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Article

Use of diatoms in determining age and paleoenvironment of the Valsequillo (Hueyatlaco) early man site, Puebla, Mexico, with corroboration by Chrysophyta cysts for a maximum Yarmouthian (430,000–500,000 yr BP) age of the artifacts

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With 3 figures, 1 plate, and 2 tables

Abstract: No other archaeological site in the world is known to be associated with such a complex, highly significant age and environmentally diagnostic diatom sequence as Valsequillo (Hueyatlaco). Bona fide artifacts have been found in situ in sedimentary deposits which, by various reputable means, have been demonstrated to be older than the Last Ice Age. Diatoms and cysts have been found in 147 samples from 22 distinct stratigraphic units at or around the Hueyatlaco archaeological site. These samples have yielded 44 extant and 39 extinct chrysophyte taxa and 467 extant and 78 extinct diatom taxa, many of which are age diagnostic indicators designating a minimum (Sangamonian *sensu lato* = 80,000–ca. 220,000 yr BP) and a maximum (Illinoian = ca. 220,000–430,000 yr BP) age for the Hueyatlaco artifacts. The biostratigraphy and paleoecology of these numerous diatoms and cysts negate the likelihood of any redeposition, inset, or unconformity claim directly associated with artifact-bearing beds at Hueyatlaco. Two diagnostic Yarmouthian (430,000–500,000 yr BP) cyst assemblages (in samples VL2149 and VL2316) occur in a bed (Unit J) which is conformably below (and older) than the lowermost artifact-bearing bed (Unit I) at the Hueyatlaco archaeological site. These two samples correlate with a third diagnostic Yarmouthian sample (68M288 = VL2243) from a core 7 km NNW at Rancho Batan. The extinctions and earliest known first occurrences of the 26 extant and 8 extinct cyst taxa in the three samples (with a minimum 430,000 yr BP Yarmouthian age) corroborate a likely maximum of 430,000 yr BP for the Hueyatlaco artifacts which previously was established by means of diatom/cyst assemblages with a maximum age of Illinoian (ca. 220,000–430,000 yr BP) in Unit I.

Key words: artifacts, biostratigraphy, cysts, diatoms, paleoecology

Introduction

Two hypotheses exist for the human migration to the Americas. The more accepted one (known as Clovis First or Late Entry) advocates that humans came from Asia late in the Last Ice Age. In contrast, the second hypothesis (Early Entry) postulates that the New World was populated by several waves of migration over an extended period. In the late 1960's and early 1970's data (from Hueyatlaco) were presented that suggested that humanity was in the New World before the

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Last Ice Age. As a revolt against Clovis First orthodoxy some New World archaeological sites have been claimed to possess pre-Clovis dates and have not been fully refuted: prominent among these is Valsequillo (Hueyatlaco) (see Fiedel 2000).

At least five independent geological age estimates indicate an old, pre-Clovis age for the Hueyatlaco site: it is highly unlikely that all five of these dating techniques could greatly overestimate the age of the site, because factors which influence the accuracy of each of these techniques are very different (Naeser ex Hardaker 2007). The Hueyatlaco archaeological site (Fig. 1) is significant because age determinations by various means, e. g., micropaleontology (including diatom and cyst fossils), geology, radiometric dating, tephrochronology, and geochronology on its artifacts have placed humanity in the Western Hemisphere at a time long before (> 6 times earlier than) the Clovis First scenario. The contributions of Felix & Lenk (1893–1899), Reichelt (1899), Hus-

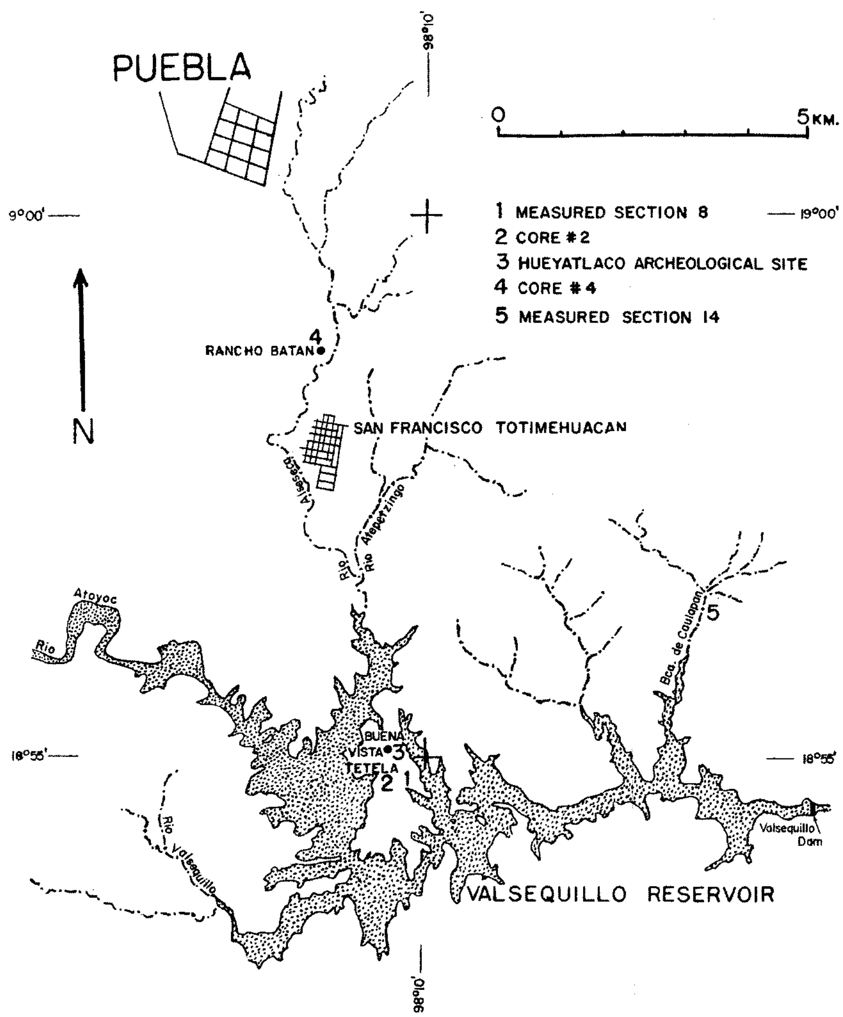

Fig. 1. Map of Valsequillo Reservoir area south of Cuidad Puebla, Mexico, showing places where diatom/ cyst deposits were sampled.

tedt (1934, 1966) and VanLandingham (2000, 2002, 2004, 2006) that use fossil cyst and diatom remains from the Hueyatlaco region, coupled with the extensive geological mapping and field investigations of Malde (1964–1973, 1968), make a very good case for the minimum age assignment of Sangamonian (*sensu lato* = 80,000–ca. 220,000 yr BP) to Illinoian (ca. 220,000–430,000 yr BP) for these artifact-bearing beds (VanLandingham 2006, 2009). The case can be enhanced by considering contributions such as those of Szabo et al. (1969) on dating rocks within the region which also denote a Sangamonian (or older) age for the Hueyatlaco artifacts.

Frequently, archaeological sites offer little specific fossil evidence to interpret the age and history of deposition. However, some American archaeological sites are well known to be associated with fossil diatoms/cysts, and archaeologists usually accept diatom/cyst age relationships (e. g., Holliday 1995, from the Clovis and Lubbock Lake sites) when they agree with the status quo of Late Entry (< ca. 11,000–12,000 yr BP) of humans in North America. But, when the diatom/cyst evidence is in disagreement, a dispute about that evidence is likely to occur. The importance of diatom/cyst dating is exemplified since dating the volcanic rocks in the Columbia Plateau of Washington using isotopic methods (i. e., K-Ar) have failed. The works by VanLandingham (1964, 1991) on the diatom and cyst fossils in non-marine sedimentary beds encased by these volcanic rocks supported the proposition that traditional micropaleontological techniques (e. g., extinct species with restricted stratigraphic ranges, dominance or acme associations) could be used to determine the age of a given fossiliferous zone. Dates supplied by diatom and cyst communities are usually in good agreement with dates derived from by other methodologies, such as the case with the Miocene/Pliocene Petaluma Formation of California (Allen & VanLandingham 2008).

Diatomaceous deposits (including diatomites) of late Pleistocene age have been known from the Puebla (Valsequillo) region for some time (see Villada 1905). In addition, extinct diatoms associated with artifacts from the Puebla region were documented over 100 years ago (e. g., Reichelt 1899). Not only do extinct diatom taxa far outnumber the extinct vertebrate and invertebrate taxa at Hueyatlaco, but fossil specimens of diatoms are probably many thousands of times more common than vertebrate and invertebrate specimens. It is likely that any one of the 22 distinct beds associated with the Hueyatlaco archaeological site has more fossil diatom taxa than all vertebrate fossil taxa from all of the beds combined (see Table 2 and Fig. 2). Chrysophytes and diatoms can complete their life cycles in a matter of a few days, and because of their great numbers and high evolutionary rates they can be much more paleoecologically indicative and age diagnostic than the less abundant, larger fossils. Unlike vertebrates, which can migrate into new localities during adverse times, cysts/diatoms usually die and are fossilized in or near the position where they lived. It is my belief that the paleoecological and age evidence from the enormous number of diagnostic cysts and diatoms should predominate over the less prolific evidence of all other fossils from Hueyatlaco. Some of the fossil evidence from Hueyatlaco agrees with the cyst/diatom evidence. For example, Maldonado-Kordell (ex Aveleyra 1964) and Malde (1966) were both inclined to accept an age for the Valsequillo fossil mammals as old as the Sangamonian. Other investigators, such as Irwin-Williams (1967, 1969, 1981) and Pichardo (1997), favored younger ages for the vertebrate fossils.

In the Valsequillo region previous investigations have used the following criteria in dating and correlating diatomaceous deposits: (1) percentage correlation factor of taxa (% of all shared taxa between any two samples under consideration with the sample containing the smallest number of taxa as the percentage base); (2) taxa extinct at the end of the Sangamonian and Illinoian; (3) earliest known first occurrences; (4) dominance/subdominance associations of taxa; and (5) pennate to centric (P:C) diatom ratios. These criteria noted are explained in detail by VanLandingham (2004, 2009). Most fossil diatom deposits include at least a few chrysophyte cysts. The first three criteria above also are useful in dating and correlating with cysts in the Valsequillo region.

The purpose of this investigation is to summarize the evidence provided by the abundance of diatom and cyst fossils at Valsequillo for a pre-Wisconsinan age (before the Last Ice Age) for the artifacts, and to supplement that evidence with a new age determination based on cyst fossils for

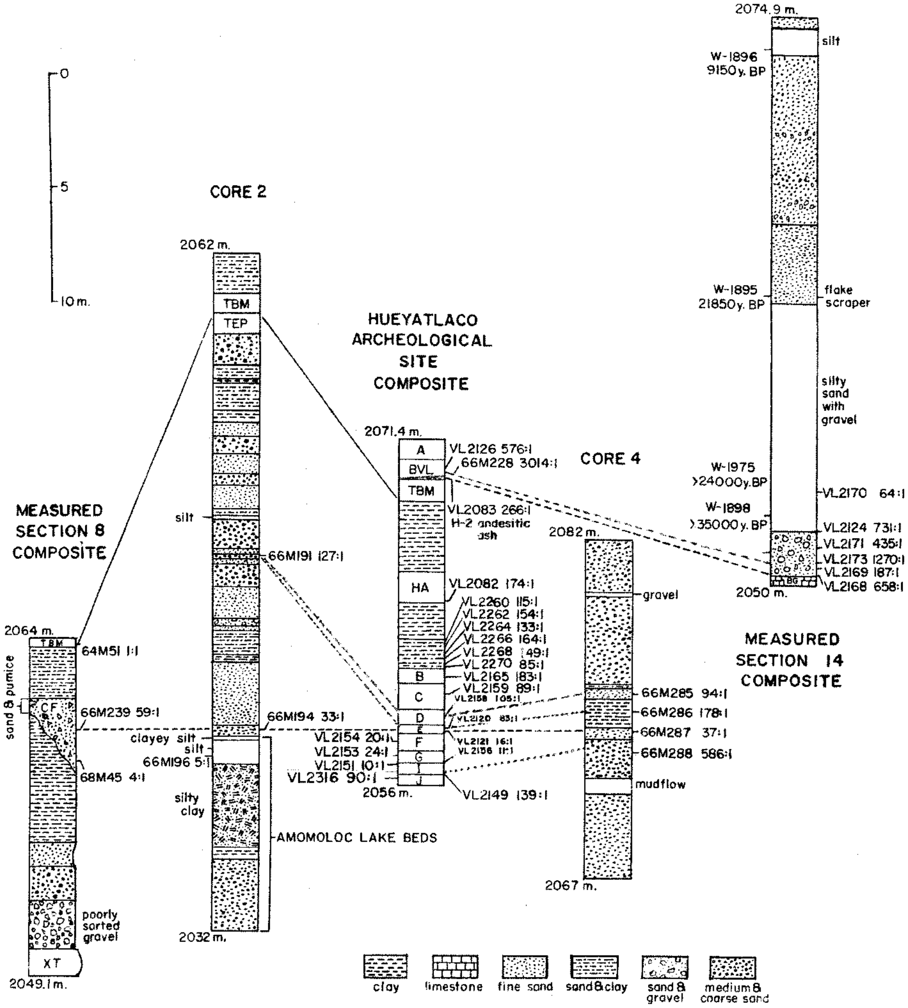

Fig. 2. Stratigraphic sections and cores (of Malde 1964–1973, 1968) in the Valsequillo Reservoir area (1–5 on Figure 1). Hueyatlaco Archaeological Site composite is modified from Steen-McIntyre et al. (1981) and Irwin-Williams (1967). Measured section 14 composite (with C^{14} dates) is modified from Szabo et al. (1969). Pennate to Centric (P:C) diatom ratio is at the right of each sample number. A-J = Irwin-Williams Units (Unit H is not shown). Base of Unit E (or time =) is the datum. BG = Balsas Group. BVL = Buena Vista Lapilli. CF = Channel Fill. HA = Hueyatlaco Ash. TBM = Tetela Brown Mud. TEP = Tepetate. XT = Xalnene Tuff. Samples in biostratigraphic correlations are described in VanLandingham (2004, 2006). Dashed lines = diatom biostratigraphic correlations. Dotted lines = cyst biostratigraphic correlations. Long solid lines = lithostratigraphic correlations.

Unit J of Irwin-Williams (1967). Unit J is a bed that is conformable under the oldest (stratigraphically lowest) artifact-bearing bed (Unit I) of Irwin-Williams (1967), and which will establish a maximum age for the artifacts at Hueyatlaco (Table 2 and Fig. 2).

Methods and Materials

All samples were prepared for microscopical examination by means of the techniques described by VanLandingham (2006). After crushing, each sample was suspended in distilled water for two hours in a 250 ml flask. To remove fine clay particles, the water was siphoned. This process was repeated three times. Each sample then was suspended in distilled water for two minutes to remove sand, silt, and larger particles. The suspension of fine material that remained in the water was poured off and allowed to settle. Excess water was siphoned and the remaining fine material (with microfossils) was allowed to dry. This dry material was scraped from the flask to make strew preparations on 18 X 18 mm cover slips which were mounted in Hyrax on 3 X 1 inch glass slides. Light microscopic examinations of two samples, VL2149 (slide numbers 4369, 4501, and 4502) and VL2316 = 04SM6/3C (slide 4478) from the Hueyatlaco site and sample 66M288 (slide 4554) from core # 4 at Rancho Batan (Fig. 1) were made. The stratigraphic positions of these three samples are shown on Figure 2. Repository of all samples and microscopical slides is the VanLandingham collection of the California Academy of Sciences, Invertebrate Zoology and Geology Department, Golden Gate Park, San Francisco, California 94118, USA.

Sample VL2149. Collected 12 June, 2001, by Virginia Steen-McIntyre at the Hueyatlaco archaeological site, E of Buena Vista Tetela, Puebla, Mexico, 7 m from SW corner of Cynthia Irwin-Williams 1966 excavation wall, in uppermost part of Unit J at the Unit J/Unit I contact, 18°55'9.6" N Lat. X 98°10'23" W Long. (Figs. 1–2).

Sample 66M288 = VL2243. Collected 19 May, 1966, by H. E. Malde from core # 4 at Rancho Batan, Puebla, Mexico, at 920–950 cm depth from coarse sand, 7 km NNW of Hueyatlaco archaeological site and 2 km N of San Francisco Totimehuacan, 18°58'53" N Lat. X 98°11"3" W Long. This sample probably corresponds to the coarse sand in Unit J of Irwin-Williams (1967) at the Hueyatlaco site. (Figs. 1–2).

Sample VL2316 = 04SM6/3C. Collected 3 June, 2004, by Virginia Steen-McIntyre at the Hueyatlaco archaeological site, E of Buena Vista Tetela, Puebla, Mexico, from Irwin-Williams Unit J, 10.6 m on M. Waters excavation interim 2004 – 4 extension profile, 18°55'9.6" N Lat. X 98°10'23" W Long. (Figs. 1–2).

Results and Discussion

Cysts (Plate 1) and diatoms have been found in 147 samples from the Valsequillo/ Hueyatlaco region (Table 2). These samples have yielded 44 extant and 39 extinct chrysophyte taxa, 467 extant and 78 extinct diatom taxa (many of which are age diagnostic marker fossils with short stratigraphic ranges), species and generic dominance/subdominance associations, earliest known first occurrences, and pennate to centric (P:C) ratios of diatoms > 80:1, all of which aid in assessing ages (and environments) of deposition to the 22 beds listed in Table 2 (VanLandingham 2000, 2002, 2004, 2006, 2009 and Covey 2002). All of the 22 Holocene, Pleistocene, and upper Pliocene deposits in the Valsequillo region have at least one diatom/cyst-bearing sample which is age diagnostic. Diatoms and cysts from these samples designate a minimum (Sangamonian) and maximum (Illinoian) age for the Hueyatlaco artifacts (VanLandingham 2009). An age later than the Sangamonian for the Buena Vista Lapilli and all underlying strata through Unit I, which

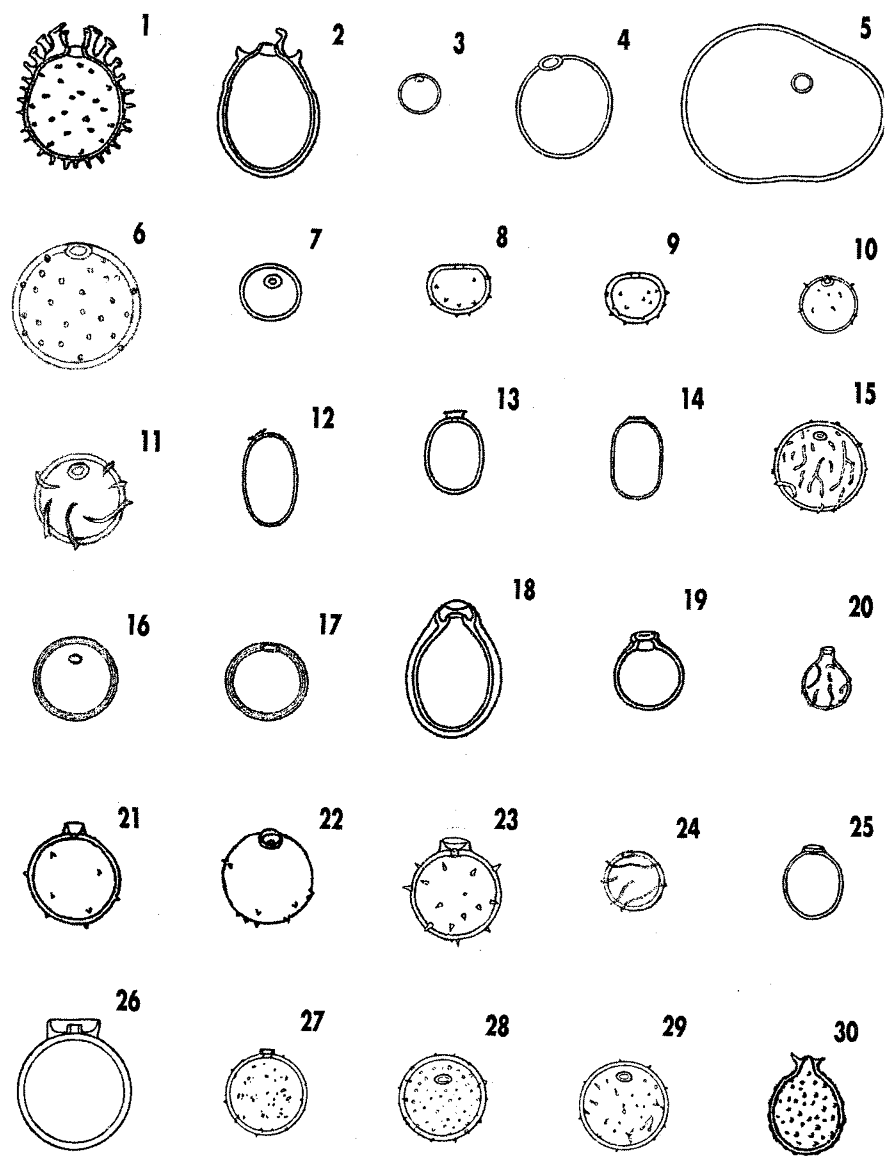

Plate 1. Extant and extinct chrysophyte cysts from samples VL2149, 66M288 = VL2243, and VL2316. Drawings are camera lucida hemispherical stereograms. Magnifications of figures 1–5, 7, 10, 12–23, 25, and 27–30 = 1500X; 6, 8–9, 11, 24, and 26 = 2400X. Extant 1–19; extinct 20–30. Figs. 1–2 and 18 are from Frenguelli (1925); 3, 10, and 15 are from VanLandingham (2002); 4 and 5 are from Frenguelli (1932); 6, 11, and 24 are originals from sample VL2149; 7–9, 12–14, 16–17, and 26 are from Nygaard (1956); 19 is from Frenguelli (1939); 20 is from Andrieu (1937); 21–23 are from Rampi (1937); 25 is from Andrieu (1936); 27–29 are from VanLandingham (1964); and, 30 is from Frenguelli (1955).

1. *Carnegia armata* Frenguelli; 2. *C. complexa* Frenguelli; 3. *Chromulina minuta* Doflein; 4–5. *Chrysostomum stanleyi* Skvortzow; 6. *Clericia granulosa* Playfair; 7. *Cysta compressa* Nygaard; 8–9. *C. depressa* Nygaard; 10. *C. microspinosa* Nygaard; 11. *C. scripta* Nygaard; 12–14. *C. teres* Nygaard; 15. *C. vermicularis* Nygaard (= Cyst type 6 of VanLandingham 1964); 16. *Dinobryon pediforme* Steinecke (= *Cysta globata* Nygaard);

Table 1. Extant and extinct chrysophyte cyst taxa from samples VL2149, 66M288 = VL2243, and VL2316.

	VL2149	66M288 =VL2243	VL2316
EXTANT CYSTS			
Carnegia armata	2		
C. complexa (= *Clericia obtecta*)	1		
C. near *frenguelli*	1		
Chromulina minuta (=*Cysta minima*)	5	3	8
Chrysostomum minutissimum	7	1	13
C. simplex	4	1	2
C. stanleyi			1
Clericia araucana v. *perlata*		1	
C. dybowski	1		
C. granulosa	2		
C. spp.	3	1	1
Cysta acetabulosa		1	1
C. compressa	3		
C. depressa			1
C. micromeles	1		
C. microspinosa	1	4	2
C. scripta	1		1
C. spp.	1	2	2
C. teres	3	1	
C. vermicularis	4		1
Dinobryon pediforme		1	
Ochromonas granularis (=*Cysta modica*)		3	1
O. nannos (=*Cysta brevis*)			2
Outesia laevis	2		
O. sphaerica	2		
Uroglena americana	1	1	1
EXTINCT CYSTS			
Clericia apollinis	1		
C. italica		1	
C. jugulata		1	
C. minuta	4		1
C. neglecta		1	1
Cysta uroglenoides	1		
Cyst type 7 of VanLandingham (1964)			2
Outesia perlifera			1
TOTAL EXTANT CYSTS	45	20	37
TOTAL EXTINCT CYSTS	6	3	5
TOTAL CYST TAXA	22	15	18
DIATOM PENNATE TO CENTRIC (P:C) RATIO	139:1	586:1	90:1

Ochromonas granularis Doflein (= *Cysta modica* Nygaard); 18. *Outesia laevis* Frenguelli; 19. *O. sphaerica* Frenguelli; 20. *Clericia apollinis* Andrieu; 21–22. *C. italica* Rampi; 23. *C. jugulata* Andrieu; 24. *C. minima* Rampi; 25. *C. neglecta* Andrieu; 26. *Cysta uroglenoides* Nygaard; 27–29. Cyst type 7 of VanLandingham (1964); and, 30. *Outesia perlifera* Frenguelli.

Table 2. Generalized composite chronology for the 22 chrysophyte cyst/diatom-bearing beds in the Valsequillo/Hueyatlaco region. Beds are in sequence with stratigraphically highest at top and lowest at bottom. Note: all chrysophyte cyst/diatom beds with early man artifacts are older than Wisconsinan. Compare with Fig. 2.

BED	STRATIGRAPHIC DEPOSIT	TOTAL SAMPLES	MAIN SAMPLE	CYST/DIATOM AGE ASSESSMENT	MAIN SAMPLE EXTANT CYST TAXA	MAIN SAMPLE EXTINCT CYST TAXA	MAIN SAMPLE EXTANT DIATOM TAXA	MAIN SAMPLE EXTINCT DIATOM TAXA	MAIN SAMPLE P:C RATIO
1	Irwin-Williams Unit A (modern soil)	3	VL2084	Postglacial, Recent	8	0	14	0	13:1
2	Barranca de Caulapan, silty sand above Bed 3	1	VL2170	Wisconsinan Glacial	1	0	37	0	64:1
3	Barranca de Caulapan, brown gravelly sand grading down into gravel (up to ca. 2 m above Balsas Group limestone)	5	VL2173	Sangamonian Interglacial	2	0	57	6	1270:1
4	Buena Vista Lapilli (BVL)	5	66M228	Sangamonian Interglacial	8	2	56	7	3014:1
5	H-2 Andesitic Ash (base of BVL)	1	VL2083	Sangamonian Interglacial	15	8	35	5	266:1
6	Tetela Brown Mud (TBM)	3	64M45	Sangamonian Interglacial	3	2	120	15	1:1
7	Diatomite at La Mata in upper Qv alluvium unit of Valsequillo Gravels	5	65M259	Sangamonian Interglacial	1	0	39	4	13:1
8	Lahar member of Valsequillo Gravels	1	66M147	Sangamonian Interglacial	3	1	59	2	19:1
9	Hueyatlaco Ash (HA)	3	VL2082	Sangamonian Interglacial	6	2	27	10	174:1
10	Unnamed beds below HA (sand grading laterally into clay)	11	VL2268	Sangamonian Interglacial	2	0	75	7	249:1
11	Irwin-Williams Unit B*	4	VL2165	Sangamonian Interglacial	3	2	145	10	183:1
12	Irwin-Williams Unit C*	4	VL2159	Sangamonian Interglacial	2	0	30	2	89:1
13	Irwin-Williams Unit D	7	VL2158	Sangamonian Interglacial	2	0	107	8	235:1
14	Irwin-Williams Unit E (top)*	22	VL2120	Sangamonian Interglacial	5	3	120	17	83:1
15	Irwin-Williams Unit E (bottom)*	21	VL2121	Sangamonian Interglacial to Illinoian Glacial	4	1	101	11	16:1
16	Irwin-Williams Unit F	7	VL2154	Sangamonian Interglacial to Illinoian Glacial	1	0	72	6	20:1
17	Irwin-Williams Unit G	13	VL2153	Sangamonian Interglacial to Illinoian Glacial	2	1	69	1	24:1
18	Irwin-Williams Unit I*	17	VL2151	Sangamonian Interglacial to Illinoian Glacial	2	1	103	7	10:1
19	Irwin-Williams Unit J	6	VL2149	Yarmounthian Interglacial	19	3	142	5	139:1
20	Atoyatenco Lake Beds	3	65M260	Preglacial Pleistocene to Nebraskan Glacial	8	1	30	5	5:1
21	Detrital interbed within the Xalnene Tuff (XT)	1	VL2346	Preglacial Pleistocene ca. 1.3 m.y.	11	4	34	6	40:1
22	Amomoloc Lake Beds	4	66M196	Upper Pliocene to Preglacial Pleistocene	24	7	35	3	5:1
	TOTAL NUMBER OF CYST/DIATOM SAMPLES	147							

* = contains artifacts

includes all Hueyatlaco artifact units (Table 2 and Fig. 2), is not possible due to the extinction of 11 cyst types (VanLandingham 2002) and 43 diatom taxa (VanLandingham 2004, 2009) by the Sangamonian. The *Cocconeis-Navicula-Synedra* and *Cocconsis-Navicula-Nitzschia-Synedra* dominance/subdominance associations are found in several samples from the artifact beds at Hueyatlaco. These associations are unknown in the fossil state after the Sangamonian, and this indicates a minimum age of 80,000 yr BP for the Hueyatlaco artifacts. The comprehensive Valsequillo/Hueyatlaco region stratigraphic relationships of Malde (1964–1973, 1968) and Steen-McIntyre et al. (1981) are confirmed by the extensive diatom/cyst biostratigraphy (Table 2). However, they are not consistent with the stratigraphies put forth by Pichardo (1997) and Gonzalez et al. (2006) who claim an age of 10,000 yr BP or less for the Tetela Brown Mud (TBM), which overlies all of the early man artifacts at the Hueyatlaco site (Table 2 and Fig. 2). The postulations that the artifact-bearing beds "are 'an inset' unconformably into an older section" and that "an unconformity separated the alluvium containing the bifacial material (Bed E and C)" on the website www.centerfirstamericans.com are not consistent with paleoecologic and biostratigraphic correlations based on diatoms and cysts (VanLandingham 2002, 2006, 2009). There is no proof of such an unconformity, because all of the evidence has been eroded away and therefore it cannot be proven.

Three samples from the TBM have 147 freshwater diatom taxa, many of which indicate deposition in environments without strong currents where redeposition is very unlikely. Diatom/cyst paleoecology and biostratigraphy offer strong evidence that redeposition or reworking of sediments is highly unlikely at Hueyatlaco. Extensive redeposition and reworking of sediments in the

Valsequillo region, as suggested by Gonzalez et al. (2006) and Pichardo (1997), was not supported by the detailed diatom/cyst data provided by VanLandingham (2000, 2002, 2004, 2006, 2009). Diatomaceous samples from artifact-bearing beds (Unit B, C, E, and I) are characteristic of communities associated with relatively still waters, and not waters of higher energy. (VanLandingham 2006, 2009).

In the 147 samples, most often, the diatoms are more age indicative than the chrysophyte cysts. But in samples VL2149 and VL2316 from the Irwin-Williams Unit J and sample 66M288 = VL2243 from Rancho Batan (which correlates with Unit J, see Fig. 2), the cysts evidently are more age diagnostic than the diatoms and denote a Yarmouthian age (430,000–500,000 yr BP). Unit J is stratigraphically below (and predates) all of the artifacts, thus indicating a maximum of 430,000 yr BP for the artifacts. These three samples yielded 8 extinct and 26 extant cyst taxa (Table 1). Extinctions, earliest known first occurrences, and dominance/subdominance associations of diatoms in samples from Unit I (the lowermost artifact-bearing unit) denote a Sangamonian to Illinoian age (VanLandingham 2009). Since Unit I rests conformably on Unit J, age diagnostic Yarmouthian cyst assemblages from Unit J would corroborate the maximum age of Sangamonian to Illinoian previously supplied by diatom studies (VanLandingham 2006, 2009) for the artifacts (Fig. 3). Evidence to support a Yarmouthian age for samples VL2149, 66M288 = VL2243, and VL2316 is supplied by two cysts, *Clericia italica* Rampi (Plate 1, Figs. 21–22) and *C. minuta* Rampi (Plate 1, Fig. 24), with extinctions by the end of the Yarmouthian, and three cysts, *Clericia granulosa* Playfair (Plate 1, Fig. 6), *C. neglecta* Andrieu (Plate 1, Fig. 25), and *Cysta scripta* Nygaard (Plate 1, Fig. 11), with earliest known first occurrences in the Yarmouthian (Fig. 3). Apparently the latest known occurrences of *Clericia italica* and *C. minuta* are in sample VL1804 from the Sappa Formation (Yarmouthian) of Hooker County, Nebraska (Bates & Biemesderfer 1960). The earliest known first occurrences of *Clericia granulosa, C. neglecta,* and *Cysta scripta* are also from sample VL1804 in the Sappa Formation of Yarmouthian age. Yarmouthian cysts from samples VL2149, 66M288 = VL2243, and VL2316 are very similar to cysts from the diatomite sample VL1804 from the Yarmouthian Sappa Formation of Hooker County, Nebraska (Bates & Biemesderfer 1960). Cysts from these three samples have a very good correlation factor of 68.0 %, 86.6 %, and 88.8 %, respectively, with VL1804 from the Yarmouthinan of the Sappa Formation.

By definition, the Centric Paucity (CP) Zone must fit at least one of the following criteria: (1) over 80:1 ratio of pennates to centrics or (2) a minimum of 18 pennate taxa with no centric taxa (see VanLandingham 2000, 2004). The CP Zone occurrences in the Pleistocene of North America are restricted to interglacial deposition in the Aftonian, Yarmouthian, and Sangamonian: e.g., in the Yarmouthian of the Sappa Formation near Mullen in Hooker County, Nebraska (Bates & Biemesderfer 1960, Elmore 1921, VanLandingham 2009). In the Yarmouthian diatomaceous deposit near Mullen, Elmore (1921) recorded a total of 61 pennate taxa and no centric forms, thus fitting well within the CP Zone criteria. Samples VL2149, 66M288 = VL2243, and VL2316 have diatom assemblages that have pennate to centric (P:C) ratios > 80:1 and which occur in the CP Zone (Fig. 2 and Table 1). These samples are from Irwin-Williams Unit J, below the series of diatom/cyst-bearing units that are not in the CP Zone, i.e., Irwin-Williams Units E (bottom half), F, G, and I (Fig. 2). These four units have cysts and diatoms that indicate an Illinoian or Illinoian to Sangamonian age. Since the CP Zone in samples VL2149, 66M288 = VL2243, and VL2316 is separated from the long series of Sangamonian CP Zone samples above by the series of Illinoian and Illinoian to Sangamonian samples which are not in this zone, it is likely that these samples belong to a Pleistocene interglacial time (i.e., Yarmouthian).

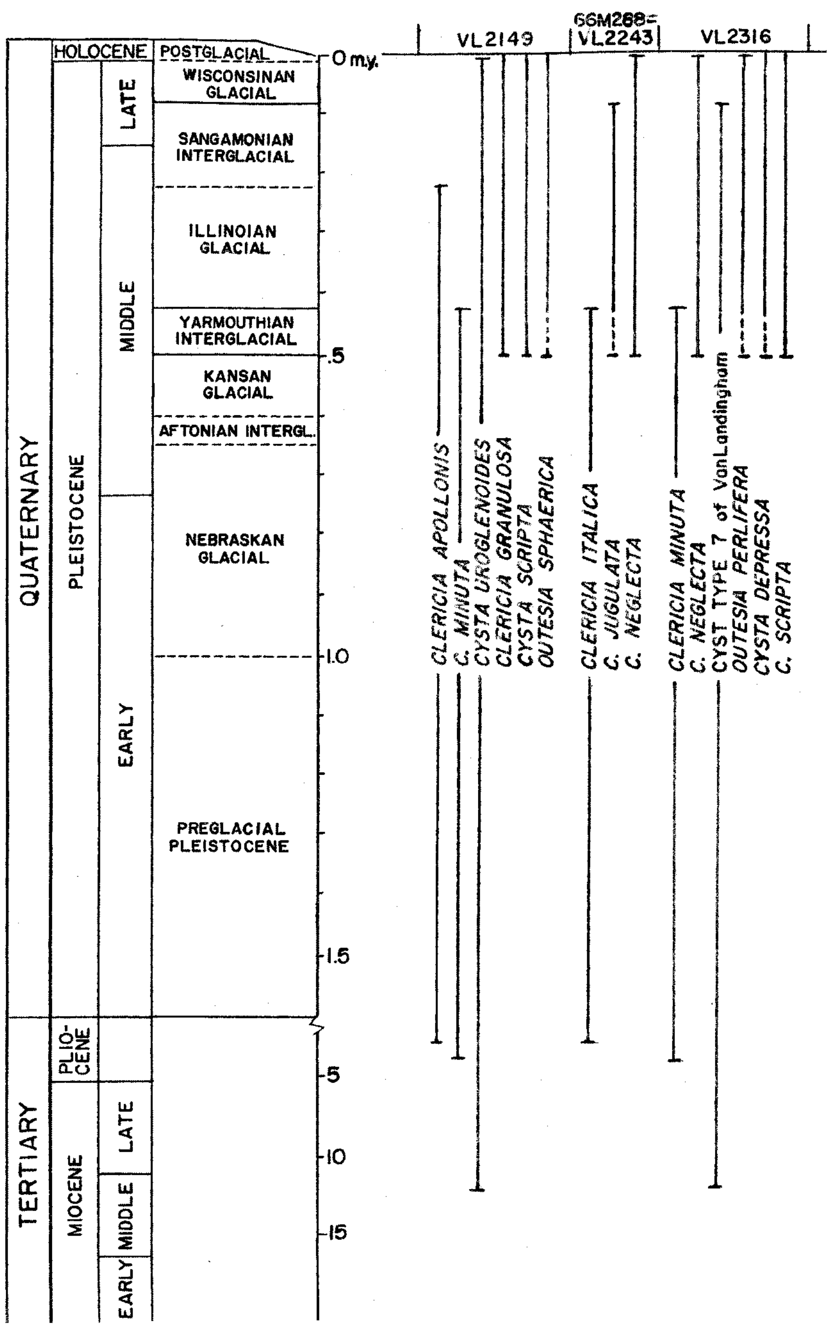

Fig. 3. Stratigraphic ranges of important chrysophyte cysts in Yarmouthian samples VL2149, 66M288 = VL2243, and VL2316. Includes all cysts extinct by the end of the Sangamonian or earlier and all extant and extinct cysts with earliest known first occurrences in the Yarmouthian Interglacial or earlier. Dashed where range is uncertain or recorded for the first time in the Yarmouthian.

Conclusions

All of the indicative diatom/cyst fossils associated with the ancient artifacts at Hueyatlaco are consistent with a Sangamonian Interglacial or older age. The evidence based on diatoms and chrysophyte cysts from this region has grown rapidly, and it is now essentially complete. The Valsequillo area has 22 distinct beds covering 30 m and representing two million years. No other archaeological site in the world is associated with such a vast variety of age diagnostic chrysophyte and diatom fossils and in such profusion. Without question, fossil evidence at Hueyatlaco has enhanced the case for the great antiquity of humanity in the New World. The extinctions and earliest known first occurrences of the 26 extant and 8 extinct cyst taxa in samples VL2149, 66M288 = VL2243, and VL2316 (all with a minimum 430,000 yr BP Yarmouthian age) corroborate a maximum of 430,000 yr BP for the Hueyatlaco artifacts.

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