Puebla) region can be characterized by how their constituent taxa fit into the standard ecological categories which correspond to the following nine spectra: (1) pH (indifferent to alkaliphilous); (2) Saprobian (mesosaprobic to oligosaprobic); (3) Nutrient (eutrophic or oligotrophic); (4) Halobion (oligohalobous indifferent=freshwater); (5) Current (limnophilous or indifferent); (6) General Habitat (lakes); (7) Specific Habitat (epipelic or epiphytic); (8) Seasons (spring and fall aspects); and, (9) Temperature (oligothermal or eurythermal). The environments of deposition of these deposits compared favorably with those from other North American localities of Sangamonian Interglacial age but not with those from deposits of other ages in the Valsequillo (Puebla) region.

INTRODUCTION

The great antiquity of such archeological sites as Valsequillo (south of Cuidad Puebla, Mexico) and Calico, California, USA, has been recognized by many investigators of diverse nationalities, cultures, institutions, training, religions, affiliations, etc. for over a century, e.g.: Reichelt (1899), Hustedt (1913), Haynes (1970), Armenta Camacho (1978), Leakey (1979), Carter (1980), Steen- McIntyre et al. (1981), Budinger and Simpson (1985), Shlemon and Budinger (1990), and Cremo and Thompson (1993). However, American archelogical studies have largely ignored the growing body of evidence that these sites are much older than 25,000 yr BP.

In the present study, computer data synthesis was used in the form of CEFDARS (continuous extinct fossil diatom age reference system), a comprehensive retrieval program based on approximately 2,000 known extinct, non-marine diatom taxa (Van Landingham 1987b) and CAESARS (continuous algal ecological spectral analysis reference system) described by VanLandingharn (1987a,1990).

CAESARS is a comprehensive, computerized retrieval program based on about 3,000 publications from which over 4,000 common and widely occurring algae (and protist) taxa are categorized into nine physical, chemical, and occurrence spectra, each of which is subdivided into four or more categories (see Table 1). Categories of each spectrum are based on theoretical and natural observations found in various published works which are discussed in detail by VanLandingham (1982, 1987a). Information from new references is used continuously to update CAESARS. Most terminology used in the categories of the spectra is self explanatory or in common use, but Lowe (1974) and VanLandingharn (1982) give detailed descriptions of each category and spectrum. A series of histograms can be made (Figures 1 & 2) by calculating the percentage of each taxon in each sample and totaling the percentages of all taxa in each category. These spectral categories and/or histograms have proven to be ideal as a standard of ecological and paleoecological comparison for various algal and diatomaceous samples from all over the world (Collingsworth et al. 1967; Duthie and Rani 1967; VanLandingham 1968, 1970, 1976, 1982, 1987a; Messina-Allen and VanLandingham 1970; Robbins and Hohn 1972; VanLandingham and Jossi 1972; Abbot and VanLandingham 1972; Lowe 1974, etc.). One of the advantages of a comprehensive algal data synthesis, like CAESARS, is that the general and specific habitat spectra in conjunction with the nutrient and saprobian spectra can be helpful in determining if an alga (or diatom) is absent from an assemblage because of lack of suitable physical habitat or because of adverse water chemistry.

DESCRIPTION OF SAMPLES

The paleoecological and environmental conditions in this investigation were interpreted by means of CAESARS and were based on microscopical examinations of 252 taxa of Bacillariophyta or diatoms (Tables 2 and 3) from the following three groups of samples.

1. Middle Pleistocene (Sangamonian Interglacial or equivalent) age, Valsequillo (Puebla) region of Mexico:

CAS191090 - Material collected and described by Hugo Reichelt in 1899 from Puebla, Mexico; slide prepared by Friedrich Hustedt in 1949; contains the syntype of *Surirella antiqua* in the California Academy of Sciences (CAS) H. E. Sovereign Collection of microscope slides.

VL1972 - Collected February 1,1930, by G. E. Sieloff from the north side of the Rio Atoyac, 75 miles southeast of Mexico City and 9 miles south of the railroad in Cuidad Puebla, Mexico; CAS G. Dallas Hanna Diatom Collection No. 2221.

VL2082 - Collected September 23, 1997, by Virginia Steen-McIntyre from the town of Buena Vista Tetela on the north side of the Valsequillo Reservoir, at the base (120-130 cm. from the surface) of the Hueyatlaco Ash; repository at CAS.

VL2083 - Collected September 24, 1997, by Virginia Steen-McIntyre from the town of Buena Vista Tetela on the north side of the Valsequillo Reservoir, at the base of the "Buena Vista Lapilli" (35-40 cm. from the surface). "Superhydration curve (for water in glass vesicles) essentially equal to Hueyatlaco Ash and to Yellowstone Tephra dated 251,000 yrs."; repository at CAS.

2. Middle Pleistocene (Sangamonian or equivalent) age, United States and Canada:

Don #6 - Collected and described by H. C. Duthie and R. G. M. Rani (1967) of the University of Waterloo, Ontario; from Don Valley brickyard, Toronto, Ontario, Canada; fourth sand (3 feet) above the Illinoian till. Don #4 (1 foot above Illinoian till), Don #11 (8 feet above the Illinoian till), and Don #20 (17 feet above Illinoian till) may be included with Don #6, all four of which correspond with the Sangamonian Interglacial Stage (based upon pollen and other fossils).

VL1904 - Collected October 28,1988, by Sam L. VanLandingham from SW 1/4 SW 1/4 SW 1/4 sec. 30, T. 42 N., R. 55 E., Elko County, Nevada, 1.5 miles northwest of bridge over the North Fork of the Humboldt River; from a stratigraphic position near the top of the Hay Ranch Formation or equivalent (Middle Pleistocene); repository at CAS.

FIGURE 1. Spectral histograms based on diatom taxa percentages from groups 1 & 2 samples.

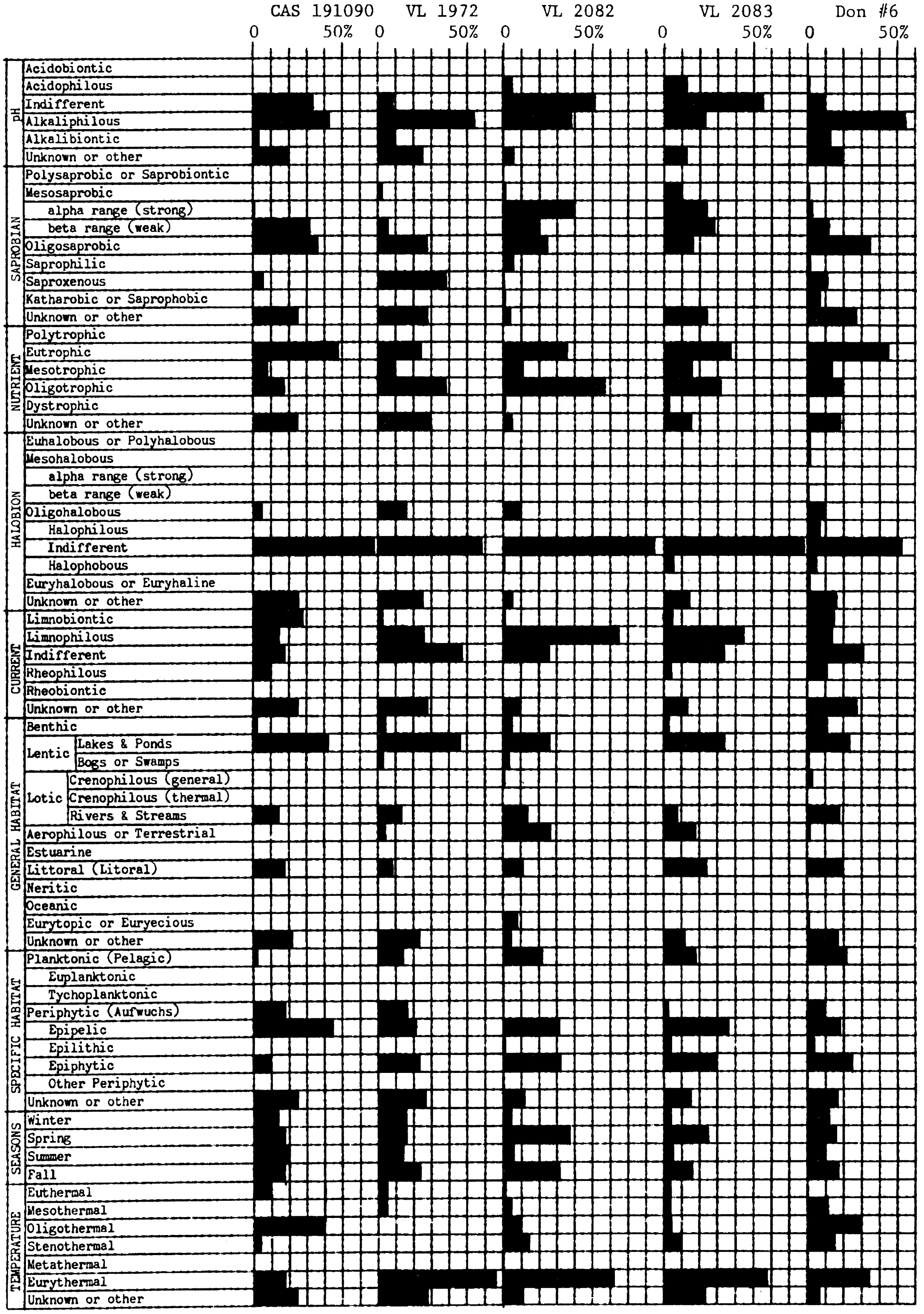
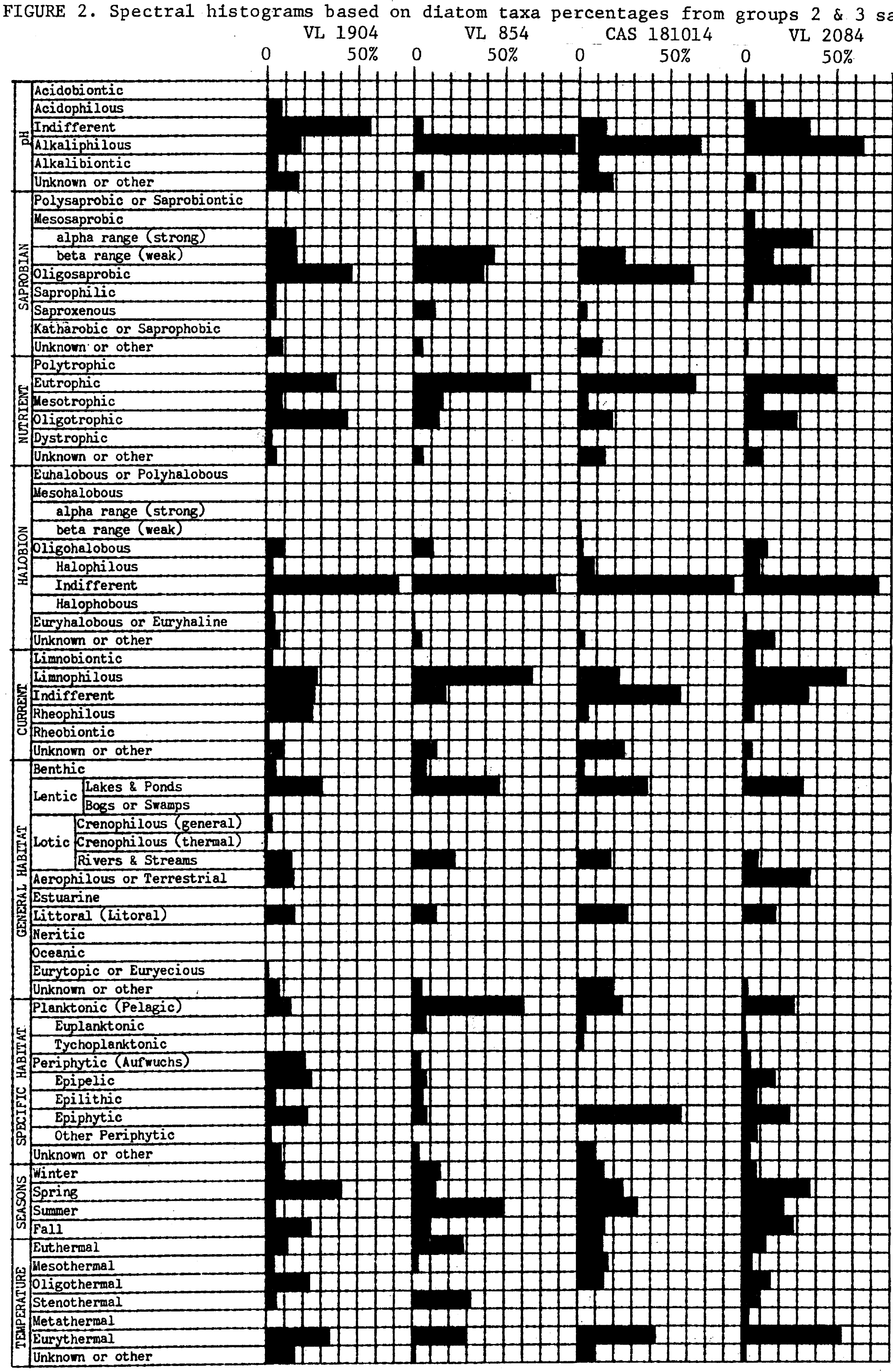


FIGURE 2. Spectral histograms based on diatom taxa percentages from groups 2 & 3 samples.



3. Modern, Recent or Postglacial age, state of Puebla and adjacent regions, Mexico:

VL854 - Obtained from General Biological Supply House Inc., Chicago, Illinois, 1966; No. 6, cleaned diatomite (Postglacial) from the Cuidad Tlaxcala area, Tlaxcala state, Mexico; repository at CAS.

CAS181014 - Collected by F. W. T. Kincaid, Summer, 1933; modern water sample from Lake Xochilmilco, Distrito Federal, Mexico; elevation 7,400 ft.; repository at CAS, H. E. Sovereign Collection slide 181014, accession No. 600350.

VL2084 - Collected September 23, 1997, by Virginia Steen-McIntyre from town of Buena Vista Tetela at the same location as sample VL2083 (but higher in the stratigraphic section than VL2083) from top 5 cm. of modern soil which rests on top of "Buena Vista Lapilli"; repository at CAS.

RESULTS AND CONCLUSIONS

The halobion spectrum (Figures 1 & 2) indicates that all samples from all three groups in this study are clearly from freshwater (oligohalobous indifferent) deposits. Other similarities in all of these samples exist: e.g., the general habitat spectrum in concert with the current spectrum indicates that all of the deposits were from well developed lake environments except VL2084, which is from a modern soil profile and shows a pronounced representation in the aerophilous category (Table 1, Figures 2). However, samples from groups 1 and 2 environmentally are markedly different from those in group 3. In respect to all samples in groups 1 and 2, those samples in group 3 are more: (1) alkaliphilous, with an extremely strong development in sample VL854; (2) oligosaprobic and eutrophic, which implies that enrichment from increasing human activities and pollution occurred in times more recent than those associated with samples from groups 1 and 2; and, (3) euthermal and estival (summer aspect), which indicates that the environments of deposition were warmer than those represented by the samples from groups 1 and 2 (Figures 1 & 2). In the specific habitat spectrum, all of the group 3 samples are more planktonic than samples in groups 1 and 2, whereas, all of the samples in groups 1 and 2 are more epipelic than samples in group 3.

Analysis by means of CAESARS indicated a very close correlation of the depositional environments of the Middle Pleistocene samples from the

Valsequillo/Puebla region (group 1) with other samples of Middle Pleistocene age from the United States and Canada (group 2). However, no such close correspondence was found between the group 1 samples and any of the group 3 samples. This is significant, since samples in groups 1 and 3 come from exactly the same sites (q.v. VL2083 and VL2084) or from nearby sites adjacent to the state of Puebla, Mexico, and would indicate that group 1 samples are unlikely to be either as young as those in group 3 or younger than Middle Pleistocene or Sangamonian in age. CEFDARS confirmed a Middle Pleistocene age for the samples in groups 1 and 2 and a Postglacial or younger age for samples in group 3. A detailed report on the important marker fossils and biostratigraphy of the Valsequillo samples will be treated in a forthcoming publication.

The "Centric Paucity" (CP) zone occurs in diatom-bearing assemblages when the ratio of pennate diatoms to centric diatoms is greater than 80 to 1. This zone (or series of zones) is associated with Miocene to Recent non-marine diatom-bearing sequences over the world in which centric diatoms are very rare or totally absent. The CP zone was first described by VanLandingham (1988, 1990). By definition, the CP zone contains only fossil assemblages and may include some Postglacial fossil deposits but does not include active, living, and modern diatom communities. Examination of a total of almost 2,000 diatomite and fossil diatom samples (from widely distributed localities over the world) from personal collections, museums, and various published works yielded only about 140 in which centric diatoms were absent or very rare. Of the 140, about half were Pliocene or Miocene, and in the remaining half, nearly all were Holocene or Recent, except for a very few in the Middle and Late Pleistocene. These few Pleistocene occurrences in North America are restricted to Aftonian (ca. 600,000-650,000 yr BP), Yarmouthian (ca. 430,000-500,000 yr BP), and Sangamonian (ca. 80,000-330,000 yr BP) Interglacial times. Apparently Pleistocene CP zone deposits in North America are absent in preglacial (Early Pleistocene = ca.750,000-1,600,000 yr BP), Nebraskan (ca. 650,000 - 750,000 yr BP), Kansan (ca. 500,000-600,000 yr BP), Illinoian (330,000-430,000 yr BP) and (all but the latest part, i.e., < 20,000 yr BP of) Wisconsinan (ca. 5,000-80,000 yr BP) Glacial times. CP zone diatomaceous assemblages of latest Wisconsinan (< 20,000 yr BP) and Postglacial age are not rare in North America and the rest of the world, and good examples do exist (e.g., Kirchner Marsh, Dakota County, Minnesota, described by Florin 1970). Almost all of the North American Pleistocene CP zone occurrences are within Sangamonian Interglacial (or =) time. Few Pleistocene CP zone occurrences are known from South America (e.g., Arica, Tarapacá, Chile, reported by Dingman and Lohman 1963) or the Eastern Hemisphere (e.g., Ermelo, Transvaal, South Africa, reported by Fritsch and Rich in 1925 to be totally devoid of centric diatoms).

The pennate to centric diatom ratios in all samples in groups 1 and 2 are >80:1, but they are all ≤13:1 in group 3 samples (Table 3). It is clear that the former samples belong in the CP zone while the latter samples do not. Since the few Pleistocene CP zone diatom assemblages in North America are mostly restricted to the Sangamonian Interglacial, except for two from Hooker County, Nebraska (MI & M2 described by Elmore 1896) in the Yarmouthian Interglacial and one in Broadwater, Morrill County, Nebraska in the Aftonian Interglacial (VanLandingham, unpublished), and since the extinct fossils from samples in groups 1 and 2 indicate a Sangamonian Interglacial age while samples in group 3 have no diagnostic or extinct fossils (Table 3), it is unlikely that samples of group 3 are of the same age as those in groups 1 and 2. It is also unlikely that samples from groups 1 and 2 are of Wisconsinan Glacial or younger age. Evidently no known CP zone diatom assemblages older than 20,000 yr BP are known to have been deposited during the Wisconsin Glacial Stage (or its time equivalent) from North America or other parts of the world. The CP zone and other diagnostic fossil diatom evidence from the Valsequillo samples precludes the likelihood of the favored assumption (by many North American archaeologists) of a late glacial (Wisconsinan Glacial = ca. 5,000 - 80,000 yr BP), Postglacial, or Holocene (<ca. 12,500 yr BP) age for the Valsequillo artifacts.

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TABLE 1. Destription of Spectra and their Categories.

pH SPECTRUM

Acidobiontic - occurring below pH 7 with optimum development below pH 5.5.
Acidophilous - occurring around pH 7 with optimum development below pH 7.
Indifferent - occurring near pH 7.
Alkaliphilous - optimum development above pH 7 but occurring around 7.
Alkalibiontic - occurring above pH 7.
Unknown or other - undesignated category to accommodate generalities or characteristics which cannot be referred directly to the other categories in the spectrum. (Note: this explanation applies to all "Unknown or other" categories in other spectra below.)

SAPROBIEN (SAPROBIAN) SPECTRUM

Polysaprobic - occurring characteristically in the predominance of reduction and cleavage processes, because of absence or low content of oxygen and because of carbon dioxide and a relatively high content of nitrogenous and putresible nutrient substances (characteristic of high hydrogen sulphide) (high dissolved organic nutrients) = **Saprobiontic** - organisms occurring only in most heavily polluted waters.
Mesosaprobic - occurring characteristically with decomposition and oxidation widely present and with decomposition products of protein, ammonia salts, etc. (moderate dissolved organic nutrients).
- α **(Strong)** - occurring characteristically where self putrification takes place rapidly.
- β **(Weak)** - occurring characteristically where self purification takes place less rapidly.

Oligosaprobic - chacteristic of clean water, associated with termination of mineralization and all agressive processes of self purification (low dissolved organic nutrients).
Saprophilic - occurring generally in organically polluted waters but occurring also in other communities.
Saproxenous - occurring primarily in biotypes other than the organically polluted ones but occurring also in the presence of organic pollution.
Katharobic - characteristic of waters that have not been exposed to dissolved organic nutrients or waters in which dissolved organic nutrients are very low or abscent. = **Saprophobic** - organisms which are not capable of thriving in organically polluted water.

NUTRIENT SPECTRUM

Polytrophic - characteristic of extreme eutrophic conditions.
Eutrophic - characteristic of waters rich in dissolved inorganic or mineral nutrient materials.
Mesotrophic - characteristic of water intermediate in dissolved inorganic or mineral nutrient materials.
Oligotrophic - characteristic of waters poor in dissolved inorganic or mineral nutrient materials.
Dystrophic - characteristic of waters rich in humic materials and with distinct oxygen consumption.

HALOBIAN SPECTRUM

Euhalobous or Polyhalobous - marine forms, 30 to 40 o/oo salt content.
Mesohalobous - brackish water forms, ca. .5 to 30 o/oo salt content.
- α **(Strong)** - NaCl minimum about 10 o/oo.
- β **(Weak)** - NaCl content about .5 to about 10 o/oo.

Oligohalobous - widespread in freshwater, about 0 to .5 o/oo salt content.
- **Halophilous** - common in freshwater but not uncommon in slightly "brackish" water.
- **Indifferent** - freshwater forms proper.
- **Halophobous** - characteristic of chloride deficient waters.

TABLE 1 (Continued).

Euryhalobous or Euryhaline - having a broad tolerance for salt concentrations, often encompassing 2 or more large spectral designations.

CURRENT SPECTRUM

Limnobiontic - forms characteristic only of stagnant waters.

Limnophilous - forms with their optimum development in stagnant waters but which also may be found in running waters.

Indifferent - forms common in both running and stagnant waters.

Rheophilous - forms with their optimum development in running waters, but which may be found in standing waters also.

Rheobiontic - forms characteristic only of running waters.

GENERAL HABITAT SPECTRUM

Benthic - organisms living on the bottom of a body of water.

Lentic - living in standing water.

Lakes - characteristic of large inland bodies of water, and **Ponds** - characteristic of small bodies of standing water.

Bogs or Swamps - characteristic of soft, wet, or marshy ground.

Lotic - living in running water.

Crenophilous (general) - occurring in spring waters in general.

Crenophilous (thermal) - occurring in hot springs.

Rivers & Streams - occurring in larger and smaller bodies of running water that have more or less continuous geographical expression.

Aerophilous or Terrestrial - organisms occurring above water, in the air or soil.

Estuarine - characteristic of areas where brackish-marine and fresh waters mix.

Littoral - organisms living in relatively shallow areas, close to shore or banks.

Neritic - occurring typically above the continental shelf (close to shore).

Oceanic - occurring typically over the deeper regions of the oceans.

Eurytopic or Euryecious - occurring in a wide variety of habitats or environments.

SPECIFIC HABITAT SPECTRUM

Planktonic or Pelagic - organisms of relatively small size which have either very small powers of locomotion or else none at all and which drift, subject to waves, currents and other water motion (**Planktonic**); or organisms living above the bottom of the body of water (**Pelagic**).

Euplanktonic - normally suspended in the water, distribution is current dependent.

Tychoplanktonic - normally associated with periphytic or terrestrial habitats but often suspended in the water.

Periphytic (Aufwuchs) - microorganisms attaching to rocks, objects, plants, etc.

Epipelic - occurring on mud.

Epilithic - occurring on rock.

Epiphytic - occurring on plants.

Other Periphytic - occurring on animals (epizooic) or wood, etc.

SEASONS SPECTRUM

Winter - optimum growth during winter.

Spring - optimum growth during spring.

Summer - optimum growth during summer.

Fall - optimum growth during fall.

TEMPERATURE SPECTRUM

Euthermal - warm-water forms usually occurring at temperatures > 30 degrees C.

Mesothermal - temperate-water forms usually ranging from 15 to 30 degrees C.

Oligothermal - cold-water forms usually occurring between 0 and 15 degrees C.

Stenothermal - occurring over a temperature range not > than 5 degrees C.

Metathermal - occurring over a temperature range from 5 to 15 degrees C.

Eurythermal - occurring over a temperature range of 15 degrees C or greater.

	CAS 191090	VL 1972	VL 2082	VL 2083	Don #6	VL 1904	VL 854	CAS 181014	VL 2084
Achnanthes affinis							X		
A. clevei					6				
A. exigua		X							
A. hauckiana		X							
A. lanceolata							X		
A. lanceolata v. dubia		X							
A. lanceolata v. elliptica		X			2				
A. lanceolata v. rostrata							X		
A. microcephala		X							
A. minutissima		X							
A. oestrupii					X				
A. peragalli		X							
Amphicampa mirabilis			2	X					
Amphora coffeaeformis		X		X			X		
A. coffeaeformis v. acutiuscula		X							
A. gigantea f. minor					X				
A. ovalis		X			2		6		
A. ovalis v. affinis							X	7	
A. ovalis v. pediculus		X							4
A. proteus					3				
A. spp.					19				
A. veneta		X							
Anomoeoneis sphaerophora		X							
A. sphaerophora v. guentheri		X							
A. sphaerophora v. sculpta		X					X		
Caloneis bacillum						2			
Cocconeis diminuta		X			16				
C. disculus					2				
C. lewisii							X		
C. pediculus					8				
C. placentula				X				4	
C. placentula v. euglypta		X					X	X	
C. placentula v. intermedia		X			1				
C. placentula v. lineata	X	X					X	26	
Coscinodiscus marginatum	X								
C. oculus iridis	X								
Cyclotella atomus		X							
C. dubius		X							
C. glomerata		X							
C. meneghiniana		X							2
Cymatopleura elliptica v. constricta	X								
C. solea								X	
Cymbella affinis		3					2		
C. aspera		X							
C. cistula		6						8	
C. cistula v. gibbosa		2					X		
C. cymbiformis		2		X			X		
C. delicatula		2							
C. gracilis				X		1			
C. hauckii		X							
C. helvetica		X					X		
C. lanceolata		X					2		
C. mexicana		X					X	3	
C. microcephala		X							

TABLE 2 Percentages of extant taxa in samples from groups 1, 2, and 3. X = < 1 %

	CAS 191090	VL 1972	VL 2082	VL 2083	Don #6	VL 1904	VL 854	CAS 181014	VL 2084
Cymbella muelleri		X							
C. muelleri v. ventricosa		X							
C. parva					X		X		
C. perpusilla					X				
C. sinuata v. ovata					X				
C. spp.							2		
C. turgida		X					X		
C. ventricosa	X	X	X	X					
C. ventricosa v. silesiaca		X							
Cymbellonitzschia diluviana		X							
Denticula elegans		16							
D. elegans v. kittoniana	X	X							
D. elegans v. valida	2	X							
Diatoma tenue v. elongatum		X							
D. vulgare v. grandis		2							
D. vulgare v. producta							X		
Diploneis bombus	X								
D. ovalis		X							
Epithemia argus	X				X				
E. argus v. longicornis	40	X							
E. goeppertiana					X				
E. irregularis	X								
E. sorex							X		
E. turgida	X		X					6	6
E. turgida v. granulata		X							
E. zebra	X	X							
E. zebra v. porcellus	X		2						
E. zebra v. proboscidia	X								
E. zebra v. saxonica	X				2				
Eunotia flexuosa				X					
E. gracilis				6					
E. lunaris			X	X					
E. monodon			X						2
E. pectinalis	X		2						4
E. pectinalis v. minor			X						
E. pectinalis v. undulata				X				X	
E. valida								X	
Fragilaria brevistriata	X	X				1			
F. brevistriata v. linearis					X				
F. capucina v. mesolepta							X		
F. constricta					X				
F. construens		X			3				
F. construens v. binodis					X				
F. construens v. venter		X			X				10
F. crotonensis		X							
F. hungarica v. istvanffyi					X				
F. intermedia					X				
F. lapponica		X			X				
F. leptostauron	X	X			X				
F. leptostauron v. rhomboides					X				
F. nitzschioides					X				
F. pinnata					X				
F. pinnata v. lancettula								X	
F. pinnata v. intercedense					2				

TABLE 2 (Continued)

	CAS 191090	VL 1972	VL 2082	VL 2083	Don #6	VL 1904	VL 854	CAS 181014	VL 2084
Fragilaria pinnata v. turgidula					7				
Gomphonema acuminatum v. montanum					X				
G. angustatum					X				
G. gracile		3					X		
G. gracile v. lanceolatum		X		6			X		4
G. intricatum							X		
G. lanceolatum v. insignis		X							
G. longiceps v. subclavata			X				X	4	
G. longiceps v. subclatata f. gracilis							X		
G. parvulum		X		7			X		
G. pfannkucheae					X				
G. subclavatum v. commutatum		X					X		
G. undulatum		X							
Gyrosigma attenuatum					X				
Hantzschia amphioxys		X	36	17		14		X	38
H. amphioxys v. capitata		X	3						
H. amphioxys v. vivax			X	15		2			
Mastogloia elliptica v. dansei	X								
Melosira ambigua								2	
M. arenaria	3								
M. granulata	X						58		2
M. italica		X	X			X		8	4
M. varians								5	
Navicula abiskoensis					X				
N. amphibola					X	1			
N. asellus					X				
N. biskanterae					1				
N. near biskanterae					X				
N. cocconeiformis					X				
N. crucicula			X						
N. cuspidata			X	6			3		6
N. cuspidata v. ambigua		X	2	X		1			
N. cuspidata v. heribaudi				X					
N. dicephala						7			
N. gastrum		X							
N. gastrum v. minor		X							
N. jaernfelti					X				
N. krasskei					X				
N. menisculus v. upsaliensis							X		
N. mutica			11	X		6			10
N. mutica v. cohnii			X			3			
N. obliqua					X				
N. pupula		X		X			X		
N. pupula v. capitata		3							
N. pupula v. rectangularis		2		10					
N. oblonga	X								
N. radiosa v. tenella	X						10		
N. schoenfeldii					X				
N. scutelloides					6				
N. semen						9			
Neidium iridis v. ampliatum		X							
N. productum	X								
Nitzschia acuta								X	
N. amphibia		X							

TABLE 2 (Continued)

	CAS 191090	VL 1972	VL 2082	VL 2083	Don #6	VL 1904	VL 854	CAS 181014	VL 2084
Nitzschia denticula		39					11		
N. fasciculata		X							
N. frustulum		X				4			4
N. hungarica	X								
N. kittlii						3			
N. lorenziana		X							
N. lorenziana v. subtilis		X							
N. oregona		X							
Opephora martyi		X			15				
O. martyi v. amphioxys							X		
O. martyi v. capitata		X							
O. pacifica					X				
O. sp.					2				
Pinnularia acrosphaeria				X					
P. biceps f. peterseni				X					
P. borealis			19	9		4			4
P. borealis v. brevistriata			X						
P. braunii v. amphicephala				X					
P. brebissonii						15			
P. brevicostata						4			
P. gibba v. linearis						2			
P. major			X				X		
P. microstauron		X	X	X		16			
P. spp.			X	5			X		
P. viridis v. minor								X	
P. viridis v. sudetica						3			
Rhoicosphenia curvata								3	
Rhopalodia gibba		X							
R. gibba v. ventricosa			X						
R. gibberula	X							X	
R. musculus	X							2	
R. parallela	25	X							
Stauroneis anceps			X	6					
S. anceps v. gracilis			2						
S. anceps v. hyalina				X					
S. near schinzii				X					
Stephanodiscus astraea v. minutula		X					X		
S. hantzschii		X							
S. invisitatus?		X							
S. niagarae		X						X	
Surirella biseriata v. rostrata								X	
S. capronii								2	
S. obscura	5							X	
S. ovalis								X	
S. spiralis	X								
Synedra acus								X	
S. rumpens v. fragilarioides							2		
S. rumpens v. meneghiniana		X						X	
S. ulna		X	14	3				6	
S. ulna v. oxyrhynchus								3	
S. ulna v. oxyrhynchus f. contracta								2	
S. vaucheriae	X								
Tabellaria fenestrata								X	
TOTAL EXTANT TAXA	32	89	27	31	49	20	40	32	14

TABLE 2 (Continued and finished)

	CAS 191090	VL 1972	VL 2082	VL 2083	Don #6	VL 1904	VL 854	CAS 181014	VL 2084
Achnanthes biasolettiana v. fossilis		X							
A. lapidosa f. robusta		X							
Caloneis creguti				X					
Cymbella cymbiformis v. producta	X	10	X	3					
C. plutonica	X								
C. provoensis		X							
C. sinuata v. laticeps					X				
C. sturii		X							
Diatoma capitata		X							
Epithemia aspeitiana	X								
E. cistula v. lunaris	X								
E. irregularis v. elongata	X								
E. zebra v. undulata	X								
Eunotia pectinalis v. undulata f. triodon ..			X						
E. serpentina v. transsilvanica			X						
Fragilaria lapponica v. attenuata		X							
F. leptostauron v. amphitetras	X								
Gomphonema duostriatum						X			
G. insigne v. acuminata		X							
G. parvulum v. clavatum		X		X					
G. parvulum v. fossilis		X							
Hantzschia amphioxys v. karelica			X			X			
Navicula bronislaae		X							
N. elginensis v. campylonema						X			
N. dorenbergi	3								
N. pseudoscutiformis v. major					X				
N. rotundella						X			
Nitzschia denticula v. pliocenica		4							
Pinnularia esox f. major		X							
P. esox f. recta		X							
P. fontellii			X						
P. major v. pagesii	X								
P. subflexuosa	20								
Rhopalodia gibba v. iugalis			2						
Stephanodiscus excentricus		X							
S. lineatus v. carconensis		X							
S. pantocseki		X							
TOTAL EXTINCT TAXA	10	17	6	3	2*	4	0	0	0
RATIOS OF PENNATE TO CENTRIC DIATOMS (Includes both extinct and extant taxa)	81:1	184:1	174:1	266:1	1618:1	250:1	1:1.2	7:1	13:1

* Extinct taxa listed here are from closely related strata at the same site as Don #6 (i.e., Don #4 and Don #20 respectively are slightly below and above the Don #6 sample).

TABLE 3. Percentages of extinct taxa in samples from group 1 (CAS 191090, VL 1972, VL 2082, and VL 2083), group 2 (Don #6 and VL 1904), and group 3 (VL 854, CAS 181014, and VL 2084). X =< 1 %. Notice that group 3 samples have no extinct taxa.