

# Corroboration of Sangamonian age of artifacts from the Valsequillo region, Puebla, Mexico by means of diatom biostratigraphy

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**ABSTRACT:** Important artifacts have been found in situ (i.e., not redeposited) within lacustrine deposits in the Valsequillo region. These deposits contain many diatoms which indicate an age corresponding to the Sangamonian Interglacial sensu lato (80,000 to ca. 220,000yr BP). Two of the four samples in this study are associated with the Dorenberg skull or with stratigraphic units which contain bifacial tools. The remaining two samples are from diatomaceous deposits which are also Sangamonian and stratigraphically above the artifact units. These four diatomaceous samples yielded 30 extinct and 143 extant diatom taxa. The ages of the four samples correspond to other diatomaceous samples (some of which are associated with artifacts) from nearby Valsequillo localities. A post-Sangamonian age for these four diatom-bearing samples is discounted by the presence of *Navicula bronislaae* and *N. dorenbergi*, both of which have short stratigraphic ranges and are known only from the Sangamonian (or its equivalents), and by 13 diatoms which evidently have known long stratigraphic ranges and extinctions before the end of the Sangamonian. An age no older than Sangamonian for the artifacts and their enclosing diatomaceous deposits is indicated by the presence of two diatoms (*Epithemia zebra* var. *undulata* and *Navicula creguti*) known only from Sangamonian (or = age) or younger and by an extant diatom, *Cymbella cistula* var. *gibbosa* (*C. gibbosa*), which has its first occurrence in the Sangamonian.

## INTRODUCTION

Diatom analysis can be quite useful in archaeological studies, as many, such as Battarbee (1988), have noted. It is still a greatly under-used technique, given the large number of important archaeological sites which are known to be associated with diatom deposition, e.g., Lubbock Lake (Hohn and Hellerman 1961), Clovis (Lohman 1935), etc. After pioneering diatom studies in archaeology by such investigators as Reichelt (1899) and Lohman (1935), in the last few decades diatom studies in relation to archaeology have greatly intensified, e.g.: Wuthrich (1971), Neolithic of Lake Neuchâtel, Switzerland; Risberg (1988), Kyrktorp, Sweden; Denys (1992), Gent, Belgium; and, Mori (1999), 48 archaeological sites in Japan.

It was known in Europe over a century ago that the so-called "Puebla Man" or Valsequillo artifacts were older than the Last Ice Age (Reichelt 1900). Despite evidence from geology, geomorphology, radiometric dating, tephrochronology and micropaleontology, most American archaeologists ignore or refuse to believe the great antiquity of these artifacts (Steen-McIntyre 2002). Claims as those, such as Picardo (1997), of 30,000yr BP or less for the tools at Valsequillo are still inconclusive (see Covey 2002). Some have made special efforts to discredit the great antiquity of important artifacts from the Valsequillo sites (including Hueyatenco) and have tried to cast doubt upon the age determinations of these artifacts and the careful archaeological work in the Valsequillo region by such investigators as Armenta Camacho (1978) and Irwin-Williams (1967).

The contributions of Reichelt (1899, 1900), Hustedt (1913, 1934, 1966), and VanLandingham (2000, 2002a) added to our knowledge of fossil diatoms and Chrysophyta cysts of the Puebla (Valsequillo) region and are adequate to make a very good case for an age assignment of Last Interglacial or Sangamonian sensu lato (= 80,000 to ca. 220,000yr BP). Nu-

merous radiometric dates mentioned by such investigators as Szabo et al. (1969) and Naeser ex Steen-McIntyre et al. (1981) from rocks within the region would also denote a last interglacial (or older) age for the Hueyatenco artifacts.

The main purpose of the present report is to demonstrate with freshwater diatom biostratigraphy that the age of the Dorenberg skull and associated Hueyatenco artifacts is Sangamonian, and not, as suggested elsewhere, a much later date.

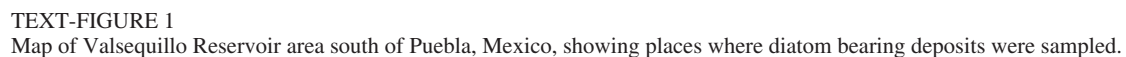
## MATERIALS AND METHODS

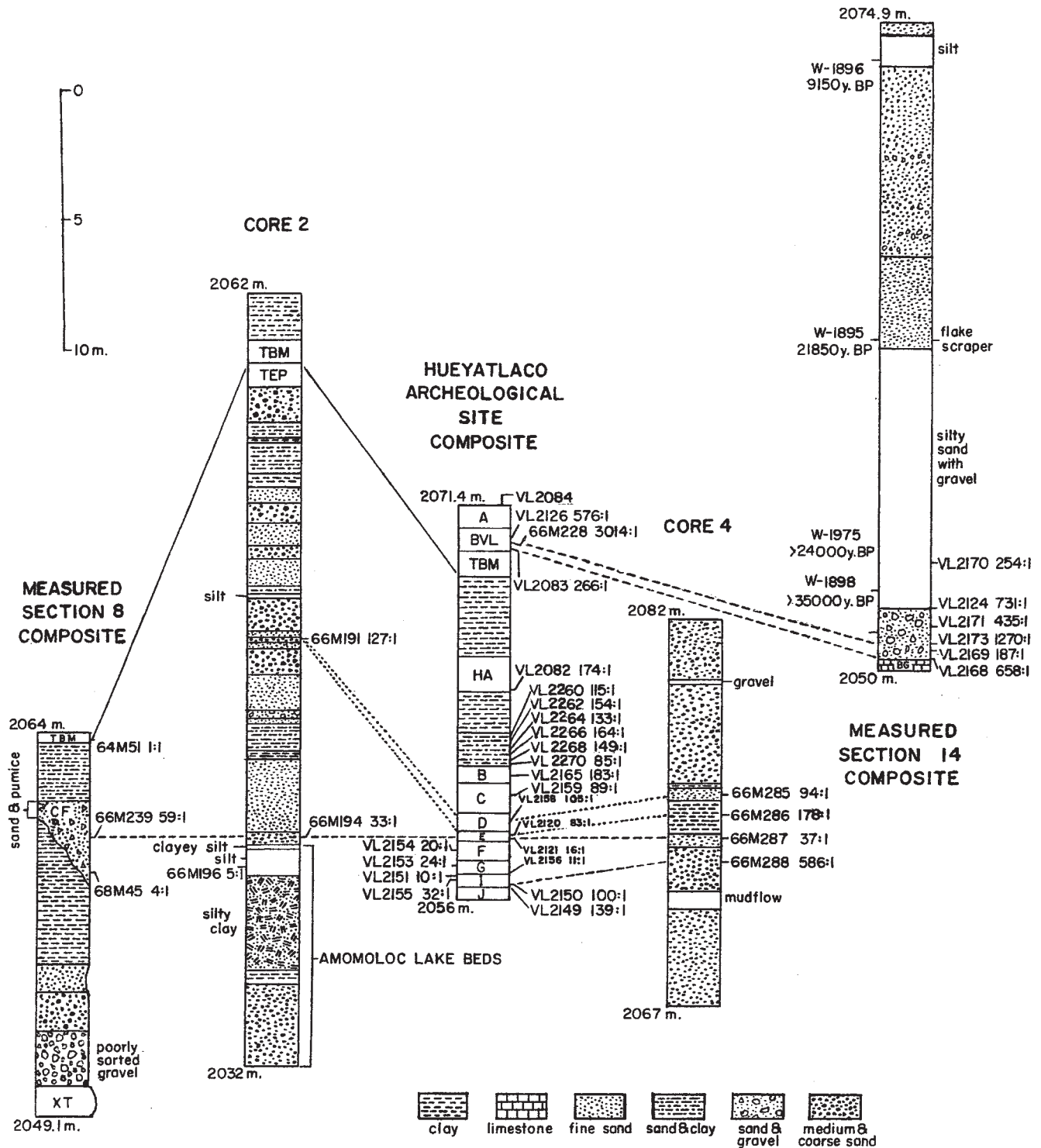
Four samples (group 1) from the Hueyatenco site were selected for comparison with two samples (group 2) of the same age but foreign to Mexico and with three samples (group 3) of younger ages from adjacent areas in Mexico. Biostratigraphic determinations were based on microscopic examinations of these 9 samples in which 246 taxa of diatoms were identified (tables 1 and 2).

Group 1. Middle Pleistocene (Sangamonian or equivalent) age, Hueyatenco and Valsequillo regions of Mexico:

CAS 191090 - Material scraped by H. Reichelt (1899) from inside the Dorenberg skull from south of Puebla, Mexico; slide prepared by F. Hustedt in 1949; corresponds with unit D - upper unit E zone (from sites 2-4 on text-figure 1; see also text-figure 2); contains the syntype of *Surirella obscura* Reichelt in Hustedt (1913) (see Mahood 1978, p. 343) and the topotypes of *Navicula dorenbergi* Reichelt (1900) and *Pinnularia subflexuosa* Hustedt (1934); from the California Academy of Sciences (CAS) H. E. Sovereign Collection of microscope slides, accession number 600000.

VL1972 - Collected February 1, 1930, by G. J. Sielaff from the north side of the Rio Atoyac, 75 miles southeast of Mexico City





TEXT-FIGURE 2

These five stratigraphic sections and cores of H. E. Malde (collected in 1964-1973) in the Valsequillo Reservoir area correspond with 1-5 on text-figure 1). Hueyatlatco Archeological Site composite is modified from Steen-McIntyre et al. (1981) and Irwin-Williams (1967, 1973). Measured section 14 composite (with 14C dates) is modified from Szabo et al. (1969). Pennate to Centric (P:C) ratio is at the right of each sample number. A-J = Irwin-Williams units (unit H is not shown). BG = Balsas Group. BVL = Buena Vista Lapilli. CF = Channel Fill. HA = Hueyatlatco Ash. TBM = Tetela Brown Mud. TEP = Tepetate. XT = Xalnene Tuff. Dotted lines = biostratigraphic correlations between diatom samples which correspond to the unit D - upper unit E zone. Long dashed lines = biostratigraphic correlations between other diatom samples. Long solid lines = lithostratigraphic correlations.

TABLE 1

Percentages of extant taxa in samples from groups 1, 2, and 3. X = &lt; 1%.

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

TABLE 1, continued.

Percentages of extant taxa in samples from groups 1, 2, and 3. X = &lt; 1%.

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

TABLE 1, continued.

Percentages of extant taxa in samples from groups 1, 2, and 3. X = &lt; 1%.

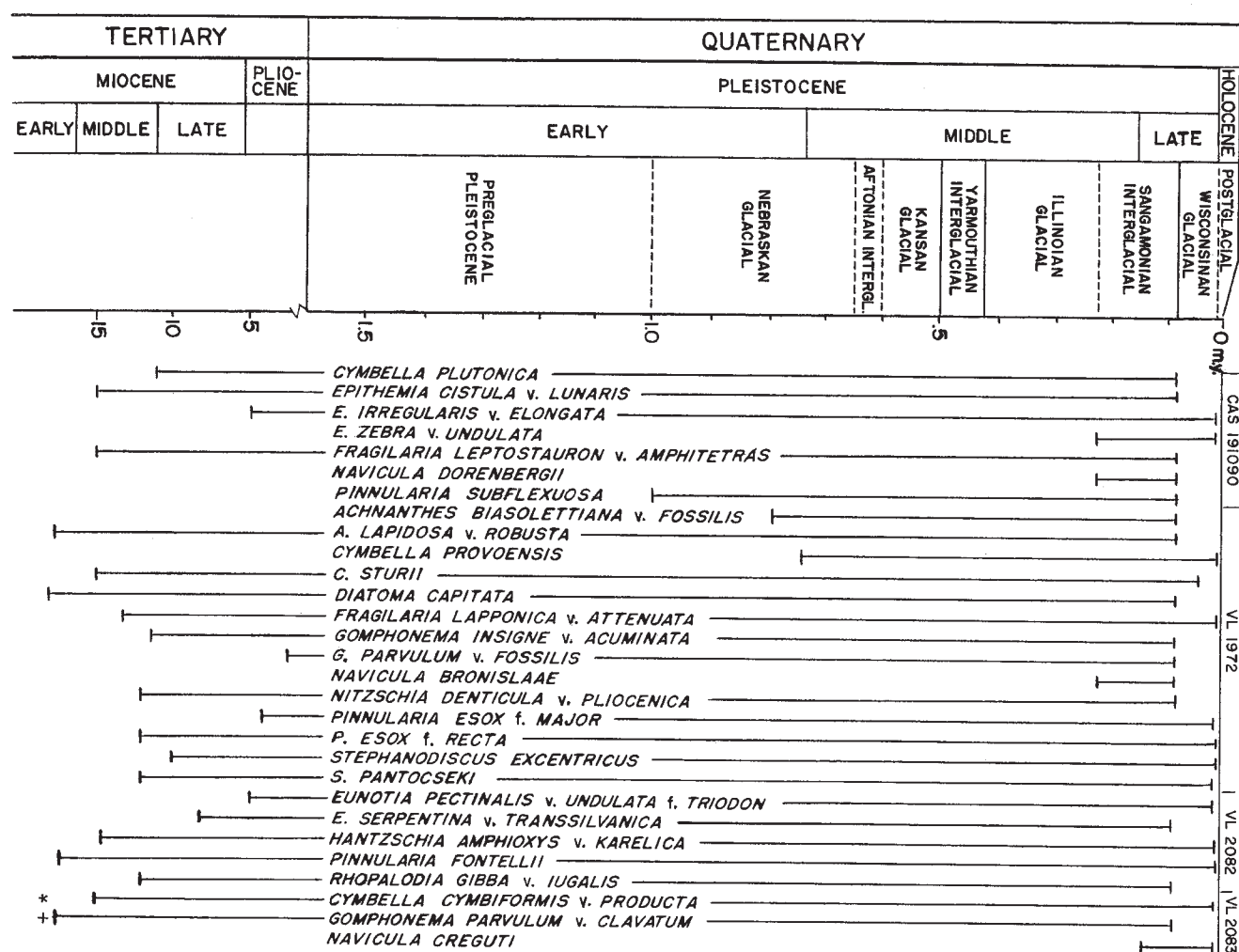
	CAS 191090	VL 1972	VL 2082	VL 2083	Don #6	VL 1904	VL 854	CAS 181014	VL 2084
<i>Fragilaria pinnata</i> v. <i>turgidula</i> .....					7				
<i>Gomphonema acuminatum</i> v. <i>montanum</i> .....					X				
<i>G. angustatum</i> .....					X				
<i>G. gracile</i> .....		3					X		
<i>G. gracile</i> v. <i>lanceolatum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



TABLE 1, continued.

Percentages of extant taxa in samples from groups 1, 2, and 3. X = &lt; 1%.

	CAS 191090	VL 1972	VL 2082	VL 2083	Don #6	VL 1904	VL 854	CAS 181014	VL 2084
<i>Nitzschia denticula</i> .....		39					11		
<i>N. fasciculata</i> .....		X							
<i>N. frustulum</i> .....		X				4			4
<i>N. hungarica</i> .....	X								
<i>N. kittlii</i> .....						3			
<i>N. lorenziana</i> .....		X							
<i>N. lorenziana</i> v. <i>subtilis</i> .....		X							
<i>N. oregona</i> .....		X							
<i>Opephora martyi</i> .....		X			15				
<i>O. martyi</i> v. <i>amphioxys</i> .....							X		
<i>O. martyi</i> v. <i>capitata</i> .....		X							
<i>O. pacifica</i> .....					X				
<i>O. sp.</i> .....					2				
<i>Pinnularia acrosphaeria</i> .....				X					
<i>P. biceps</i> f. <i>peterseni</i> (= <i>P. interrupta</i> )....				X					
<i>P. borealis</i> .....			19	9		4			4
<i>P. borealis</i> v. <i>brevicostata</i> .....			X						
<i>P. braunii</i> v. <i>amphicephala</i> .....				X					
<i>P. brebissonii</i> .....						15			
<i>P. brevicostata</i> .....						4			
<i>P. gibba</i> v. <i>linearis</i> .....						2			
<i>P. major</i> .....			X				X		
<i>P. major</i> v. <i>pagesii</i> .....	X								
<i>P. microstauron</i> .....		X	X	X		16			
<i>P. spp.</i> .....			X	5			X		
<i>P. viridis</i> v. <i>minor</i> .....								X	
<i>P. viridis</i> v. <i>sudetica</i> .....						3			
<i>Rhoicosphenia curvata</i> .....								3	
<i>Rhopalodia gibba</i> .....		X							
<i>R. gibba</i> v. <i>ventricosa</i> .....			X						
<i>R. gibberula</i> .....	X							X	
<i>R. musculus</i> .....	X							2	
<i>R. parallela</i> .....	25	X							
<i>Stauroneis anceps</i> .....			X	6					
<i>S. anceps</i> v. <i>gracilis</i> (= <i>S. gracilis</i> ).....			2						
<i>S. anceps</i> v. <i>hyalina</i> .....				X					
<i>S. near schinzii</i> .....				X					
<i>Stephanodiscus astraia</i> v. <i>minutula</i> .....		X					X		
<i>S. hantzschii</i> .....		X							
<i>S. invisitatus?</i> .....		X							
<i>S. niagarae</i> .....		X						X	
<i>Surirella biseriata</i> v. <i>rostrata</i> .....								X	
<i>S. capronii</i> .....								2	
<i>S. obscura</i> .....	5							X	
<i>S. ovalis</i> .....								X	
<i>S. spiralis</i> .....	X								
<i>Synedra acus</i> .....								X	
<i>S. rumpens</i> v. <i>fragilarioides</i> .....							2		
<i>S. rumpens</i> v. <i>meneghiniana</i> .....		X						X	
<i>S. ulna</i> .....		X	14	3				6	
<i>S. ulna</i> v. <i>oxyrhynchus</i> .....								3	
<i>S. ulna</i> v. <i>oxyrhynchus</i> f. <i>contracta</i> .....								2	
<i>S. vaucheriae</i> .....	X								
<i>Tabellaria fenestrata</i> .....								X	
TOTAL EXTANT TAXA	34	89	27	31	49	20	40	32	14



TEXT-FIGURE 3

Stratigraphic ranges of extinct diatoms in group 1 samples of table 2. \* = present in all four samples. + = present also in sample VL 2082.

and 9 miles south of the railroad in Ciudad Puebla, Mexico; corresponds with unit D - upper unit E zone (from sites 2-4 on text-figure 1; see also text-figure 2); CAS G. Dallas Hanna Diatom Collection accession number 2221.

VL2082 - Collected September 23, 1997, by V. Steen-McIntyre at the Hueyatenco archaeological site (3 on text-figure 1) (see also text-figure 2) on the north side of the Valsequillo Reservoir, at the base (120-130cm from the surface) of the Hueyatenco Ash; repository at CAS.

VL2083 - Collected September 24, 1997, by V. Steen-McIntyre at the Hueyatenco archaeological site (3 on text-figure 1) (see also text-figure 2) on the north side of the Valsequillo Reservoir, at the base of the Buena Vista Lapilli (35-40cm from the surface). "Superhydration curve (for water in glass vesicles) essentially equal to Hueyatenco Ash and to Yellowstone Tephra dated 251,000yr"; repository at CAS.

Group 2. Middle Pleistocene (Sangamonian) 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 (.92m) above the Illinoian till. Don #4 (.3m above Illinoian till), and Don #20 (5.5m above Illinoian till) may be included with Don #6, all three of which correspond with the Sangamonian Interglacial Stage (based upon pollen and other fossils).

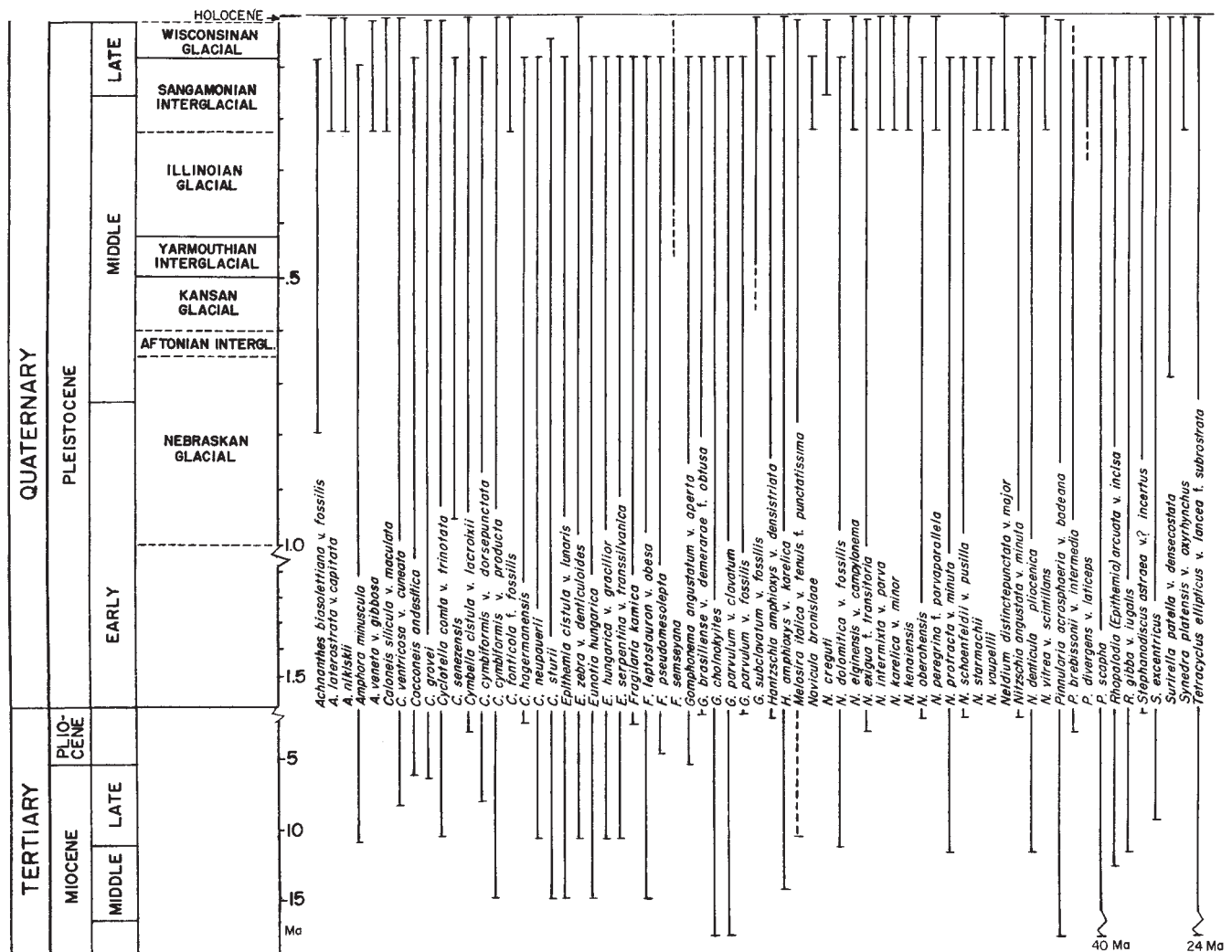
VL1904 - Collected October 28, 1988, by S. L. VanLandingham from SW 1/4 SW 1/4 SW 1/4 sec. 30, T. 42 N., R. 55 E., Elko County, Nevada, 2.4km northwest of bridge over the North Fork of the Humboldt River; from a stratigraphic position near the top of the Hay Ranch Formation (middle Pleistocene); repository at CAS.

Group 3. Modern, Holocene 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 Ciudad Tlaxcala area, Tlaxcala State, Mexico; repository at CAS.

CAS 181014 - Collected by F. W. T. Kincaid, Summer, 1933; modern water sample from Lake Xochimilco, Distrito Federal,





TEXT-FIGURE 4

Stratigraphic ranges of 65 extinct diatom taxa from the six lines of biostratigraphic correlation shown in text-figure 2. See table 3 for taxon occurrence within the 15 samples used in the six lines of biostratigraphic correlation.

Mexico; elevation 2,260m; repository at CAS, H. E. Sovereign Collection slide CAS 181014, accession No. 600350.

VL2084 - Collected September 23, 1997, by V. Steen-McIntyre at Hueyatenco archaeological site (3 on text-figure 1) in unit A of Irwin-Williams (see text-figure 2); from top 5cm of modern soil which rests on top of Buena Vista Lapilli; repository at CAS.

Other biostratigraphic work included the microscopic examination of additional samples from measured sections 8 and 14, cores 2 and 4, and the Hueyatenco archaeological site (text-figure 1) which yielded the 65 extinct diatoms listed in table 3 and text-figure 4 and which resulted in the six lines of biostratigraphic correlation shown in text-figure 2.

## RESULTS

The biochronology of diatom-bearing sequences in samples collected by H. E. Malde of the United States Geological Survey in 1964-1970 from four localities in the Valsequillo region

(measured section 8, core 2, core 4, and measured section 14) all correlated with numerous diatomaceous samples from the Hueyatenco archaeological site including the four samples in group 1 (see text-figures 1 and 2). These biostratigraphic correlations between samples were based on taxa extinct at the end of the Sangamonian, earliest known first occurrences, dominance/subdominance associations, and Pennate to Centric (P:C) ratios. These correlations are consistent with a Sangamonian age (determined by the diatoms and Chrysophyta cysts in two previously published studies, i.e., VanLandingham 2000, 2002a) for the group 1 samples associated with the Hueyatenco site and its artifacts (including the Dorenberg skull).

## Taxa extinct at the end of the Sangamonian

These two previous studies of sedimentary deposits surrounding artifacts at the Hueyatenco archaeological site have yielded a list of 4 Chrysophyta cysts (VanLandingham 2002a) and 15 diatoms (VanLandingham 2002b) which were extinct at the end of the Sangamonian (i.e., ostensibly not known after the start of the last ice age): a late glacial or postglacial age for the four

TABLE 2

Percentages of extinct taxa in samples from groups 1, 2, and 3. Notice that group 3 samples (VL 854, CAS 181014, and VL 2084) have no extinct taxa. X = < 1%.

	CAS 191090	VL 1972	VL 2082	VL 2083	Don #6	VL 1904	VL 854	CAS 181014	VL 2084
<i>Achnanthes biasolettiana</i> v. <i>fossilis</i> .....		X							
<i>A. lapidosa</i> f. <i>robusta</i> .....		X							
<i>Cymbella cymbiformis</i> v. <i>producta</i> .....	X	10	X	3					
<i>C. plutonica</i> .....	X								
<i>C. provoensis</i> .....		X							
<i>C. sinuata</i> v. <i>laticeps</i> .....					X				
<i>C. sturii</i> .....		X							
<i>Diatoma capitata</i> .....		X							
<i>Epithemia cystula</i> v. <i>lunaris</i> .....	X								
<i>E. irregularis</i> v. <i>elongata</i> .....	X								
<i>E. zebra</i> v. <i>undulata</i> .....	X								
<i>Eunotia pectinalis</i> v. <i>undulata</i> f. <i>triodon</i> ..			X						
<i>E. serpentina</i> v. <i>transsilvanica</i> .....			X						
<i>Fragilaria lapponica</i> v. <i>attenuata</i> .....		X							
<i>F. leptostauron</i> v. <i>amphitetras</i> .....	X								
<i>Gomphonema duostriatum</i> .....						X			
<i>G. insigne</i> v. <i>acuminata</i> .....		X							
<i>G. parvulum</i> v. <i>clavatum</i> .....		X		X					
<i>G. parvulum</i> v. <i>fossilis</i> .....		X							
<i>Hantzschia amphioxys</i> v. <i>karelica</i> .....			X			X			
<i>Navicula bronislaae</i> .....		X							
<i>N. creguti</i> .....				X					
<i>N. elginensis</i> v. <i>campylonema</i> .....						X			
<i>N. dorenbergi</i> .....	3								
<i>N. pseudoscutiformis</i> v. <i>major</i> .....					X				
<i>N. rotundella</i> .....						X			
<i>Nitzschia denticula</i> v. <i>pliocenica</i> .....		4							
<i>Pinnularia esox</i> f. <i>major</i> .....		X							
<i>P. esox</i> f. <i>recta</i> .....		X							
<i>P. fontellii</i> .....			X						
<i>P. subflexuosa</i> .....	20								
<i>Rhopalodia gibba</i> v. <i>iugalis</i> .....			2						
<i>Stephanodiscus excentricus</i> .....		X							
<i>S. lineatus</i> v. <i>carconensis</i> ? .....		X							
<i>S. pantocseki</i> .....		X							
TOTAL EXTINCT TAXA	8	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).

samples in group 1 is eliminated by these 19 extinct taxa. The 4 extinct chrysophyte cysts are: *Outesia membranosa* (*Trachelomonas yberiensis* v. *membranosa*) Frenguelli (1932) and Cyst type 5, 11 (plate 7, figure 76), and 14 of VanLandingham (1964) (see Covey 2002 and VanLandingham 2002a). The 15 extinct diatoms (shown in text-figure 3) are: *Achnanthes biasolettiana* v. *fossilis* Frenguelli (1936), *A. lapidosa* f. *robusta* Moiseeva (1960) (plate 6, figure 1-2), *Cymbella*

*plutonica* Pantocsek (1892) (plate 4, figure 1), *Diatoma capitata* Lauby (1910) (plate 6, figure 23-25; plate 8, figure 6), *Epithemia cystula* v. *lunaris* Grunow (1882) (plate 4, figure 4-7; plate 8, figure 2), *Eunotia serpentina* v. *transsilvanica* Pantocsek (1892) (plate 7, figure 40), *Fragilaria leptostauron* v. *amphitetras* Grunow (1882) (plate 4, figure 9; plate 8, figure 11-14), *Gomphonema insigne* v. *acuminata* Héribaud (1902) (plate 8, figure 9), *G. parvulum* v. *clavatum* Okuno (1952)

TABLE 3

Percentages of extinct diatom taxa from the correlated samples of the six lines of biostratigraphic correlation shown in text-figure 2. Samples range from the youngest correlation at the left to the oldest correlation at the right. Note: sample 66M191 correlated not only with VL2158 and 66M285 but also with VL2120 and 66M286 (see text-figure 2). X = < 1%.

	66M288	VL2173	VL2083	VL2168	66M191	VL2158	66M285	VL2120	66M286	66M239	66M194	VL2121	66M287	VL2150	66M288
<i>Achnanthes biasolettiana</i> v. <i>fossilis</i> .....										X		X			
<i>A. laterostrata</i> v. <i>capitata</i> .....										X					
<i>A. nikiskii</i> .....										X					
<i>Amphora minuscula</i> .....										X					
<i>A. veneta</i> v. <i>gibbosa</i> .....		X				X									
<i>Caloneis silicula</i> v. <i>maculata</i> .....								X			X				
<i>C. ventricosa</i> v. <i>cuneata</i> .....															
<i>Cocconeis andesitica</i> .....							X								
<i>C. grovei</i> .....					X			2							
<i>Cyclotella comta</i> v. <i>trinotata</i> .....							X		X						
<i>C. senezensis</i> .....									X						
<i>Cymbella cistula</i> v. <i>lacroixii</i> .....											1			X	
<i>C. cymbiformis</i> v. <i>dorsepunctata</i> .....												X			
<i>C. cymbiformis</i> v. <i>producta</i> .....			3												
<i>C. fonticola</i> f. <i>fossilis</i> .....									X						
<i>C. hagermanensis</i> .....												X	X		
<i>C. neupauerii</i> .....												X			
<i>C. sturii</i> .....						X		X				X			
<i>Epithemia cistula</i> v. <i>lunaris</i> .....					X		1	X	X						
<i>E. zebra</i> v. <i>denticuloides</i> .....								X	X						
<i>Eunotia hungarica</i> .....				X				X					1		
<i>E. hungarica</i> v. <i>gracilior</i> .....	X	X		X								1			
<i>E. serpentina</i> v. <i>transsilvanica</i> .....	X						X								
<i>Fragilaria kamica</i> .....														1	
<i>F. leptostauron</i> v. <i>obesa</i> .....														1	
<i>F. pseudomesolepta</i> .....										1					
<i>F. semseyana</i> .....										X					
<i>Gomphonema angustatum</i> v. <i>aperta</i> .....	X														
<i>G. brasiliense</i> v. <i>demerarae</i> f. <i>obtusum</i> .....								X							
<i>G. cholnokites</i> .....									X						
<i>G. parvulum</i> v. <i>clavatum</i> .....			X												
<i>G. parvulum</i> v. <i>fossilis</i> .....									X					X	X
<i>G. subclavatum</i> v. <i>fossilis</i> .....		X				X								X	
<i>Hantzschia amphioxys</i> v. <i>densistriata</i> .....											1				
<i>H. amphioxys</i> v. <i>karelica</i> .....	X	X										X			
<i>Melosira italica</i> v. <i>tenuis</i> f. <i>punctatissima</i> .....												X			
<i>Navicula bronislaae</i> .....									X			X			
<i>N. creguti</i> .....			X												
<i>Navicula dolomitica</i> v. <i>fossilis</i> .....															X
<i>N. elginensis</i> v. <i>campylonema</i> .....									1						
<i>N. exigua</i> f. <i>transitoria</i> .....								X							
<i>N. intermixta</i> v. <i>parva</i> .....		X													
<i>N. karelica</i> v. <i>minor</i> .....									X						
<i>N. kenaiensis</i> .....									X						
<i>N. oberohensis</i> .....															1
<i>N. peregrina</i> f. <i>parvaparallela</i> .....												X			
<i>N. protracta</i> v. <i>minuta</i> .....								X							
<i>N. schoenfeldii</i> v. <i>pusilla</i> .....						X									
<i>N. starmachii</i> .....						X									
<i>N. vaupellii</i> .....	X														
<i>Neidium distinctepunctata</i> v. <i>major</i> .....	X														
<i>Nitzschia angustata</i> v. <i>minuta</i> .....									1						
<i>N. denticula</i> v. <i>pliocenica</i> .....	1		X		X	1	1	X	X						
<i>N. vitrea</i> v. <i>scintillans</i> .....										X					
<i>Pinnularia acrosphaeria</i> v. <i>badeana</i> .....								X							
<i>P. brebissonii</i> v. <i>intermedia</i> .....	X														
<i>P. divergens</i> v. <i>laticeps</i> .....								X							
<i>P. scapha</i> .....								X							
<i>Rhopalodia</i> ( <i>Epithemia</i> ) <i>arcuata</i> v. <i>incisa</i> .....									X						
<i>R. gibba</i> v. <i>iugalis</i> .....		X	X			X						X		1	
<i>Stephanodiscus astraea</i> v. ? <i>incertus</i> .....								X							
<i>S. excentricus</i> .....	X						1	X		X	1		X		X
<i>Surirella patella</i> v. <i>densecostata</i> .....						X		X							
<i>Synedra platensis</i> v. <i>oxyrhynchus</i> .....														X	
<i>Tetracyclus ellipticus</i> v. <i>lancea</i> f. <i>subrostrata</i> ..							X								
TOTAL EXTINCT TAXA .....	5	9	4	3	3	8	6	16	12	8	4	8	4	7	3
TOTAL TAXA EXTINCT BY THE END OF SANGAMONIAN ....	3	4	1	3	2	4	4	6	6	3	1	5	2	4	3
TOTAL EXTINCT TAXA UNKNOWN BEFORE SANGAMONIAN ...		3				2		2	5	3		2		1	
TOTAL EXTINCT TAXA RESTRICTED TO SANGAMONIAN ....		1				1		1				1			
RATIOS OF PENNATE TO CENTRIC DIATOMS .....	3,014:1	1,270:1	266:1	658:1	127:1	105:1	94:1	83:1	178:1	59:1	33:1	16:1	37:1	100:1	586:1
(Includes both extinct and extant taxa)															

(plate 6, figure 26), *G. parvulum* v. *fossilis* Manguin (1949) (plate 8, figure 10), *Navicula bronislaae* Kaczmarzka (1976) (plate 9, figure 22), *N. dorenbergi* Reichelt (1900) (plate 4, figure 8, 10; plate 5, figure 5; plate 8, figure 3), *Nitzschia denticula* v. *pliocenic*a Frenguelli (1934) (plate 6, figures 30-41), *Pinnularia subflexuosa* Hustedt (1934) (plate 4, figures 11-12; plate 5, figures 6-11), and *Rhopalodia gibba* v. *iugalis* Bonadonna (1964) (plate 7, figures 53-54). All of these diatoms evidently have long stratigraphic ranges except *N. bronislaae* and *N. dorenbergi* which apparently are restricted to the Sangamonian (text-figure 3 and table 2). The above taxa (in table 2) often have been reported from many localities over the world from early Miocene through last interglacial (but not after the last interglacial), e.g.: *Gomphonema parvulum* v. *clavatum* from Yubari and Yufuin (Okuno 1952 and Fukushima 1957) and Valsequillo (VanLandingham 2000, 2002b, 2003). The deposits associated directly with the artifact-bearing units (B through E and I) of Irwin-Williams (1973) at the Hueyatla archaeological site have many fossil diatoms which indicate an age no younger than Sangamonian Interglacial time (sensu lato = 80,000 to ca. 220,000yr BP) for these units.

In table 3 the last 11 samples on the right are from units B through E and I (text-fig. 2), and these 11 samples contain 30 diatom taxa which evidently became extinct in the Sangamonian (text-figure 4). Numerous reports of these taxa (in Table 3) are known from various fossil localities over the world from Eocene, Oligocene and Miocene through last interglacial (but not after the last interglacial), for example: (1) *Cymbella neupauerii* Pantocsek (1889) (plate 9, figure 11), from Erdobénye (Pantocsek 1889, Tempère and Peragallo 1911), from Gyöngyös-Pata (Pantocsek 1889, Tempère and Peragallo 1909), from Lutilla (Pantocsek 1913b), and from Banska Bystrica (Reháková 1971); (2) *Epithemia cistula* v. *lunaris* Grunow (1882) (plate 4, figures 4-7; plate 8, figure 2), from Dubravica (Grunow 1882, Kitton 1885, Pantocsek 1892 and 1905, Fricke 1904, Tempère and Peragallo 1912, and

Reháková 1971 and 1980), from Bory (Tempère and Peragallo 1889-1895 and 1911, Pantocsek 1892 and 1905, Fricke 1904, and Reháková 1980), from Jastraba (Tempère and Peragallo 1912), from Lutilla (Pantocsek 1913a, Reháková 1980), from Kopacsel (Pantocsek 1913b), from Lugarde and La Garde (Héribaud 1908, Tempère and Peragallo 1912), from Saga (Skvortzow 1937), and from Valsequillo (VanLandingham 2000 and 2003); (3) *Navicula oberohensis* Hustedt (1954) (plate 9, figure 18), from Lueneberger Heide (Hustedt 1954 and 1962); and, (4) *Nitzschia denticula* v. *pliocenic*a (plate 6, figures 30-41), from Las Guayquerías (Frenguelli 1934) and Valsequillo (VanLandingham 2000 and 2003). *Navicula bronislaae* (plate 9, figure 22) has previously been reported only from the last interglacial (e.g., Kaczmarzka 1976, from Imbramowice and VanLandingham 2000 and 2003, from Valsequillo), and a last interglacial age (=Sangamonian, Eemian, etc.) for samples VL2120 and VL2121 (table 3) from Erwin-Williams unit E (text-fig. 2), which contains bifacial tools, is denoted.

#### Earliest known first occurrences

An age no older than Sangamonian for the Valsequillo artifacts and their associated diatomaceous samples of group 1 is indicated by the presence of 4 extinct diatoms which are found only in deposits of Sangamonian (or =) age or younger: *Epithemia zebra* v. *undulata* Héribaud (1893) (plate 5, figures 1-2), *Navicula creguti* Héribaud (1893), *N. bronislaae*, and *N. dorenbergi*, the last two of which are restricted to the Sangamonian (text-figure 3 and table 2). One of the four Valsequillo diatomaceous samples (CAS 191090) contains an extant diatom which has its first occurrence in deposits of Sangamonian (or =) age: *Cymbella cistula* v. *gibbosa* (C. *gibbosa*) Brun (1895) (table 1). Samples associated directly with artifact-bearing units B through E and I have 12 extinct taxa unknown before the Sangamonian (text-figure 2, 4, and table 3), and an age no older than the last interglacial for these samples is indicated. Examples of previous reports of such ex-

### PLATE 1

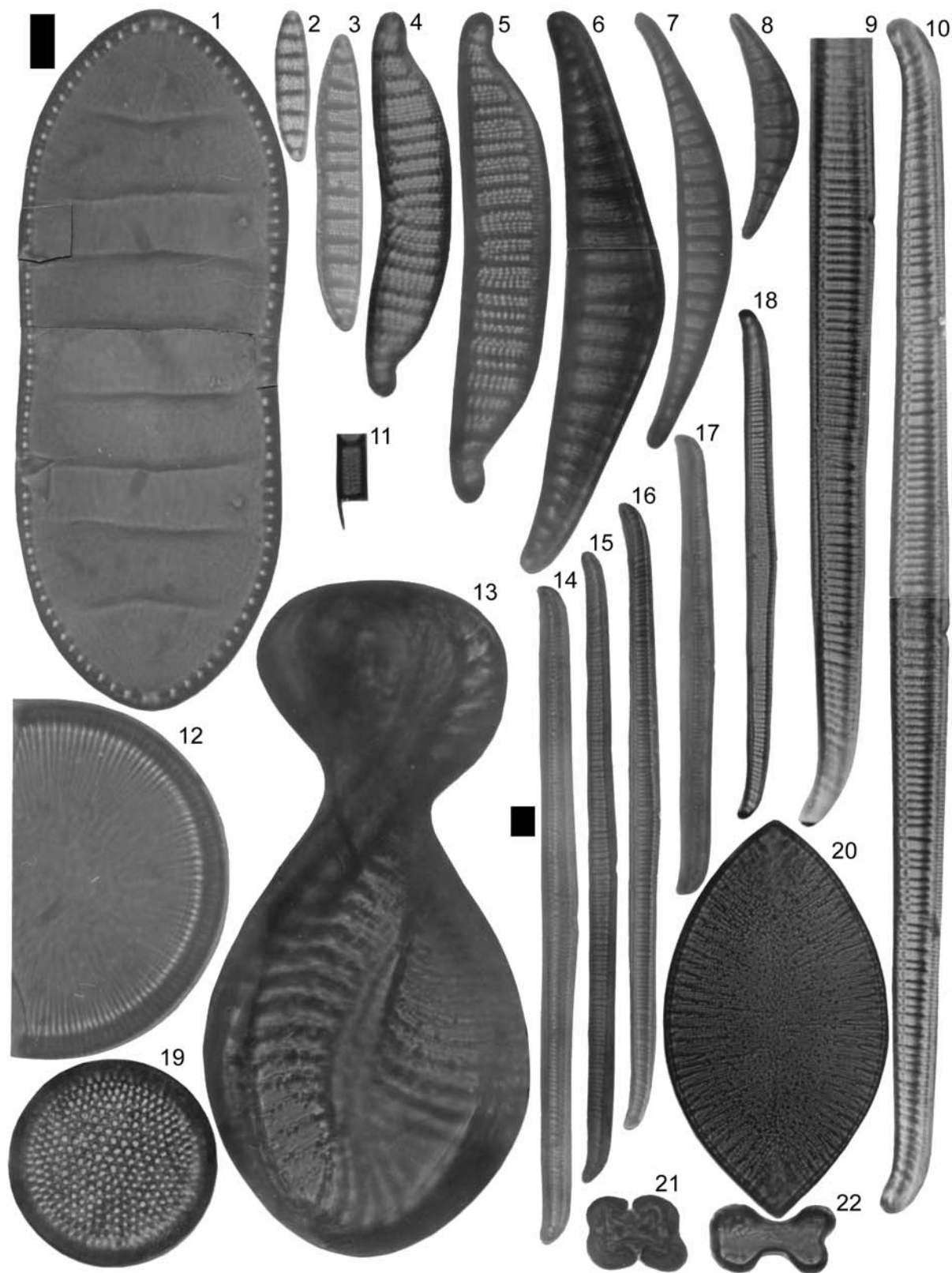
Figures 1-22: extant diatoms and phytoliths from CAS 191090.

Both long and short black bars = 10µm. Long bar applies to figures 1-13, 21-22. Short bar applies to figures 14-20.

Figures 1-20 are diatoms; 21-22 are grass phytoliths, Family Gramineae, Panicoid subfamily, classified according to Twiss (1987).

- |  |   |
|--|---|
| 1 <i>Cymatopleura elliptica</i> v. <i>constricta</i> Grunow;                         | 12 <i>M. arenaria</i> Moore;                                      |
| 2 <i>Denticula elegans</i> v. <i>valida</i> Pedicino = <i>D. lauta</i> J. W. Bailey; | 13 <i>Surirella spiralis</i> Kuetzing;                            |
| 3 <i>D. elegans</i> v. <i>kittoniana</i> ;   | 14-18 <i>Rhopalodia gibba</i> Ehrenberg;                          |
| 4-5 <i>Epithemia zebra</i> v. <i>porcellus</i> Kuetzing;                             | 19 <i>Coscinodiscus marginatus</i> ;                              |
| 6-8 <i>Rhopalodia gibberula</i> Ehrenberg;   | 20 <i>Surirella obscura</i> ;                                     |
| 9-10 <i>R. parallela</i> Grunow;   | 21 Grass phytolith, 3a cross, thick shank (rare compressed type); |
| 11 <i>Melosira granulata</i> Ehrenberg, valve showing isolated spine;                | 22 Grass phytolith, 3d dumbbell, long shank.                      |





tinct taxa which are found in these samples include: *Achnanthes laterostrata* v. *capitata* Stone in McLaughlin and Stone (1986) (plate 9, figures 3-4), from Kenai (McLaughlin and Stone 1986) and Valsequillo (VanLandingham 2000); *Navicula bronislaae* (plate 9, figure 22), from Imbramowice (Kaczmarek 1976) and Valsequillo (VanLandingham 2000 and 2003); and, *N. elginensis* v. *campylonema* McLaughlin in McLaughlin and Stone (1986) (plate 9, figure 14), from Kenai (McLaughlin and Stone 1986).

#### Fossil dominance/subdominance associations

In this investigation, the taxon with the largest % of the total in a fossil assemblage is defined as the dominant, as codominant if two or more taxa equally share the largest % of the total (or are within 90% of the total of the largest dominant), and/or as subdominant, if a taxon composes at least 5% of the total and is as great or greater than 33 1/3% of the largest dominant taxon but is not >90% of the total of that dominant taxon. Four categories of dominance/subdominance occur in the group 1 samples and other Valsequillo samples shown in text-figure 2.

(1) Species dominance/subdominance. Assemblages with dominance/subdominance of the following two taxa are common in fossil occurrences from the Sangamonian and younger (as is the case in sample VL2083, table 1) but are unknown below the Sangamonian: *Navicula pupula* v. *rectangularis* Gregory (1854), e.g., Jatkari et al. (1979), Bogaczewicz-Adamczak and Latalowa (1985) and VanLandingham (2000), and *Stauroneis anceps* Ehrenberg (1854), e.g., Valovirta (1965), Glezer et al. (1974), Lagerback and Robertsson (1988), Loseva (2000) and VanLandingham (2000).

(2) Two genus dominance/subdominance association. The *Gomphonema-Hantzschia* dominance/subdominance association is found in sample VL2083 of group 1, and although it has been reported from Sangamonian through postglacial times

(e.g., Björck et al. 1994; VanLandingham 2000), it evidently is not known below the Sangamonian.

(3) Three genus dominance/subdominance association. Sample VL2082 of group 1 (see table 1) and sample VL2168 (text-figure 2) have the dominance/subdominance association of *Navicula-Pinnularia-Synedra* which has been noted commonly in deposits of the last interglacial (Sangamonian) and below, e.g., Mahony (1912) and Crespin (1947) and VanLandingham (2000): this association is unknown in fossil deposits later than the last interglacial.

(4) Four genus dominance/subdominance association. Sample VL2083 of group 1 (see table 1) has the *Gomphonema-Hantzschia-Navicula-Pinnularia* dominance/subdominance association and has been previously reported as fossil only in the Sangamonian (e.g., VanLandingham 2000, table 2). The *Hantzschia-Navicula-Pinnularia-Synedra* dominance/subdominance association previously has been found in non-marine fossil assemblages only in the Sangamonian (e.g., VanLandingham 2000, table 2), and this association occurs in sample VL2082 of group 1 (table 1).

#### Pennate to Centric (P:C) ratios

Diatom assemblages in the Centric Paucity (CP) zone must fit at least one of the following criteria: (1) over 80:1 ratio of pennate to centric frustules and valves or (2) minimum of 18 pennate taxa with no centric taxa. This zone (or series of zones) is associated with Miocene to Holocene non-marine diatomaceous sequences over the world in which centric diatoms are very rare or totally absent. The CP zone and the ratio of pennate to centric diatoms are very important in the artifact-bearing Valsequillo/Hueyatenco region, because they help to define the extent of the interglacial (Sangamonian) deposition and the age of the artifacts. The first descriptions of the CP zone were provided by VanLandingham (1988, 1990). By definition, the CP

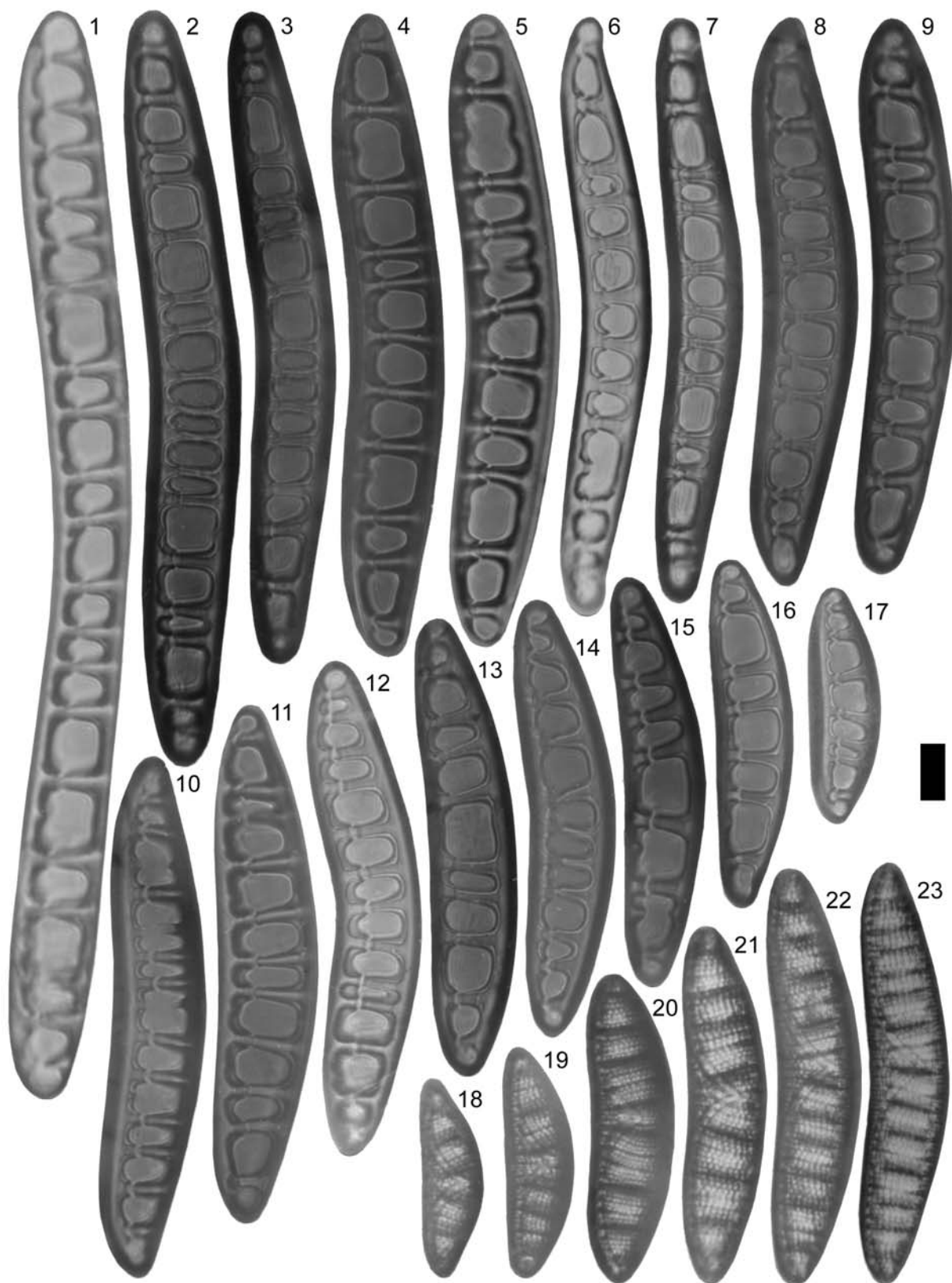
## PLATE 2

Figures 1-23: extant diatoms from CAS 191090. Bar = 10µm and applies to all figures on plate.

1-3,9, *Epithemia argus* Ehrenberg intercalary bands;  
13-16  
4-8, 10, *E. argus* v. *longicornis* Ehrenberg intercalary bands;  
12, 17

18-22 *E. argus* frustules;  
23 *E. argus* v. *longicornis* frustule.





zone contains only fossil assemblages and may include some postglacial fossil deposits but does not include active, living, and modern diatom communities. According to VanLandingham (2000), examination of a total of almost 2,000 diatomaceous 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 Miocene or Pliocene, and in the remaining half, nearly all were Holocene or modern, except for a few in the middle and late Pleistocene. These few Pleistocene occurrences in North America are restricted to interglacial deposition: Aftonian, Yarmouthian, and Sangamonian Interglacial times (see text-figures 3 and 4). Apparently Pleistocene CP zone deposits in North America are absent in preglacial or early Pleistocene, Nebraskan, Illinoian, and (all but the latest part, i.e., < ca. 20,000yr BP) of Wisconsinan glacial times. Diatomaceous assemblages in the CP zone of latest Wisconsinan (< ca. 20,000yr 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); but, most of the North American Pleistocene CP zone occurrences are within Sangamonian Interglacial time, e.g., group 1 samples from the Valsequillo region (see text-figure 3). Few Pleistocene CP zone occurrences are known from South America, e.g., Arica, Tarapaca, Chile, reported by Dingman and Lohman (1963) or the Eastern Hemisphere, e.g., Ermelo, Transvaal, South Africa, reported by Fritsch and Rich (1925) to be totally devoid of centric diatoms. The CP zone evidently is associated with warmer climatic conditions (including interglacial and interstadial times) in diatomaceous deposits from middle Miocene to present times. No CP zone occurrences of > ca.

20,000yr BP in the Wisconsinan or = age are known in the Western Hemisphere; however, in the Eastern Hemisphere, two assemblages of Lagerback and Robertsson (1988) in the lithounit C (= Odderade Interglacial) at Onttoharjut in northern Sweden fit the CP zone criteria. Mangerup ex Lagerback and Robertsson (1988) correlated the Odderade Interstadial with isotope stage 5a dated ca. 75,000 - 85,000yr BP which slightly overlaps the younger age limits of the Sangamonian and the older age limits of the Wisconsinan.

The Hueyatenco site and measured section 14 were correlated on the basis of extremely high (>700:1) P:C ratios of 3,014:1 in sample 66M228 and 1,270:1 in sample VL2173 and on relatively high (>185:1) P:C ratios of 266:1 in sample VL2083 and 658:1 in sample VL2168 (text-figs. 2, table 3). The unit D-upper unit E zone links samples 66M191, VL2158 and 66M285 (comprising the upper boundary of the zone) and 66M191, VL2120 and 66M286 (comprising the lower boundary of the zone) in core 2, Hueyatenco site, and core 4 on the basis of relatively intermediate (80:1 to 185:1) P:C ratios (text-figure 2, table 3). In the correlation of the base of Unit E at Hueyatenco with cores 2 and 4 and measured section 8 (text-fig. 2), samples 66M239, 66M194, VL2121, and 66M287 all had similar, relatively low P:C ratios (< 80:1) of 59:1, 33:1, 16:1, and 37:1 respectively (and were not in the CP zone which is prominent directly above the unit D-upper unit E zone and below in the correlation of the bottom of unit I with core 4 (text-figure 2, table 3). The basal portion of Unit I at Hueyatenco (sample VL2150, text-figure 2) is related to a corresponding position in core 4 (sample 66M288) on the basis of moderate to higher P:C ratios ranging from 100:1 in the former to 586:1 in the latter.

### PLATE 3

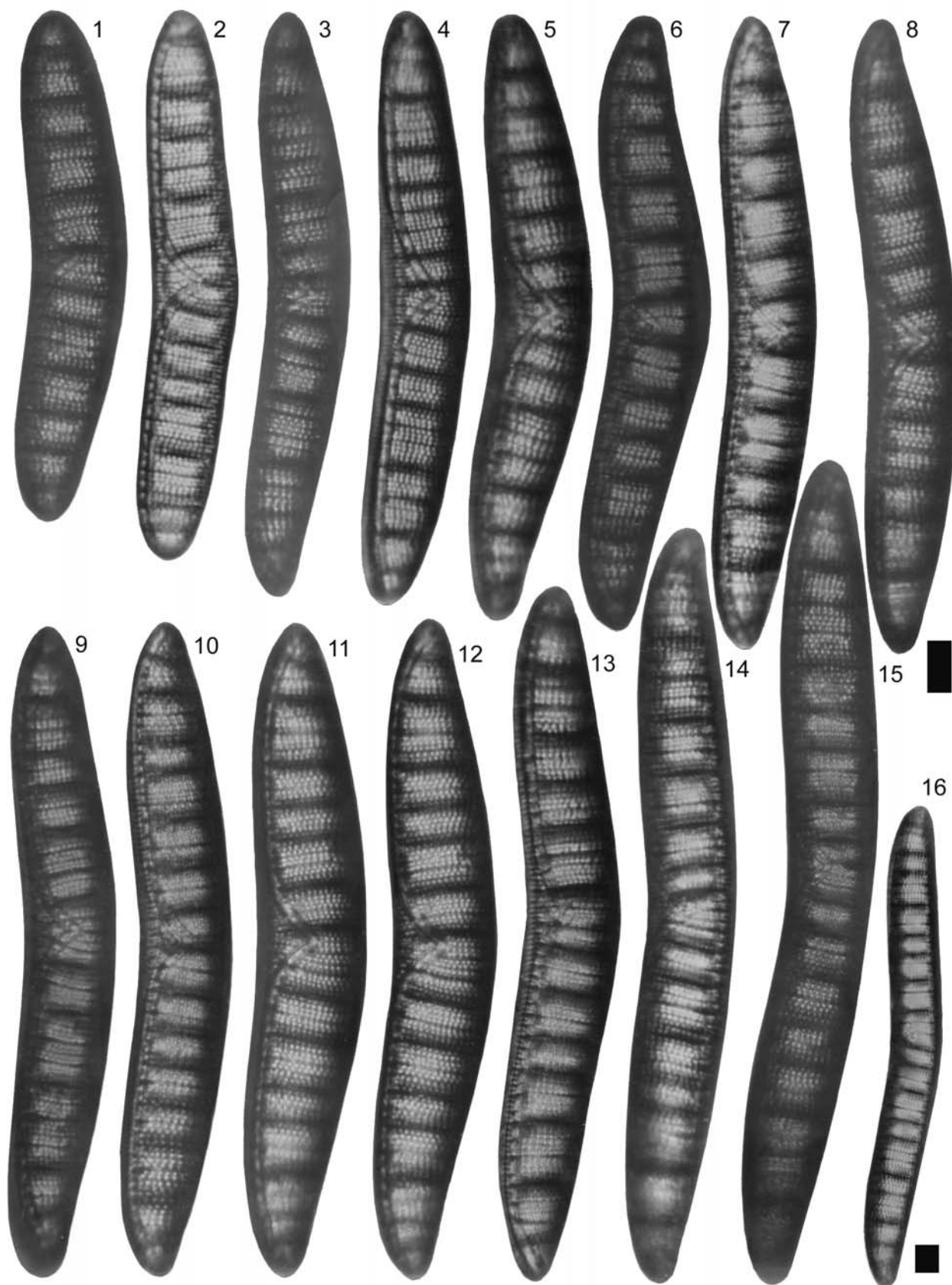
Figures 1-16: extant diatoms from CAS 191090.

Both long and short bars = 10µm; short bar applies only to figure 16, long bar applies to all other figures on plate.

1,4 *Epithemia argus*;

3,5-16 *E. argus* v. *longicornis*.

2 *E. argus* atypical form;





## DISCUSSION

### Correlations and age relationships

In this study, the artifacts (including the Dorenberg skull) from the Hueyatenco site are considered to be older than the last ice age, because the first two samples (CAS 191090 and VL1972) of Sangamonian age in group 1 are associated directly with the zone which intercepts unit D and the upper part of unit E of Irwin-Williams (1973), and the last two samples of group 1 (VL2082 and VL2083) are from diatomaceous deposits which are also Sangamonian and stratigraphically above the artifact-bearing units (B through E and I, in text-figure 2). The unit D - upper (half of) unit E zone intercepts sediments which contain bifacial tools and is also defined by all of its diatomaceous samples (VL2120, VL2158, 66M191, 66M285, and 66M286) having relatively intermediate (80:1 to 185:1) P:C ratios (table 3, text-figure 2). The bottom portion of the unit D - upper unit E zone (i.e., 66M191, VL2120, and 66M286) is distinguished by the presence of *Denticula elegans* v. *kittoniana* Grunow in Van Heurck (1881) (plate 7, figures 14-16) and *D. elegans* f. *valida* Pedicino (1867): neither of these uncommon diatoms occur together in any of the many other known fossil diatom samples of the Hueyatenco area or the Valsequillo region, except in samples CAS 191090 and VL 1972 (table 1). Although ascertained to be from the Valsequillo region (probably near Buena Vista Tetela, see text-figure 1), the precise positions of these two samples (CAS 191090 and VL1972) are unknown; however, they correspond to the bottom portion of the unit D - upper unit E zone, because they have both *D. elegans* v. *kittoniana* and *D. elegans* f. *valida* and P:C ratios of 81:1 and 184:1 respectively. *Coscinodiscus marginatus* Ehrenberg (1854) (plate 1, figure 19), a common marine diatom but an extremely rare contaminant in non-marine deposits, is found in sample CAS 191090 and in sample VL2120 from the bottom of the unit D - upper unit E zone (text-figure 2). Both of these samples are clearly non-marine (VanLandingham 2000, 2002a). *C. marginatus* serves as a diagnostic signature or "fingerprint" (see VanLandingham 2002a, figure 3) to link the Dorenberg skull

sample (CAS 191090) with sample VL2120 and the bottom of the unit D - upper unit E zone at Hueyatenco (text-figure 2).

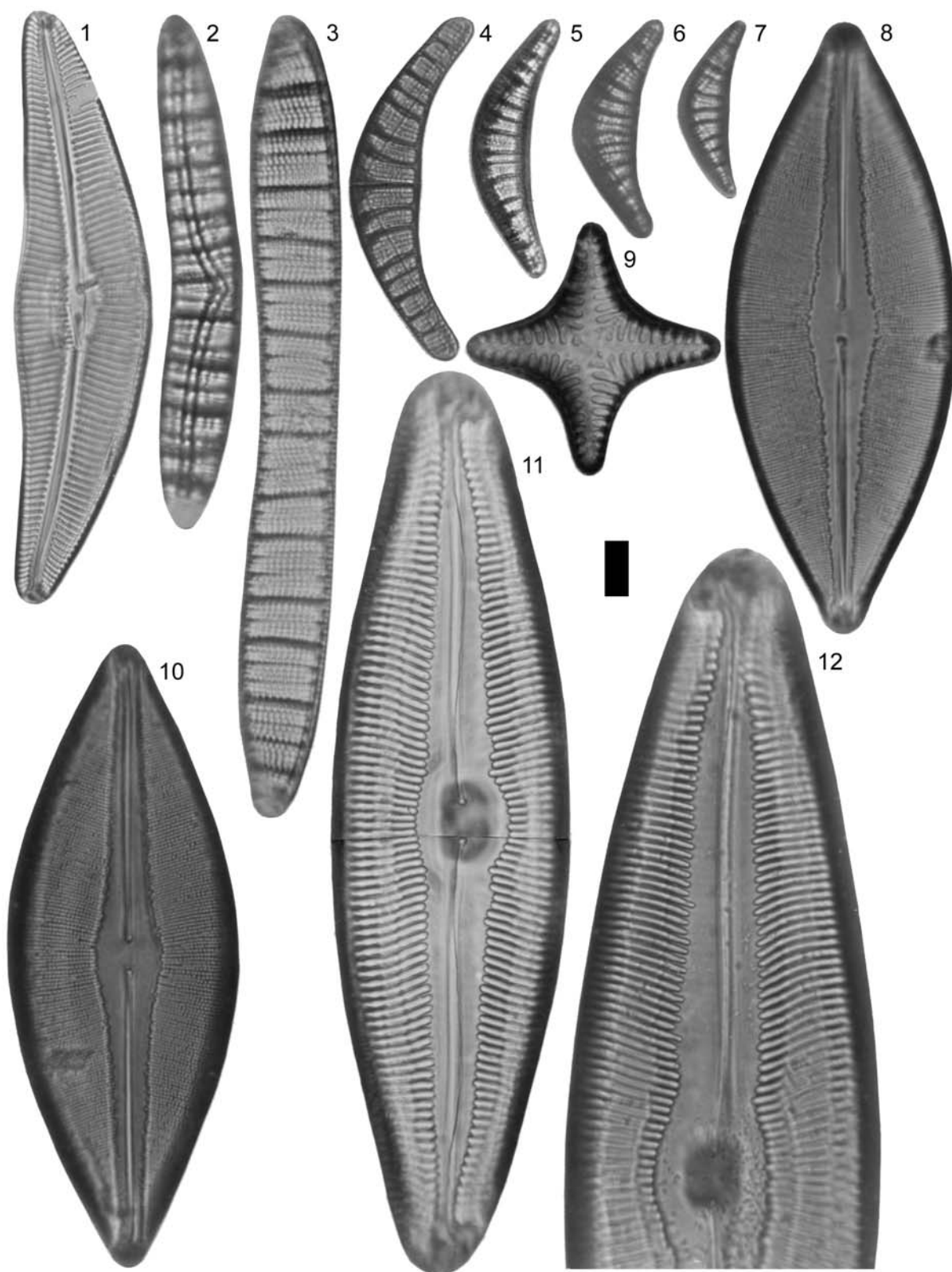
### Reworking and Redeposition

Evidence of redeposition or reworking of deposits is more common in marine than in freshwater environments, because of the greater possibility of high energy water (e.g., deltas, coastal currents, etc.) in the former environments. Excellent demonstrations of this can be found in the reworked marine early Tertiary/late Cretaceous diatoms from coastal and lower elevations in the Pleistocene of Scania, Sweden (Miller 1979) and in the five distinct phases of redeposited fragments of fossil marine (but no corresponding freshwater) diatoms in the Neopleistocene of the East European Platform and Komi-Vychev Region of Europe (Loseva 2001). In my 45 years of experience investigating over 2,500 freshwater fossil diatom deposits in detail, only 8 had unequivocal evidence of prominent redeposition or reworking of allochthonous diatom fossils from deposits of a significantly older geological age. All 8 deposits were strongly influenced by lotic environments, and evidently the older allochthonous fossils originated in similar, preexisting freshwater environments: allochthonous marine diatoms were very rare, if present at all. Freshwater fossil diatom deposits which contain significant numbers of marine diatoms, e.g., deposits between Agadem and Dibella in Niger (Faure et al. 1963), are rare. The mixtures of diverse diatom forms from deposits which have only small geological age differences (like those resulting from glacial-interglacial-interstadial cycles) are not rare, but usually these redeposited, allochthonous forms are few and are associated with coastal or lower elevations, e.g., kettleholes connected to eskers associated with reworking of Weichselian Unit E into Unit D of Lagerback and Robertsson (1988) at Onttoharjut in northern Sweden. Usually, there is little or no evidence of redeposition by rivers (especially in high elevations and intermontane areas, like those in the Valsequillo-Hueyatenco region), because the high energy waters of mountainous river systems eventually destroy or obscure most, if not all, of their own redepositions. This is one of the main reasons

## PLATE 4

Figures 1-12: diatoms from CAS 191090, figure 2 is extant, all others are extinct. Bar = 10µm and applies to all figures on plate.

- |  |  |
|--|--|
| 1 <i>Cymbella plutonica</i> ;              | 8,10 <i>Navicula dorenbergi</i> ;  |
| 2 <i>Epithemia aspeitiana</i> Héribaud;    | 9 <i>Fragilaria leptostauron</i> v. <i>amphitetras</i> ;   |
| 3 <i>E. sp.</i> undetermined (sp. nov. ?); | 11-12 <i>Pinnularia subflexuosa</i> (= <i>P. dactylus</i> v. <i>dariana</i> sensu Reichelt 1899, nec al.). |
| 47 <i>E. cistula</i> v. <i>lunaris</i> ;   |  |



that paleoplacers are rare. Although crenophilous diatomaceous deposits (associated with postglacial springs) are not rare, very few pre-Holocene strata are known to have diatom assemblages in which fluvial or lotic (rheophilous and rheobiontic) species predominate.

Many such authorities as Loseva (2001, p. 464) use the good quality of preservation of diatom valves as one of the criteria for determining if an assemblage is autochthonous, as opposed to fragmented or poorly preserved diatom valves as a criterion for allochthonous, displaced or reworked assemblages: e.g., in a diatomaceous sample from the central Mexican Highlands, Metcalfe and Hales (1990, p. 512) envisaged an environment of deposition associated with low energy water, "Good valve preservation in this sample supports this idea." Intercalary bands of diatoms are very delicate, and the good preservation (lack of fragmentation) of them can be used as a criterion to determine if the waters of deposition were swift enough to greatly fragment the bands and to be indicative of redeposition involving both the diatoms and artifacts. Valve (and frustule) preservation is very good in all of the Valsequillo samples in group 1 (tables 1 and 2) and in the 15 samples listed in table 3. *Epithemia argus* v. *longicornis* Ehrenberg (1854) (plate 2, figures 4-8, 10, 12, 17, 23; plate 3, figures 3, 5-16) is very prominent in the group 1 samples (table 1), and this taxon produces abundant intercalary bands. Almost all of the intercalary bands of *E. argus* v. *longicornis* and related taxa in these samples were wholly intact (e.g., see plate 2), and this would indicate relatively still waters and discount the possibility of redeposition. According to VanLandingham (2000, figure 1 and 2002a, figure 1), in all of the group 1 samples from Valsequillo, limnophilous or limnophilous (lentic) diatoms and chrysophyte cysts greatly outnumber those which are rheobiontic or rheophilous (lotic), and this would denote still water deposition and preclude redeposition or reworking of the diatoms, cysts, and artifacts.

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#### PLATE 5

Figures 1-12: diatoms from CAS 191090. Figure 12 is extant, all others are extinct. Bar = 10µm and applies to all figures on plate.

1-2 *Epithemia zebra* v. *undulata*;

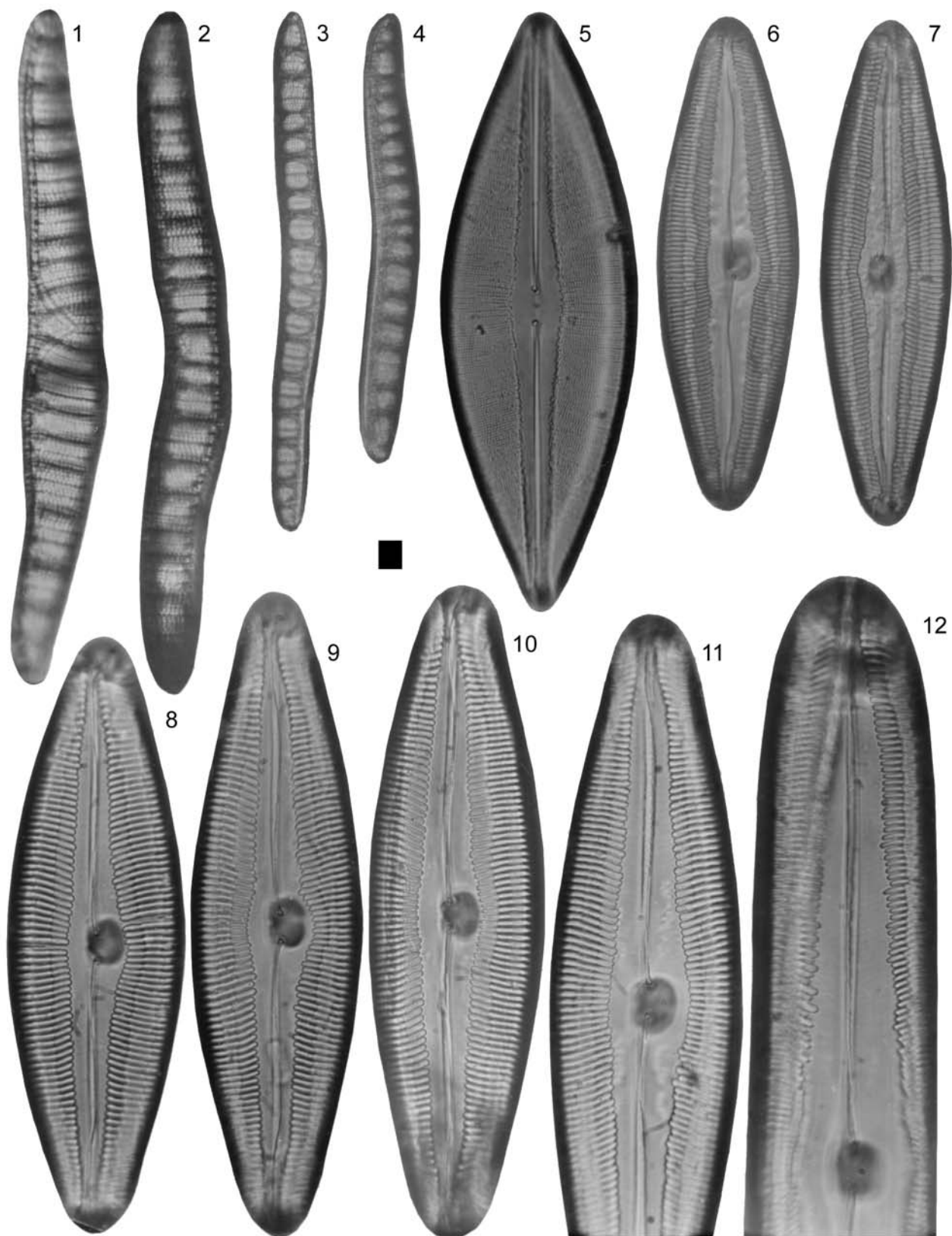
3-4 *E. irregularis* v. *elongata* Fritsch and Rich;

5 *Navicula dorenbergi*;

6-11 *Pinnularia subflexuosa*;

12 *P. major* v. *pagesii* Héribaude.



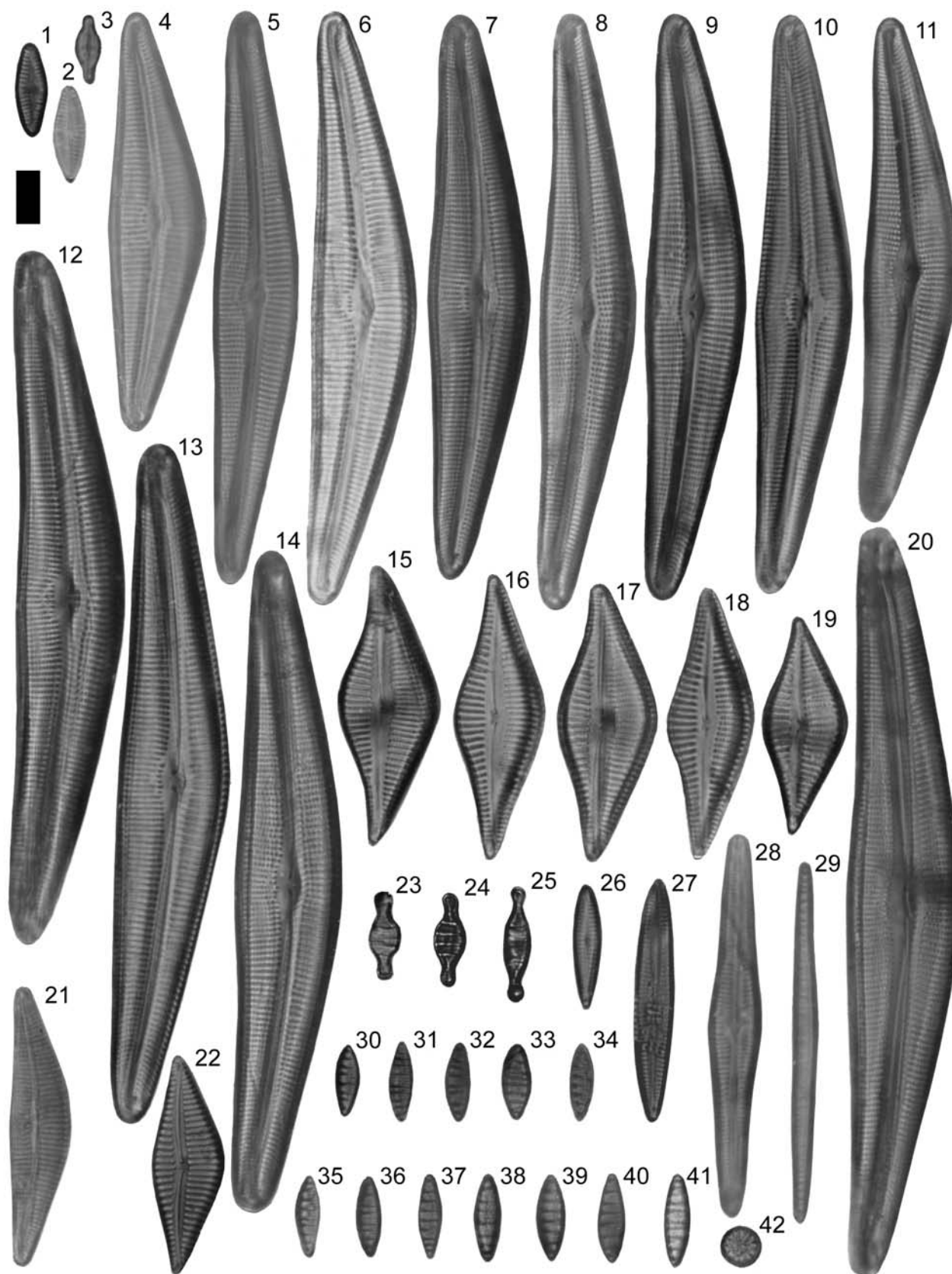


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## PLATE 6

Figures 1-42: diatoms from sample VL 1972. Bar = 10µm and applies to all figures on plate.

- |   |  |
|---|--|
| 1-2 <i>Achnanthes lapidosa</i> f. <i>robusta</i> (frustule at two different focal planes; 1, pseudoraphe valve; 2, raphe valve);  | 22 <i>C. sp.</i> undetermined;                                   |
| 3 <i>A. laterostrata</i> v. <i>capitata</i> Stone?;   | 23-25 <i>Diatoma capitata</i> ;                                  |
| 4-14 <i>Cymbella cymbiformis</i> v. <i>producta</i> Pantocsek (figure 4 with 2 isolated ventral stigmata, figure 5 with 3 isolated ventral stigmata, figure 6 with 4 isolated ventral stigmata, figure 7-8 with 5 isolated ventral stigmata, and figure 9-14 with 6 isolated ventral stigmata); | 26 <i>Gomphonema parvulum</i> v. <i>clavatum</i> ;               |
| 15-19 <i>C. provoensis</i> Lohman;  | 27 <i>G. sp.</i> undetermined (note broad raphe);                |
| 20 <i>C. sturii</i> Grunow;   | 28 <i>G. near intricatum</i> (with 2 distinct isolated punctae); |
| 21 <i>C. sp.</i> undetermined;  | 29 <i>Nitzschia near denticula</i> (deformed);                   |
|   | 30-41 <i>Nitzschia denticula</i> v. <i>pliocenica</i> ;          |
|   | 42 <i>Stephanodiscus excentricus</i> Hustedt.                    |





pp.1-79 (1902); deuxième mémoire, pp. 1-166 (1903); troisième mémoire, pp. 1-70 (1908).

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## PLATE 7

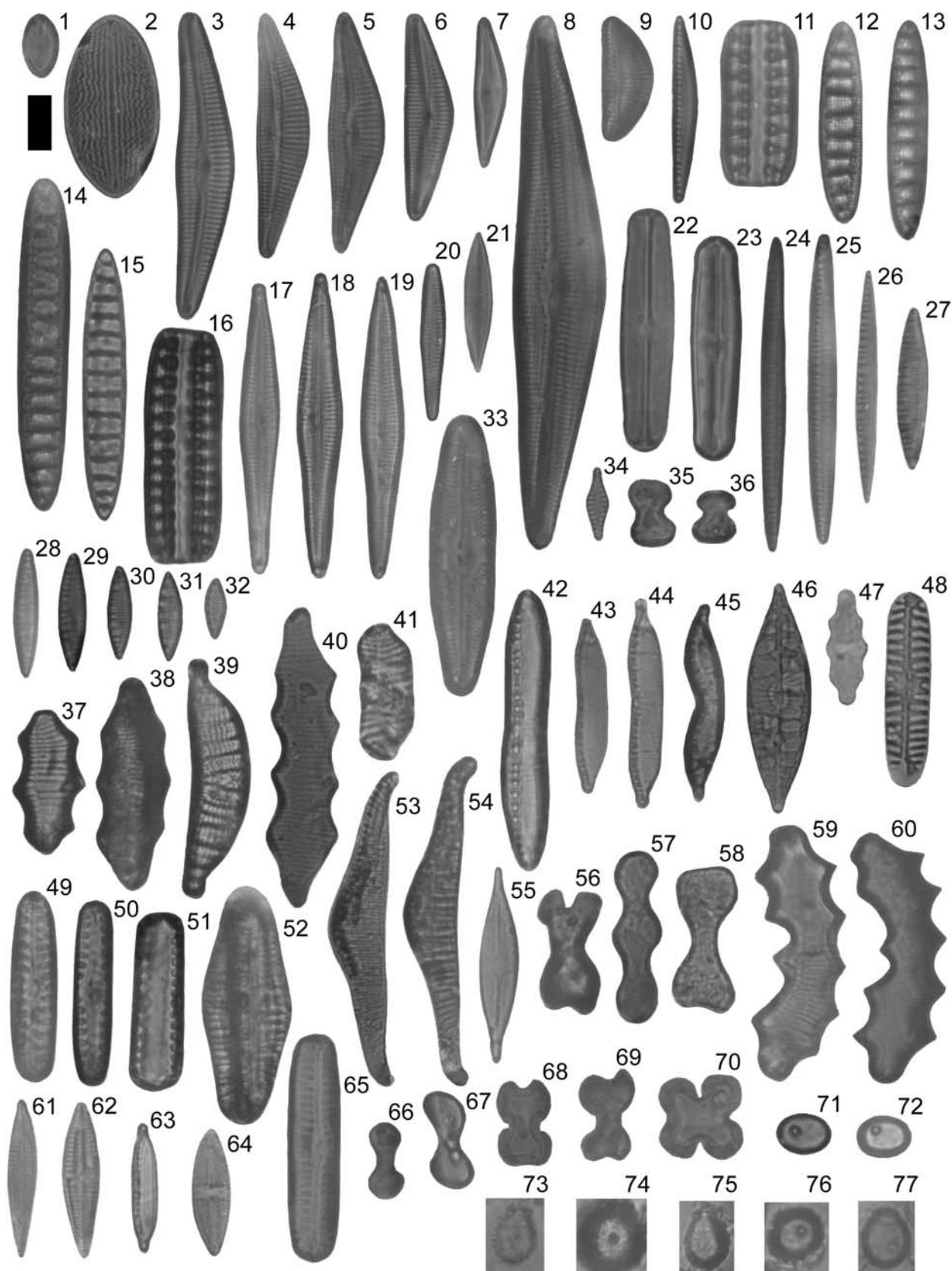
Figures 1-77: diatoms, Chrysophyta cysts, and phytoliths from samples VL 1972, VL 2082, and VL 2083.

Bar = 10µm and applies to all figures on plate. All figures are extant unless otherwise specified.

Figures 1-36, sample VL 1972; figures 37-58 and 77, sample VL 2082; figures 59-76, sample VL 2083.

All Figures are of diatoms except figures 35-36, 56-58 and 66-70 which are grass phytoliths, Family Gramineae, Panicoid subfamily, classified according to Twiss (1987) and figures 71-77 which are Chrysophyta cysts.

- |   |  |
|---|--|
| 1 <i>Cocconeis diminuta</i> Pantocsek;  | 44 <i>H. amphioxys</i> v. <i>capitata</i> Otto Mueller;  |
| 2 <i>C. placentula</i> v. <i>euglypta</i> Ehrenberg rapheless valve;  | 45 <i>H. amphioxys</i> v. <i>karelica</i> Cleve-Euler, extinct;  |
| 3-6 <i>Cymbella affinis</i> Kuetzing;   | 46 <i>Navicula cuspidata</i> Kuetzing, craticulate frustule;   |
| 7 <i>C. delicatula</i> Kuetzing;  | 47 <i>Navicula mutica</i> v. <i>cohnii</i> Hilse;  |
| 8 <i>C. helvetica</i> Kuetzing;   | 48-51 <i>Pinnularia borealis</i> Ehrenberg (48-50 = valve views, 51 = girdle view);                              |
| 9 <i>C. ventricosa</i> Agardh;  | 52 <i>Rhopalodia gibba</i> v. <i>ventricosa</i> Kuetzing;  |
| 10 <i>Cymbellonitzschia diluviana</i> Hustedt;  | 53-54 <i>R. gibba</i> v. <i>iugalis</i> , extinct;   |
| 11-13 <i>Denticula elegans</i> Kuetzing (11 = girdle view, 12-13 = valve views);                            | 55 <i>Stauroneis anceps</i> v. <i>gracilis</i> Ehrenberg;  |
| 14-16 <i>D. elegans</i> v. <i>kittoniana</i> Grunow (14-15 = valve views, 16 = girdle view);                | 56-58 Grass phytoliths (56 = 3b cross, thin shank, 57 = 3i complex dumbbell, 58 = 3c dumbbell, long shank);      |
| 17-19 <i>Gomphonema gracile</i> v. <i>lanceolata</i> Kuetzing;  | 59-60 <i>Amphicampa mirabilis</i> sensu Ehrenberg (1854) non Patrick and Reimer (1966);                          |
| 20 <i>G. subclavatum</i> v. <i>commutatum</i> Grunow;   | 61 <i>Gomphonema gracile</i> v. <i>lanceolatum</i> Kuetzing;   |
| 21 <i>Navicula radiosa</i> v. <i>tenella</i> Brebisson;   | 62 <i>Gomphonema parvulum</i> Kuetzing;  |
| 22-23 <i>N. pupula</i> v. <i>capitata</i> Hustedt;  | 63 <i>Hantzschia amphioxys</i> ;   |
| 24-31 <i>Nitzschia denticula</i> Grunow;  | 64 <i>Navicula mutica</i> Kuetzing;  |
| 32 <i>N. amphibia</i> ;   | 65 <i>Pinnularia borealis</i> ;  |
| 33 <i>Pinnularia microstauron</i> Ehrenberg;  | 66-70 Grass phytoliths (65-66 = 3c dumbbell, long shank, 67-68 = 3b cross, thin shank, 69 = cross, thick shank); |
| 34 <i>Opephora martyi</i> v. <i>capitata</i> Héribaud;  | 71-72 <i>Cysta compressa</i> Nygaard;  |
| 35-36 Grass phytoliths, 3a cross, thick shank;  | 73 <i>Carnegia armata</i> Frenguelli;  |
| 37-38 <i>Amphicampa eruca</i> sensu Ehrenberg (1854) = <i>A. mirabilis</i> sensu Patrick and Reimer (1966); | 74 <i>Cysta vermicularis</i> Nygaard;  |
| 39 <i>Epithemia zebra</i> v. <i>porcellus</i> Kuetzing;   | 75 <i>Outesia perlifera</i> Frenguelli, extinct;   |
| 40 <i>Eunotia serpentina</i> v. <i>transsilvanica</i> , extinct;  | 76 Cyst type # 11, extinct;  |
| 41 <i>Amphicampa mirabilis</i> ?;   | 77 <i>Outesia torquata</i> Frenguelli.   |
| 42-43 <i>Hantzschia amphioxys</i> Ehrenberg;  |  |



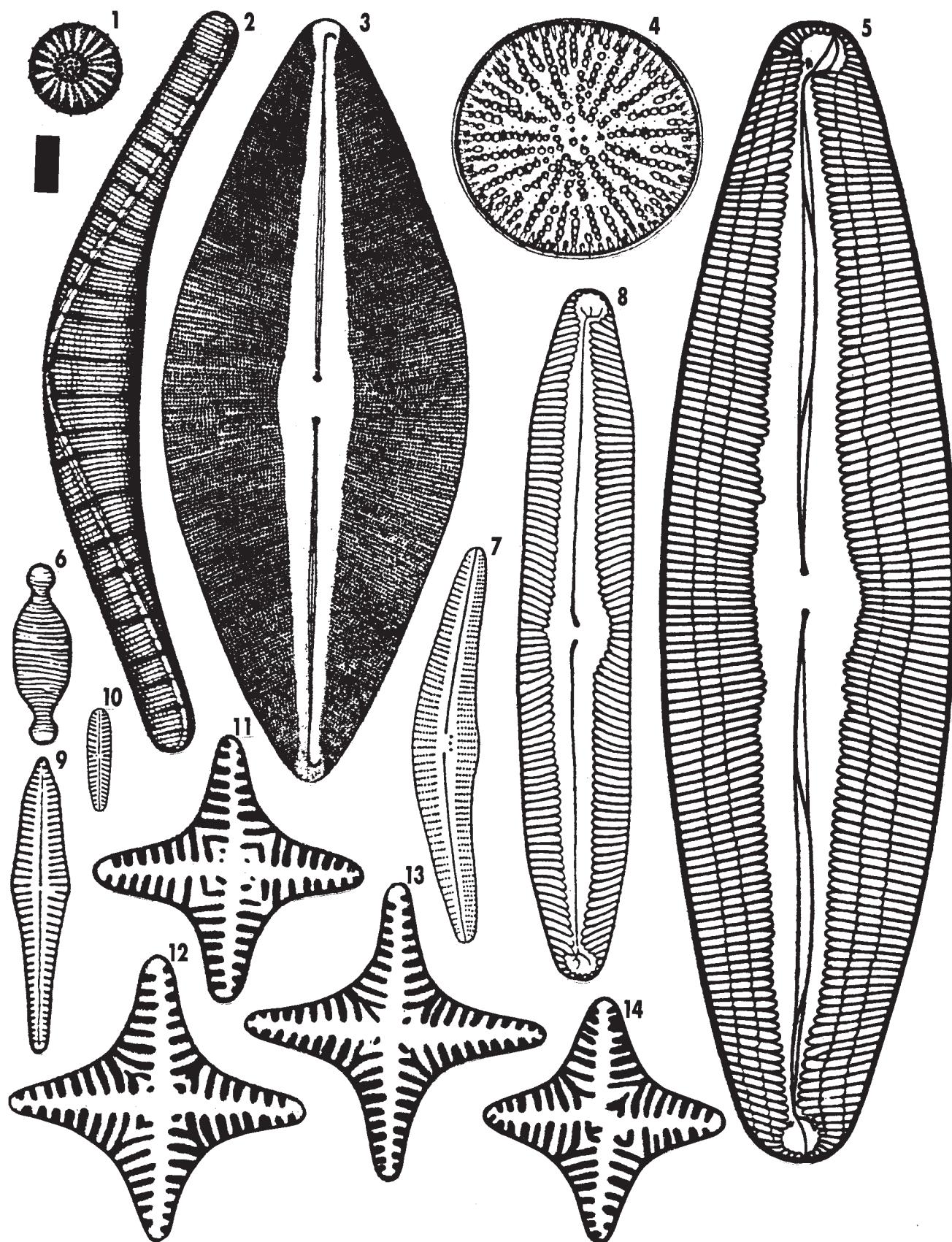
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## PLATE 8

Figures 1-14: extinct diatoms from CAS 191090 and VL 1972. Bar = 10µm and applies to all figures on plate. Figures 1-2, 4, 6-10 from VL 1972 and figures 3, 5, 11-14 are from CAS 191090. Figures 1 and 7 are from VanLandingham (1990); 2 from Fricke (1904); 3 from Heiden (1903); 4 from Fricke (1901); 5 from Hustedt (1934); 6 from Lauby (1910); 8 from Heribaud (1903); 9 from Heribaud (1902); 10 from Manguin (1949); and, 11-14 from Hustedt (1913).

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|--|--|
| 1 <i>Stephanodiscus excentricus</i> ;          | 7 <i>Cymbella cymbiformis</i> v. <i>producta</i> ;           |
| 2 <i>Epithemia cistula</i> v. <i>lunaris</i> ; | 8 <i>Pinnularia esox</i> v. <i>recta</i> Heribaud;           |
| 3 <i>Navicula dorenbergi</i> ;                 | 9 <i>Gomphonema insigne</i> v. <i>acuminata</i> ;            |
| 4 <i>Stephanodiscus pantocseki</i> ;           | 10 <i>Gomphonema parvulum</i> v. <i>fossilis</i> ;           |
| 5 <i>Pinnularia subflexuosa</i> ;              | 11-14 <i>Fragilaria leptostauron</i> v. <i>amphitetras</i> . |
| 6 <i>Diatoma capitata</i> ;                    |  |





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## PLATE 9

Extinct (figure 1-23) and extant (figure 24) diatoms from samples listed in table 3.

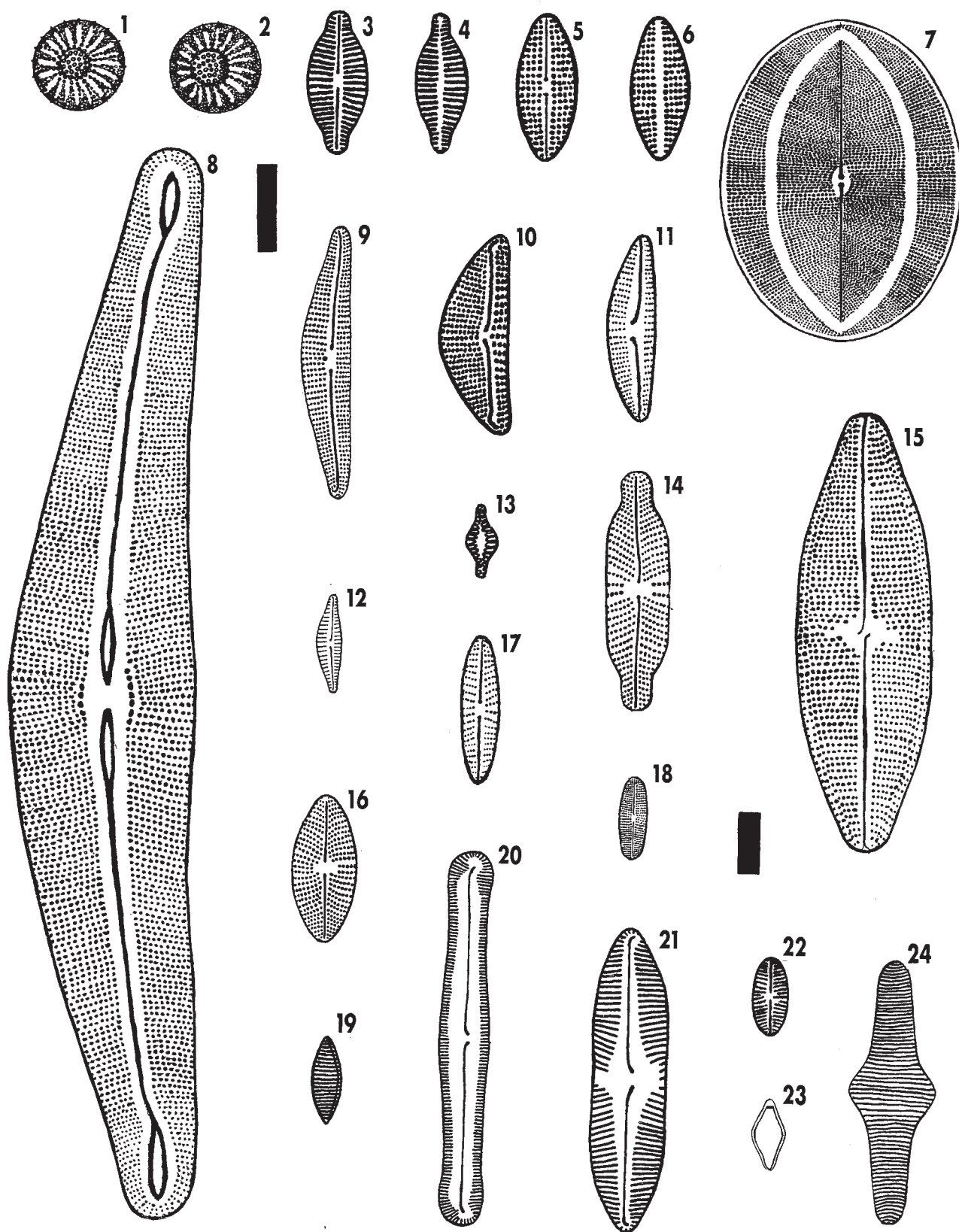
Magnifications: short black bar = 10µm, applies to 1-2 and 7-24, ×1000; long black bar = 10µm, applies to 3-6, ×1500.

1 (from VanLandingham 1990) and 23, 66M285; 2, 13, and 18, 66M288;

3-6, 66M239; 20 and 24, VL2120; 7, 66M191; 8, VL2158;

9, 11 and 22, VL2121; 10, 66M287; 12, 14, 17, and 19, 66M286; 15 and 16, VL2173; and, 21, 66M228.

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|--|--|
| 1-2 <i>Stephanodiscus excentricus</i> ;                            | 14 <i>Navicula elginensis</i> v. <i>campylonema</i> McLaughlin;                                    |
| 3 <i>Achnanthes laterostrata</i> v. <i>capitata</i> , raphe valve; | 15 <i>Neidium distinctepunctatum</i> v. <i>major</i> Sreenivasa;                                   |
| 4 <i>A. laterostrata</i> v. <i>capitata</i> , rapheless valve;     | 16 <i>Navicula intermixta</i> v. <i>parva</i> Stone;   |
| 5 <i>A. nikiskii</i> Stone, raphe valve;                           | 17 <i>N. karelica</i> v. <i>minor</i> Cleve-Euler;   |
| 6 <i>A. nikiskii</i> , rapheless valve;                            | 18 <i>N. oberohensis</i> Hustedt;  |
| 7 <i>Cocconeis grovei</i> ;  | 19 <i>Nitzschia angustata</i> v. <i>minuta</i> Krasske;  |
| 8 <i>Cymbella sturii</i> ;   | 20 <i>Pinnularia acrosphaeria</i> v. <i>badeana</i> Hérivaud;                                      |
| 9 <i>C. cymbiformis</i> v. <i>dorsepunctata</i> Reháková;          | 21 <i>P. brebissonii</i> v. <i>intermedia</i> M. Peragallo;  |
| 10 <i>C. hagermanensis</i> Lohman;                                 | 22 <i>Navicula bronislaae</i> ;  |
| 11 <i>C. neupauerii</i> Pantocsek;                                 | 23 <i>Tetracyclus ellipticus</i> v. <i>lancea</i> f. <i>subrostrata</i> Hustedt, intercalary band; |
| 12 <i>C. fonticola</i> f. <i>fossilis</i> Manguin;                 | 24 <i>Fragilaria floridiana</i> Hanna  |
| 13 <i>Fragilaria leptostauron</i> v. <i>obesa</i> Lohman;          |  |



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