J Paleolimnol (2006) 36:101–116
DOI 10.1007/s10933-006-0008-4

ORIGINAL PAPER

Diatom evidence for autochthonous artifact deposition in the Valsequillo region, Puebla, Mexico during the Sangamonian (*sensu lato* = 80,000 to ca. 220,000 yr BP and Illinoian (220,000 to 430,000 yr BP))

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Received: 21 May 2005/Accepted: 24 January 2006
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Abstract Fossil diatoms in the Valsequillo area are important in supplying adequate paleoecological evidence for the *in situ* deposition (in the absence of strong water currents necessary for the displacement and redeposition) of artifacts as large as those at the Hueyatlaco Archaeological Site. The paleoecology of lacustrine diatom-bearing samples from four nearby localities in the Valsequillo region all correlated with numerous diatomaceous samples from the Hueyatlaco Site (Puebla, Mexico) and indicate an autochthonous deposition of the artifacts at that site. This correlative evidence is consistent with a deposition in Sangamonian to Illinoian time and is based on the relationships of percentages of taxa in categories of the current, pH, and halobian spectra in six lines of correlation of samples between the Hueyatlaco Site and the four localities.

Keywords Paleoecology · Redeposition · Diatoms · Archaeology · Mexico

Introduction

Artifacts at the Hueyatlaco Site (18°55′00″ N, 98°10′00″ W) 10 km southeast of the city of Puebla (Fig. 1) are of considerable interest because of their great antiquity determined by various dating methods (including uranium-series, fission track, and fossils). However, some controversy has arisen concerning the possibility of redeposition of the artifacts (e.g., redeposition of a fossil camel pelvis associated with bifacial tools). Irwin-Williams (1967a, b) conducted extensive explorations and excavations at Valsequillo and presented reasons for the *in situ* deposition of the artifacts. Independent observers (H. M. Wormington, R. S. MacNeish, and F. A. Petersen) subsequently examined the Hueyatlaco Site in detail, and Irwin-Williams (1969) corroborated the multiple reasons they presented for the *in situ* deposition of the artifacts. Because of their frequent occurrence in the area, VanLandingham (2000, 2004) made use of fossil diatoms in determining the Sangamonian age of the artifacts at the site and presented some paleoecological evidence from diatoms for the autochthonous deposition of the Hueyatlaco artifacts. In this paper, additional diatom-based paleoecological techniques are used to provide further evidence against redeposition at Hueyatlaco.

Often important clues concerning the presence or absence of redeposition are contained in the sedimentary or stratigraphic context (matrix) of an artifact, such as associated diatoms and other microfossils. Frequently archaeological sites offer little specific paleoecological evidence to interpret the history of deposition of the sediments which contain artifacts at those sites in order to determine if

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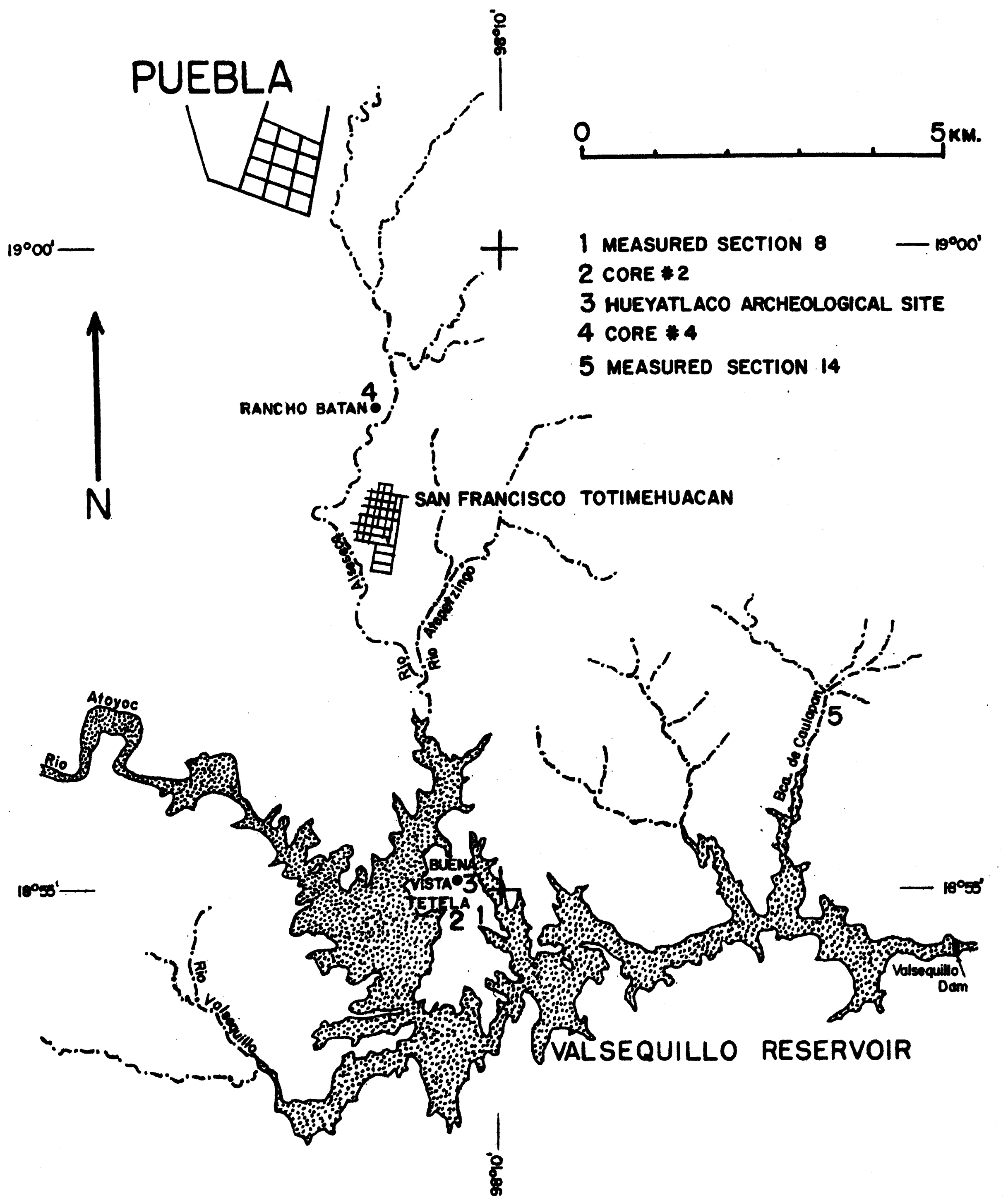

Fig. 1 Map of Valsequillo reservoir area south of Puebla Mexico, showing places where diatom-bearing deposits were sampled

those artifacts are *in situ* or allochthonous (redeposited), for example, terminal Pleistocene and early Holocene archaeological sites in the Great Basin (Huckleberry et al. 2001). Although uncommon, examples of archaeological sites with good paleoecological assessments of the depositional sequences in relation to reworking are known (Huckleberry et al. 2001). The Hueyatlaco artifacts (described by Irwin-Williams 1967a, b) are directly associated with a well developed sequence of diatom and chrysophyte microfossils in which the paleoecology is well known (VanLandingham 2000, 2002, 2004).

Unlike autochthonous deposition, problems with allochthonous deposition or redeposition at archaeological sites are manifested in three main ways: (1) older artifacts are reworked into younger sediments and strata, e.g., stone artifacts secondarily redeposited by Wisconsinan continental ice in the Peace River area, Alberta, Canada (Chlachula and Leslie 1998); (2) younger artifacts are reworked into older sediments and strata, such as the artifactual and faunal material derived from the top of the stratigraphic section and directly associated with coarse sands and gravels at the Sunshine Locality, north-central Nevada, USA (Huckleberry et al. 2001); and, (3) artifacts might be reworked, but evidence is insufficient, as in the case of the 1991 excavation and survey in the Malloura Valley, central Cyprus (Toumazou et al. 1992).

The chief purpose of this investigation is to demonstrate with diatom paleoecology that the above three problems so often associated with allochthonous (redeposited) artifacts do not apply to the autochthonous deposition of the Hueyatlaco artifacts. Diatom paleoecological evidence is provided which corroborates the correspondence of the four groups of samples listed in Table 1 (from the five localities shown in Fig. 1) along six lines of biostratigraphic correlation (Fig. 2) on the basis of: (1) taxa extinct at the end of the Sangamonian, (2) earliest known first occurrences of taxa, (3) dominance/subdominance associations of taxa, and (4) Pennate to Centric (P:C) ratios, all of which were provided in a previous diatom stratigraphic investigation (VanLandingham 2004) concerning the Hueyatlaco (Valsequillo) artifacts.

Methods and materials

All samples in this study are from the north side of the Valsequillo Reservoir, Puebla State, Mexico: repository for all samples (VanLandingham Collection) is at the California Academy of Sciences (CAS), Invertebrate Zoology and Geology Department, 875 Howard Street, San Francisco, CA 94103. After crushing, each sample was suspended in distilled water for 2 h in 250 ml flasks. To remove the fine clay particles, the water was siphoned. This process was repeated three times. Each sample was then suspended in distilled water for 2 min to remove silt, sand, 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 diatomaceous material was allowed to dry. This dry material was scraped from the flask and stored in 10 ml glass vials. Strew preparations on 18 × 18 mm cover slips were heated for 5 min at 250 °F on a hot plate and mounted in Hyrax mounting medium on 3 × 1″ glass microscope slides.

The correlations and paleoecological conditions in this investigation were based on microscopical examinations of 355 extant and 65 extinct taxa (the most important of which are listed in Table 1) from 5 localities in the Valsequillo region south of Puebla, Mexico (Fig. 1). Most terminology used in the categories of the ecological spectra (i.e., current, halobion, and pH) used in the study of the 15 samples is self explanatory or in common use, but Lowe (1974) gives detailed descriptions of each category and spectrum. In the current spectrum, taxa are described as follows: limnobiontic (characteristic only of stagnant waters); limnophilous (optimum development in stagnant waters); indifferent (common in running and stagnant waters); rheophilous (optimum development in running waters); and, rheobiontic (characteristic only of running waters). In the halobion spectrum, oligohalobous (0 to 5‰ salt content) taxa are described as: halophilous (common in freshwater, but not uncommon in slightly brackish water); indifferent (freshwater); and, halophobous (characteristic of chloride deficient water). Taxa in the pH spectrum are designated: 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 (occurring around pH 7 with optimum development above pH 7); and, alkalibiontic (restricted to pH above 7). In this study diatom taxa were assigned to the above categories on the basis of

Table 1 Percentages of dominant, codominant and subdominant taxa in the four sample groups

	Group 1				Group 2					Group 3				Group 4	
	66M228	VL2173	VL2083	VL2168	66M191	VL2158	66M285	VL2120	66M286	66M239	66M194	VL2121	66M287	VL2150	66M288
Amphora ovalis Kützing		X			1	1		X	X	1	1	X		10	8*
A. ovalis v. *affinis* Kützing								7*							
A. perpusilla Grunow								4*	X	2		2			13
A. veneta Kützing	2	3			2	2		X	X	18		X			
Cocconeis placentula v. *lineata* Ehrenberg		3		1	22	2	1	5*	30	4	5	3	16	2	5*
Cyclotella meneghiniana Kützing					1	1		1	1	X		5*		X	
Epithemia argus v. *protracta* Mayer									X			1			5*
E. turgida Ehrenberg		4		8*	X	2	8*	1	5	1	19	2	8*	4*	
Eunotia gracilis Ehrenberg			6*												
Fragilaria brevistriata Grunow					13*				2				3	X	1
F. construens v. *venter* Ehrenberg									2			5*			1
F. pinnata Ehrenberg					8*										9*
Gomphonema gracile v. *lanceolatum* Kützing			6*	2											
G. parvulum Kützing	4	1	7*		2	2	1	X	3	2		X	4	X	1
Hantzschia amphioxys Ehrenberg	14*	2	17	2	1	1	12	5*	X	X	11*	X	12*	X	4
H. amphioxys v. *vivax* Grunow			16					X			1				
Navicula cryptocephala Kützing		1		3	2	5*		6*	X	X		6*		4*	
N. cryptocephala v. *veneta* Kützing	X	1		3	X	4*		X	X	4		4*	1	10	X
N. cuspidata Kützing	7	1	6*				2	1		1				X	
N. mutica Kützing	24	2	X	4		X	8*	X	1	X	4	X	7*		2
N. pupula v. *rectangularis* Gregory	X	X	10*							1					X
N. pygmaea Kützing		X				5*			1					X	
Nitzschia amphibia Grunow		6		1	X	X		2	1	9*		2		1	
N. columbiana Sovereign								3				7*			
N. communis Rabenhorst				7*						X					
N. constricta Kützing						4*		12	X	5		X			
N. fonticoloides Sovereign								6*				2			
N. frustulum Kützing		3			3	5*	2		X	3		1		3	
N. frustulum v. *subsalina* Hustedt		26				2		1		2		2		X	
N. linearis Agardh					1			X	1			5*			
N. palea Kützing	X	X		6*		3			1	4	1	X	2	6*	
Opephora martyi Héribaud															8*
Pinnularia appendiculata Agardh			X	8*					X						
P. borealis Ehrenberg	5	X	9*				12	1	1	X	9*		8*		1

Table 1 continued

	Group 1				Group 2					Group 3				Group 4	
	66M228	VL2173	VL2083	VL2168	66M191	VL2158	66M285	VL2120	66M286	66M239	66M194	VL2121	66M287	VL2150	66M288
Rhoicosphenia curvata Kützing	2	1			X	2	5*	X	1		3	X	4	X	X
Rhopalodia gibberula Ehrenberg		X			4	X		1	5	2	3	11	2	2	1
R. gibberula v. *vanheurckii* Müller						X		1				7*			
Stauroneis anceps Ehrenberg	1		6*			X			X					X	
Synedra ulna Nitzsch	X	8	3	13	8*	8	4	3	5	4	5		2	9	2
S. ulna v. *oxyrhynchus* Kützing						4*			1			X	X	5*	5*
Total Extant Taxa	50	57	35	44	64	107	33	120	90	85	30	103	37	68	46

Extant diatom taxa in the correlated samples of group 1 through 4 shown in Fig. 2. Although 355 extant diatom taxa occur in group 1 through 4, only the percentages of the 40 taxa which are dominant, codominant, and/or subdominant in at least one sample from the four groups are listed. Sample numbers are arranged according to six lines of correlation corresponding to group 1 and 2 (each with two subgroups) and group 3 and 4, with the youngest correlation at the left to the oldest correlation at the right (Fig. 2). Group 1 has two subgroups, including 66M228 and VL2173 in the first and VL2083 and VL2168 in the second (Fig. 2). Group 2 also has two subgroups, including 66M191, VL2158, and 66M285 in the first and VL2120 and 66M286 in the second (see Fig. 2). Note: in group 2, sample 66M191 correlated not only with VL2158 and 66M285 but also with VL2120 and 66M286 (compare with Fig. 2). X = presence of taxon but with a frequency of less than 1%. Percentages which are underlined indicate dominance or codominance; percentages with asterisk (*) indicate subdominance. Based on counts of 100 diatoms in each sample

consensus from over 3,000 published works from a compilation (VanLandingham 2000). The 15 samples occur in four correlation groups involving five stratigraphic locations (Figs. 1 and 2, Table 1).

Group 1 (Hueyatlaco site—section 14)

66M228. ''Buena Vista Lapilli'' collected May 9, 1966, by Harold E. Malde from bed 13–14 cm thick, graded finer at top; Hueyatlaco Archaeological Site, in the eastern part of the town of Buena Vista Tetela; 18°55′00″ N, 98°10′00″ W.

VL2173. Collected June 16, 2001, by Sam L. VanLandingham from Barranca de Caulapan, ca. 300 m south of Puebla-Tecali road, from measured section 14 (Figs. 1 and 2); on east bank of creek; 2 m above contact with Balsas Group (limestone); 18°56′ 31″ N, 98°07′42″ W.

VL2083. Collected September 24, 1997, by Virginia Steen-McIntyre from town of Buena Vista Tetela; H-2 andesitic ash layer overlying the Tetela Brown Mud; approximately the same age as the Buena Vista Lapilli with ''superhydration curve (for water in glass vesicles) essentially equal to Hueyatlaco Ash and to Yellowstone Tephra dated 251,000 yr BP'' (see Steen-McIntyre et al. 1981); 18°55.1′ N, 98°10.4′ W.

VL2168. Collected June 16, 2001, by Sam L. VanLandingham from Barranca de Caulapan; ca. 100 m south of Puebla–Tecali road at measured section 14; on east bank of creek; 1 cm above contact with Balsas Group (limestone); 18°56′37″ N, 98°07′42″ W.

Group 2 (core 2—Hueyatlaco site—core 4)

66M191. Collected April 29, 1966, by Harold E. Malde from core 2; 0.5 km south of town of Buena Vista Tetela; coarse sand and grit (Valsequillo Gravels) at 1320 cm depth; 18°54′44″ N, 98°10′22″ W.

VL2158. Collected June 14, 2001, by Sam L. VanLandingham from Hueyatlaco Archaeological Site; east of town of Buena Vista Tetela, 6.5 m east of southwest corner of the Cynthia Irwin-Williams (1973) trench; from the median part of her unit D; 18°55′ 9.6″ N, 98°10′23″ W.

66M285. Collected May 18, 1966, by Harold E. Malde from core 4 at Rancho Batan; north side of

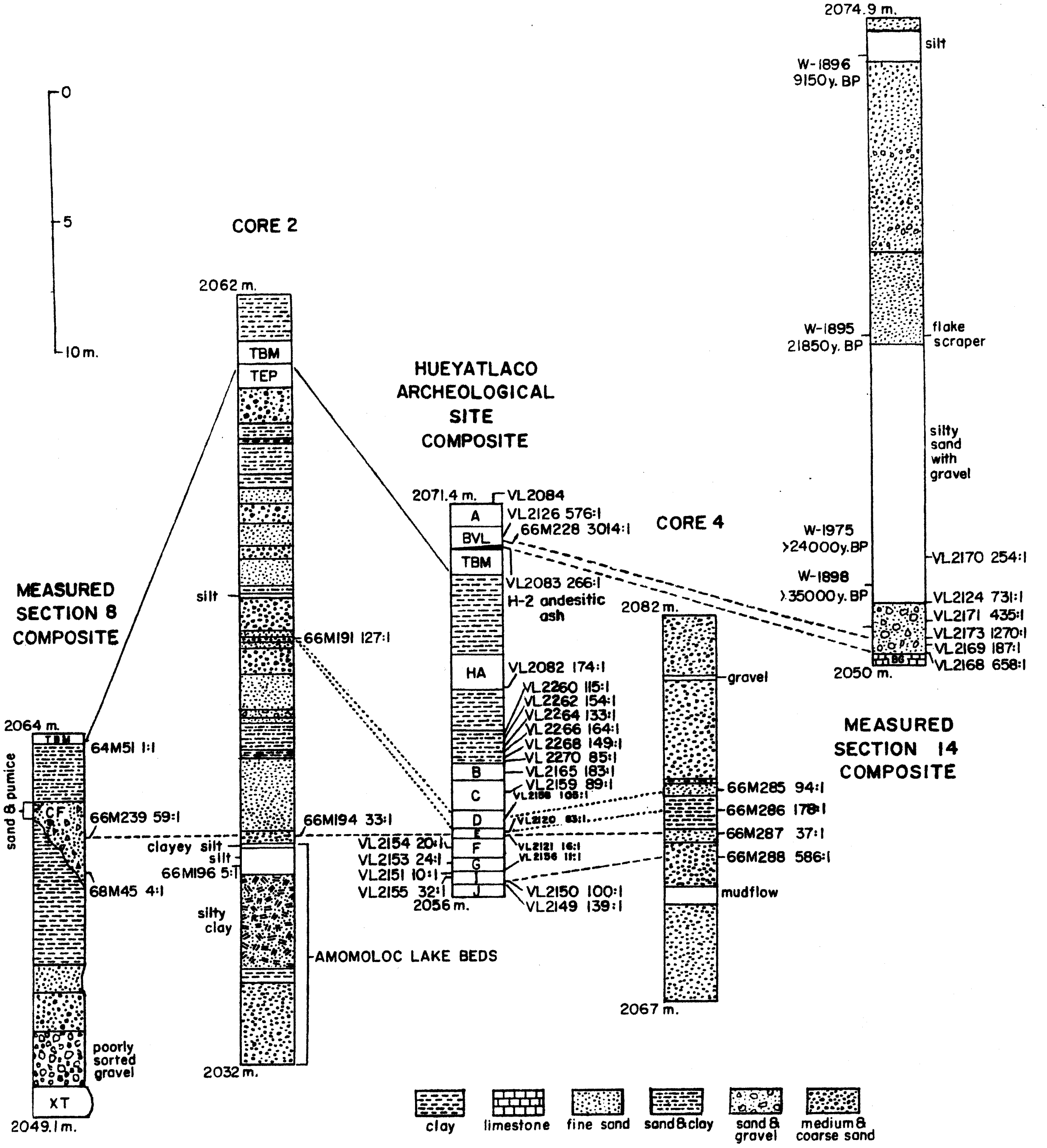

Fig. 2 Stratigraphic sections and cores of H. E. Malde (collected 1964–1973) from the Valsequillo Reservoir area (1–5 on Fig. 1). Hueyatlaco archeological site composite is modified from Steen-McIntyre et al. (1981) and Irwin-Williams (1967a). Measured section 14 composite (with ^{14}C dates) is modified 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 = Hueyatlaco 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

Rio Alseseca; 1.75 km north of San Francisco Totimehuacan; soft fine sand at 670–690 cm depth (Valsequillo Gravels); 18°58′53″ N, 98°11′03″ W.

VL2120 (= Steen-McIntyre sample 73SM19). Collected May, 1973, by Virginia Steen-McIntyre from town of Buena Vista Tetela at Hueyatlaco Archaeological Site; brown sand with occasional plant fragments; bed ca. 110–130 cm above base of channel filled with sand, ash, and fine lapilli, overlying gravel; wall B of Cynthia Irwin-Williams (1973) trench; directly associated with bifacial tools; elevation 1518 m; older than the Hueyatlaco Ash; from Irwin-Williams unit E; 18°55.1′ N, 98°10.4′ W.

66M286. Collected May 18, 1966, by Harold E. Malde from core 4 at Rancho Batan; 1.75 km north of San Francisco Totimehuacan; brittle to crumbly clay at 710–760 cm depth; 18°58′53″ N, 98°11′03″ W.

Group 3 (section 8—core 2—Hueyatlaco site—core 4)

66M239. Collected May 9, 1966, by Harold E. Malde from measured section 8; 0.6 km southeast of town of Buena Vista Tetela; lapilli in channel which occurs as massive crossfill of pumice lapilli in units B, C, and E of Cynthia Irwin-Williams (described by Steen-McIntyre et al., 1981); 18° 54′ 45″ N, 98° 09′57″ W.

66M194. Collected April 29, 1966, by Harold E. Malde from core 2, 0.5 km south of town of Buena Vista Tetela; fine to coarse brown sand at 2100 cm depth; 18° 54′44″ N, 98°10′22″ W.

VL2121 (Steen-McIntyre sample 73SM21). Collected May, 1973, by Virginia Steen-McIntyre from town of Buena Vista Tetela; Hueyatlaco site; bedded lapilli and coarse ash-rich sand in small channel, 30 cm deep by 70 cm exposed width, on fine gravel; horizon 30–55 cm above base of channel; wall B of Cynthia Irwin-Williams 1973 trench; directly associated with bifacial tools; elevation 1518 m; older than Hueyatlaco Ash; from Irwin-Williams unit E; 18° 55.1′N, 98°10.4′W.

66M287. Collected May 18, 1966, by Harold E. Malde from core 4 at Rancho Batan; 1.75 km north of San Francisco Totimehuacan; very fine sand at 830–855 cm depth; 18° 58′ 53″ N, 98°11′03″ W.

Group 4 (Hueyatlaco site—core 4)

VL2150. Collected June 12, 2001, by Sam L. VanLandingham from Hueyatlaco Archaeological Site, east of town of Buena Vista Tetela; 7 m east from southwest corner of Cynthia Irwin-Williams 1966 trench wall; Irwin Williams unit I;10 cm from top of Irwin-Williams unit J; 18°55′9.6″ N, 98°19′23″ W.

66M288. Collected May 19, 1966, by Harold E. Malde from core 4 at Rancho Batan, 1.75 km north of San Francisco Totimehuacan; compact, poorly sorted sand; 920–950 cm depth; 18°58′53″ N, 98°11′03″ W.

Comparisons with samples not in groups 1–4

In addition to those in groups 1 through 4, other diatomaceous samples from the Valsequillo region are important to this study. Four uncorrelated Valsequillo samples not associated with artifacts and not in the four groups were used for paleoecological comparisons: VL2082, VL2084, 66M196 (Figs. 2–5) and 68M45 (Figs. 2 and 3). The first two of these samples are described in detail by VanLandingham (2000, p. 83). The third sample is from the Amomoloc Lake Beds at a depth of 2150–2260 cm in core 2, 0.5 km south of the town of Buena Vista Tetela, and the last sample is from section 8, 0.5 km southeast of Buena Vista Tetela (Figs. 1 and 2).

Figure 3 shows a triangular coordinate comparison of percentages of rheophilous/rheobiontic, indifferent, and limnophilous/limnobiontic taxa in the current spectrum from the four groups of Valsequillo samples (all of which are characterized by non-fluviatile deposition and little chance of redeposition) with examples of samples (1–14) from localities of evident fluviatile environments of varying times over the world. Most of the 14 examples are clearly associated with allochthonous or secondary assemblages of reworking and redeposition, and some (such as examples 9 and 12) would have been associated with waters strong enough to carry displaced objects (pebbles, etc.) the size of artifacts and relocate them. If redeposition of objects as large as lithic artifacts had occurred at Hueyatlaco (Valsequillo), diatomaceous samples bearing those artifacts would be likely to have a position in the current spectrum which is closer to the 14 examples than to the four groups of Valsequillo

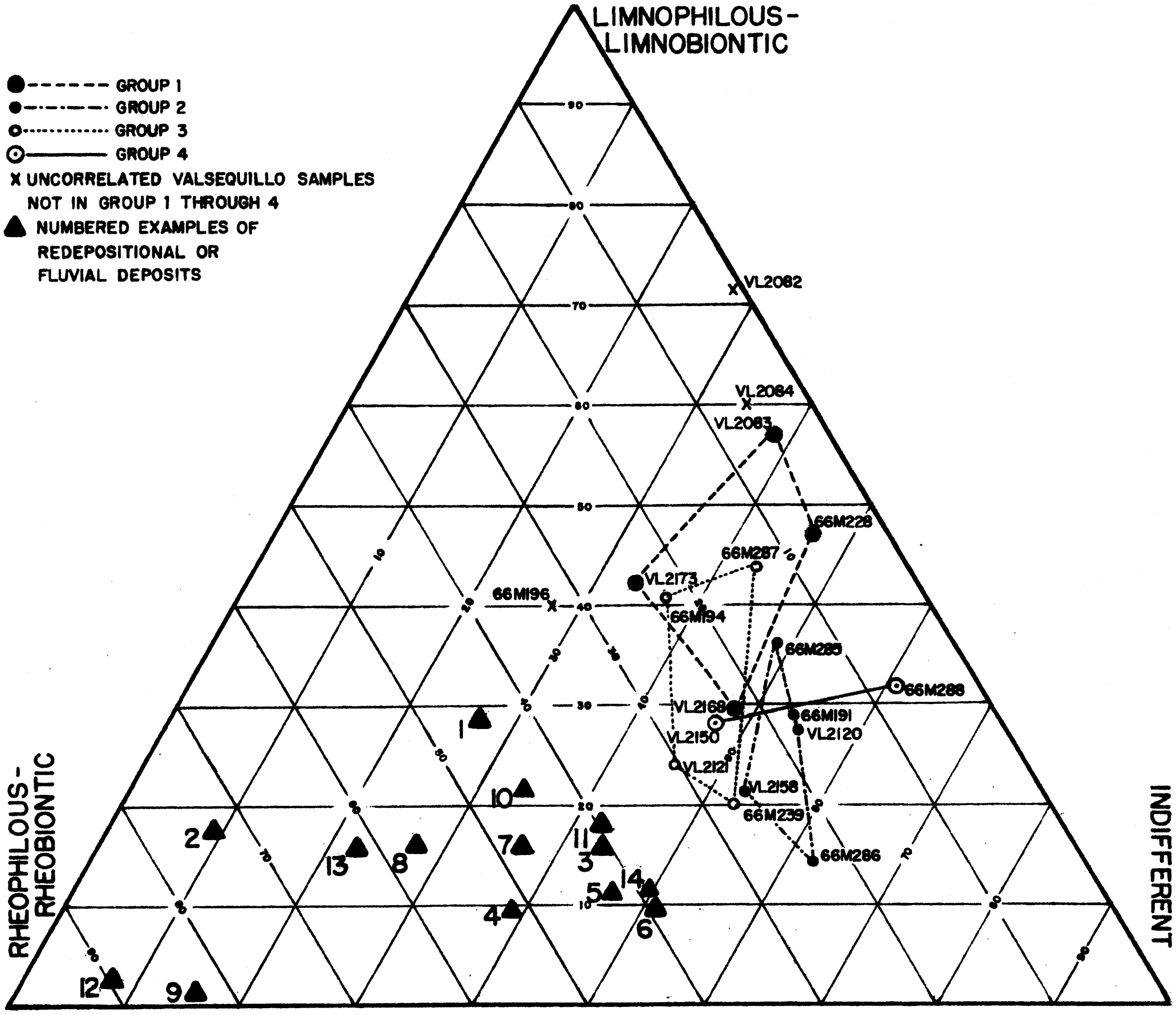

Fig. 3 Triangular coordinate comparison of percentages of rheophilous/rheobiontic, indifferent, and limnophilous/limnobiontic taxa in the current spectrum from the four groups of Valsequillo samples. Three uncorrelated Valsequillo samples (VL2082, VL2084, and 66M196) are shown for comparison

samples (Fig. 3). Examples 1–14: 1 and 2, Brander (1935), Bålen-Beckens, Sodermanland, Sweden, postglacial, samples 715 and 716 respectively; 3, Crabtree and Round (1967), Slapton Ley, United Kingdom, Subboreal (ca. 3000–400 BC), 45 cm (associated with increased flowing water and erosion); 4, Gasse (1974), Afar, Ethiopia, Holocene, sample 174; 5, Heinonen (1957), central Ostrobothnia, Finland, probably late glacial, #10 with fossils redeposited through glacial till (diatoms are allochthonous or secondary); 6. Lagerback and Robertsson (1988), Onttoharjut, Sweden, Weichselian age (>45,000 yr BP), unit E reworked in unit D; 7. Matsuoka et al. (1984), Yamagata Basin, Honshu, Japan, >31,350 yr BP, Nariyasu I 263.1 m (fluvial assemblage); 8, Matsuoka et al. (1984), Yamagata Basin, Honshu, Japan, <19,850 yr BP, fluviatile assemblage from Imazuka A 2.05 m; 9, Matsuoka et al. (1984), Yakagata Basin, Honshu, Japan, last interglacial–glacial (>29,130 yr BP), Imazuka E 46.05 m (fluvial assemblage); 10. Mölder (1945), Stubaier Alps, Austria, postglacial, sample 47; 11, Rymer et al. (1988), Lake County, California, upper Cache Formation (1.8–3.0 Ma), sample 3 (associated with pebble to cobble-sized conglomerate); 12, Schauderna (1983), Nördlinger Ries, Bavaria, Miocene, sample FBNO 73

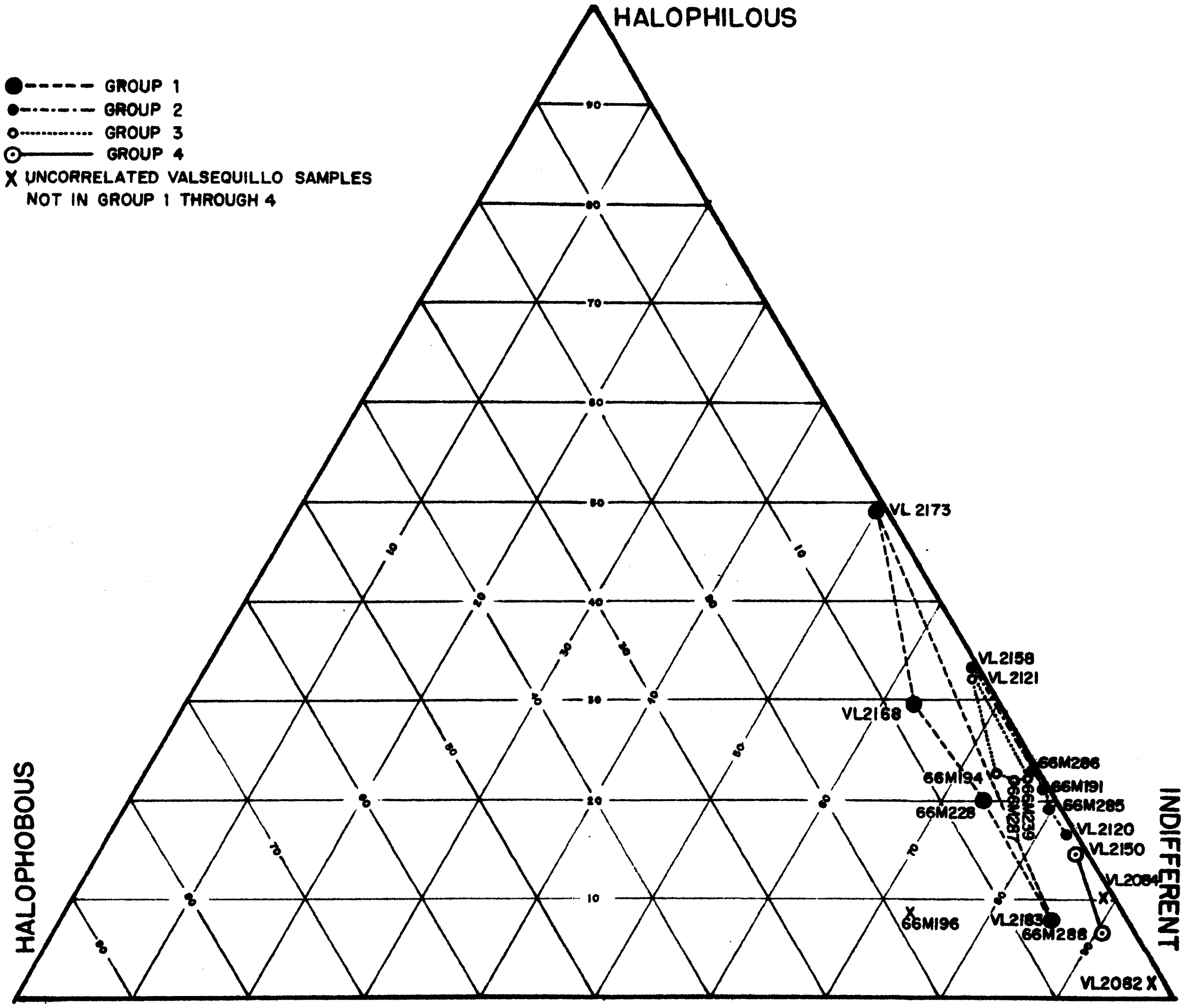

Fig. 4 Triangular coordinate comparison of percentages of halophobous, indifferent, and halophilous diatom taxa in the halobion spectrum from the four correlated groups of Valsequillo samples. Three uncorrelated Valsequillo samples (VL2082, VL2084, and 66M196) not in groups 1 through 4 are shown for comparison

IV 36.6 m; 13, Servant-Vildary (1982), Ichu Kkota glacial valley, Bolivia, late Holocene to ca. 15,000 yr BP, Khara Kkota core at 85 cm (associated with moraines and last deglaciations with glacial runoff and reworking by meltwater streams); and, 14, sample 68M45 from the base of the channel fill (with gravel) in measured section 8 (Fig. 2).

Results

Redeposition and reworking

Many such authorities as Loseva (2001) use the 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. Metcalfe and Hales (1990) used the presence of well-preserved diatoms to support their interpretation of the site in the central Mexican Highlands of Guanajuato as a low energy, stabilized catchment environment. Valve and frustule preservation is very good in all of the Valsequillo samples in group 1 described by VanLandingham (2000, 2004) and in the 15 samples listed in Table 1. In all of the group 1 samples from Valsequillo (CAS 191090, VL1972, VL2082, and VL2083) of VanLandingham (2000; 2002) from

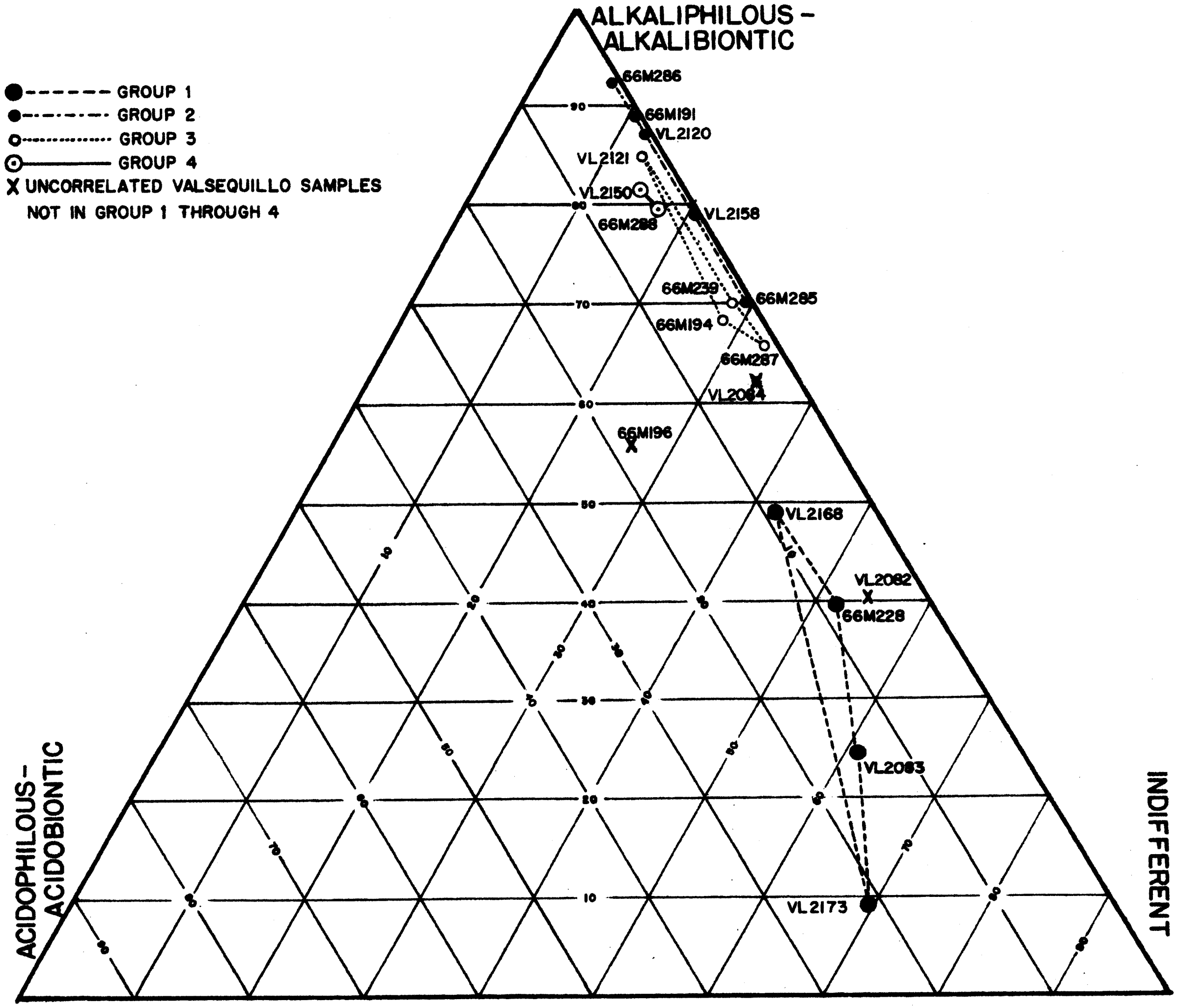

Fig. 5 Triangular coordinate comparison of percentages of acidophilous/acidobiontic, indifferent, and alkaliphilous/alkalibiontic taxa in the pH spectrum from the Valsequillo group 1 through 4 samples. Three uncorrelated Valsequillo samples (VL2082, VL2084, and 66M196) not in groups 1 through 4 are shown for comparison

Valsequillo, limnobiontic 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. Moreover, no evidence of redeposition was found in the four groups of correlated samples from the Valsequillo region. Redeposition involving artifacts as large as those at the Hueyatlaco archaeological site would be associated with evidence of very coarse sedimentation (i.e., gravels and pebbles, etc.), such as that found at the Sunshine Site by Huckleberry et al. (2001). Although rare, coarse depositions of gravels and pebbles are known in the Valsequillo region, but they are not found in direct association with the Hueyatlaco Archaeological Site composite (see Fig. 2), and the likelihood of redeposition of the Hueyatlaco artifacts must be discounted. Sample 68M45 (section 8 in Fig. 2; example 14 in Fig. 3) had more fragmented diatoms than any of the other Valsequillo samples: this sample probably was directly associated with high energy water and was redeposited, unlike the other Valsequillo samples from the four groups in Fig. 3. Sample 68M45 compared favorably with other examples of redeposition and/or high energy water deposits from lotic (rheophilous/rheobiontic) environments from various times and places over the world (compare example 14 with 1–13 in Fig. 3). Of all of the numerous diatomaceous samples from the five localities shown in Fig. 2, sample 68M45 is the only one associated with environments favorable for redeposition of objects as large as the Valsequillo artifacts. Even though section 8 has diatomaceous samples, no artifacts are known from the area associated with this locality (Fig. 2).

Current, halobion, and pH spectrum relationships

Prominent redeposition of gravel-sized particles or larger is most likely when the percentage of taxa in the rheophilic/rheobiontic categories of the current spectrum compose greater than one third of the total assemblage (examples 1–14 in Fig. 3), VanLandingham, personal observations. None of the correlated diatomaceous samples of the four groups from the Valsequillo region fit this condition. These four groups of samples from the Valsequillo region have considerable overlap with each other in relation to the percentages of rheophilous/rheobiontic, indifferent, and limnophilous/limnobiontic taxa (Fig. 3). All of the samples in these four groups have considerably less than 1/3 of the percentages of taxa which are in the rheophilous/rheobiontic category, indicating that fluviatile or lotic water of high energy did not predominate the depositional environment. Although some of these assemblages appear to be influenced by lotic environments, none display rheophilous or rheobiontic characteristics strong enough to categorize them as associated with currents swift or constant enough to cause noteworthy displacement or transport and relocation (redeposition) of artifacts as large and heavy as those at the Hueyatlaco Archaeological Site.

Diatoms which are dominant/subdominant in most of the samples of the four groups are predominantly indifferent with respect to the current spectrum: e.g., *Cocconeis placentula* v. *lineata* Ehrenberg (Foged 1954; Haworth 1976) (Plate 1:9; Table 1); *Navicula (Luticola) mutica* Kützing (Foged 1948, 1959; Mori 1999) (Plate 1:23; Table 1); and, *Pinnularia borealis* Ehrenberg (Foged 1948, 1954; Haworth 1976) (Plate 1: 28–31; Table 1). Many diatoms which commonly occur in the four sample groups are predominantly limnophilous/limnobiontic, e.g., *Fragilaria (Staurosira) construens* v. *venter* Ehrenberg (Foged 1948, 1954) (Table 1), *Nitzschia frustulum* Kützing (Foged 1948, 1954; Haworth 1976) (Table 1), and *Stauroneis anceps* Ehrenberg (Haworth 1976) (Table 1). In Fig. 3, examples 1–13 from redepositional and fluviatile environments are dominated/subdominated by many such diatoms as: *Ceratoneis (Hannaea) arcus* Ehrenberg (rheophilous according to Mori 1999, or rheobiontic according to Hustedt 1957); *Diatoma hiemale* v. *mesodon* Ehrenberg (rheobiontic according to Hustedt 1957); *Melosira (Aulacoseira) italica* v. *valida* Grunow (rheophilous according to Shirshov 1933); and *Meridion circulare* Greville (rheophilous according to Foged 1959 and Mori 1999), e.g., in examples 3, 5, 7, and 13 of Fig. 3. These four taxa are examples of diagnostic rheophilous/rheobiontic diatoms and none of them are found in any of the four groups of correlated samples from the Valsequillo region.

Figure 4 indicates group 1 through 4 samples form four distinct, isolated patterns and correspond to each of the four sample groups in the halophobous, indifferent, and halophilous subcategories of oligohalobous diatom taxa in the halobion spectrum. All samples in the four correlated groups are predominantly indifferent: such taxa as *Eunotia gracils* Ehrenberg (described as halophobous by Fjerdingstad 1954) are few and are found mainly in group 1 (Table 1). Samples in group 2 are less halophobous than those in the other three groups (Fig. 4). *Hantzschia amphioxys* Ehrenberg (Plate 1:17–19) is the only diatom found in all samples of all four groups (Table 1), and it is described as indifferent by Herbst and Maidana (1989).

In Fig. 5 percentages of the taxa in the samples in each of the four groups form four distinct, isolated patterns on the basis of their pH characteristics expressed in triangular coordinates. Figure 5 demonstrates that the samples in group 1 are considerably more indifferent and acidophilous/acidobiontic than those in the other three groups. In the four groups, such taxa as *Eunotia pectinalis* Dillwin, described as acidophilous by Ehrlich (1973) and Przybyłowska-Lange (1981), are few and occur mainly in group 1 samples (Fig. 5). Such taxa as *Navicula (Luticola) mutica* (Plate 1:23), which are described as predominantly pH indifferent by Hustedt (1957) and Herbst and Maidana (1989) are more prominent in group 1 than in the other three groups (Table 1, Fig. 5). Many such alkaline taxa as *Rhopalodia gibberula* Ehrenberg, described by most

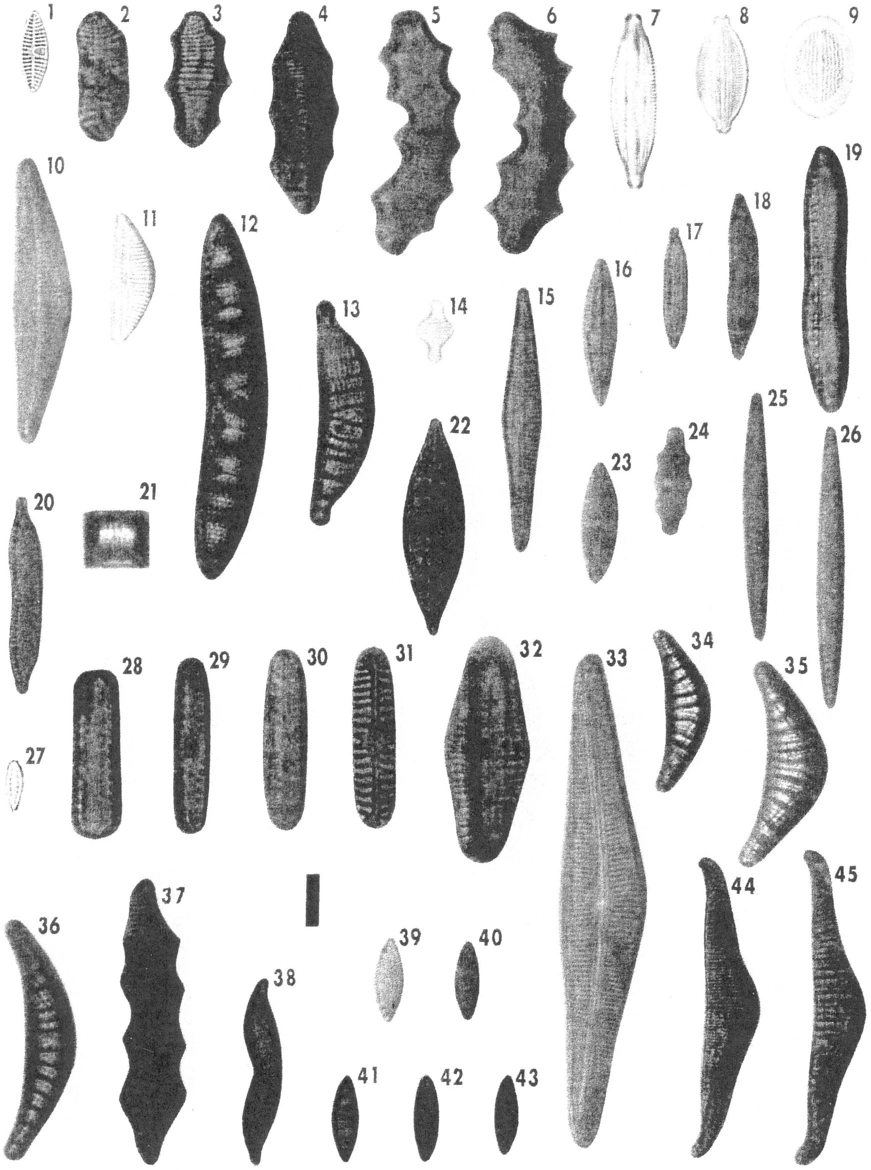

Plate 1. Extant (1–32) and extinct (33–44) diatoms all of which are from group 1 through 4 samples, except those from VL2082 which is an uncorrelated sample stratigraphically between groups 1 and 2 (see Fig. 2). Valve views unless otherwise specified. Magnification × 700, black bar = 10 μ. 1 and 2, VL2121; 2–4, 13, 16, 18–20, 22, 24, 28–32, and 44–45, VL2082; 5–6, 8, 11, 15, 17, 23, and 33, VL2083; 7, 66M228; 9, 66M286; 10, VL2150;12, 66M194; 14, 27, and 37–38, 66M288; 25, 41, and 42, VL2173; 26 and 43, VL2168; 34, 66M191; 35–36, 66M285; 39, VL2158; and, 40–41, VL2120. 1, *Achnanthes lanceolata* v. *rostrata* Östrup, raphaeless valve; 2–4, *Amphicampa (Eunotia) eruca* Ehrenberg; 5–6, *A. mirabilis* sensu Ehrenberg; 7–8, *Amphora coffeaeformis* Agardh; 9, *Cocconeis placentula* v. *lineata*;10, *Cymbella affinis* Kützing; 11, *C. ventricosa* Agardh; 12, *Epithemia argus* Ehrenberg; 13, *E. zebra* v. *porcellus Kützing*;14, *Fragilaria (Staurosira) construens* Ehrenberg; 15, *Gomphonema gracile* v. *lanceolatum*;16, *G. parvulum*; 17–19, *Hantzschia amphioxys*; 20, *H. amphioxys* v. *capitata* Müller; 21, *Melosira (Aulacoseira) distans* Ehrenberg; 22, *Navicula cuspidata* Kützing; 23, *N. (Luticola) mutica*; 24, *N. (Luticola) mutica* v. *cohnii* Hilse; 25–26, *Nitzschia denticula* Grunow; 27, *Opephora martyi*; 28, *Pinnularia borealis*, girdle view; 29–31, *P. borealis*; 32, *Rhopalodia gibba* v. *ventricosa* Kützing; 33, *Cymbella cymbiformis* v. *producta* Pantocsek; 34–36, *Epithemia cistula* v. *lunaris* Grunow; 37, *Eunotia serpentina* v. *transsilvanica* Pantocsek; 38, *Hantzschia amphioxys* v. *karelica* Cleve-Euler; 39–43, *Nitzschia denticula* v. *pliocenica* Frenguelli; and, 44–45, *Rhopalodia gibba* v. *iugalis* Bonadonna

authorities (e.g., Foged 1959) as alkaliphilous, and *Amphora ovalis* Kützing, which is alkalibiontic (according to Ehrlich 1973), are much more common in groups 2, 3, and 4 (Table 1, Fig. 5).

Many samples from the Valsequillo region occur stratigraphically below (such as 66M196), between (such as VL2082), and above (such as VL2084) correlated samples in group 1 through 4 (Fig. 2). The paleoecology of diatoms in these uncorrelated samples is not closely related to that of the correlated samples in group 1 through 4, particularly with respect to the current, halobion, and pH spectra (Figs. 3–5 respectively). These samples show no paleoecological or lithostratigraphic similarities to the samples in group 1 through 4 (see Figs. 2–5).

Discussion

Those who favor the late arrival (very late glacial or postglacial) of humans into the New World often claim that no American sites exist to support the early arrival scenario. They claim that evidence associated with purported early sites is flawed and that either the associations of human artifacts and early dates are inconclusive or the deposits are mixed and disturbed (Bryant 1992). Unlike some well documented examples, such as the Burnham site in northwestern Oklahoma, USA (Wyckoff et al. 2004) which utilized detailed stratigraphic, pedological, sedimentary, paleontological, and chronological analysis, evidence for disturbed or relocated (redeposited) artifacts often is speculative or lacking. In spite of being redeposited, the stone artifacts at the Burnham site were considered as evidence of humans in North America well before the full Wisconsinan glaciation.

Evidence of redeposition or reworking of diatomaceous 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. Many excellent demonstrations of this can be found in such references as Loseva (2001) which describes five distinct phases of redeposited fragments of fossil marine (but no corresponding freshwater) diatoms in the Neopleistocene of the East European Platform and KomiVychegda Region of Europe.

In my experience from over 2,500 freshwater fossil diatom deposits, 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 the older allochthonous fossils are believed to have originated in similar, preexisting freshwater environments. Allochthonous marine diatoms were very rare, if present at all. Mixtures of diverse diatom forms from deposits with 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, for example, at Onttoharjut in northern Sweden (Lagerback and Robertsson 1988).

Prominently redeposited, reworked, or allochthonous diatom assemblages are not common in higher elevations of tropical regions (like those of Valsequillo). Paleoecological evidence of high energy or fluviatile water is not rare in mountainous areas of central Mexico, such as the Valsequillo region and the Charo-Morelia sub-basin of Michoacán (Israde-Alcantara and Garduño-Monroy 1999), but deposits from these lotic environments (containing rheophilous/rheobiontic assemblages) in alpine regions usually are not large and frequently are carried to lower elevations by later lotic waters, floods, etc. Often these lotic deposits are associated with ephemeral fluvial currents (vide Israde-Alcantara and Garduño-Monroy 1999). Usually there is little or no evidence of redeposition by rivers, because the high energy waters of mountainous river systems eventually destroy or obscure most, if not all, of their own redepositions (especially in high elevations and in intermontane areas, like those in the Valsequillo-Hueyatlaco region). Although crenophilous diatomaceous deposits (associated with postglacial springs) are not rare, very few pre-Holocene strata are known to have diatom assemblages in which fluviatile or lotic (rheophilous and rheobiontic) species predominate.

In the Valsequillo region of Puebla, redepositions of varying magnitudes have been reported, such as the very fine biotite-bearing pumices or ashes transported and redeposited in the Valsequillo area by the Alceseca River (Cornwall 1971) and the reworked chunks of pumice in the Tetela Brown Mud (Fig. 2) at Hueyatlaco reported by Steen-McIntyre (1985), but evidently none are known to be directly associated with artifacts. Another example of redeposition by currents swift enough to relocate large artifacts can be found in the northwest part of Barranca Caulapan (see Fig. 1) (Bunde 1973, Profil 189). These allochthonous fossil remains (e.g., large bison skull fragments) are not associated with artifacts and are younger and stratigraphically higher than the artifacts in the Hueyatlaco section (Fig. 2). According to Irwin-Williams (1973), Hueyatlaco unit A, the youngest and uppermost in the sequence (Fig. 2), produced pottery, tiny fragments of redeposited fossil bone, and glass, but diatoms indicated that such redeposition is absent in relation to the older artifact-bearing units C, E, and I (see Figs. 2 and 3).

Usually little or no geochronological, paleoecological, or sedimentological evidence is presented for the relocation of artifacts by those who argue that redeposition has occurred. Steen-McIntyre et al. (1981) reported fission track dates of 600,000 ± 340,000 yr BP for a camel fossil in the Tetela Brown Mud at Hueyatlaco (Valsequillo) while Pichardo (1997) argued that the fossil cannot be older than 10,000 yr BP, on the basis of faunal zones, and proposed that fossils from zone III (Bunde, 1973) were redeposited in zone II. Such a redeposition at Hueyatlaco is doubtful because: (1) redeposition of a bone as large as a camel pelvis (associated with bifacial tools) would require high energy water as that associated with very coarse sedimentation (pebble to cobble size or larger) which, according to the diatom paleoecology, is absent in the artifact-bearing beds (Irwin-Williams units C, E, and I in Figs. 2 and 3); and, (2) the camel pelvis dated by U-series at 245,000 ± 40,000 yr BP (Steen-McIntyre et al. 1981) at Hueyatlaco was part of an articulated skeleton. If this bone were over 10 times the age of its enclosing sediments and had been relocated by waters swift enough to carry it away, it would not have remained articulated.

On the Center for the Study of the First Americans web site, www.centerfirstamericans.com, the Hueyatlaco, Mexico item under the topic of research states, ''An unconformity separated the alluvium containing the bifacial material (Bed E and C).'' In the group 3 samples, the direct NNW-SSE line of correlation between 66M239 and VL2121 (Fig. 2) passes through this alleged unconformity (in the north end of the 2004 excavation) at Hueyatlaco. In the group 2 samples, the direct NE-SW line of correlation between 66M191 and VL2120 (Fig. 2) passes within 2 m of the questionable unconformity. Samples VL2120 and VL2121 are less than 2 m from the alleged unconformity. Samples 66M239 and VL2121 (group 3) and samples 66M191 and VL2120 (group 2) also are closely related ecologically to each other as well as to other samples in groups 2 and 3, in relation to the current (Fig. 3), halobion (Fig. 4), and pH (Fig. 5) spectra. Diatom correlations and paleoecology of samples from groups 2 and 3 would negate the likelyhood of the nearby ''unconformity'' which would be associated with an interruption in the deposition and the associated paleoecology of the samples.

Conclusions

I conclude that current and previous examinations show that diatom fossils associated with the ancient artifacts of the Valsequillo region are present in the correct places (and absent from the places where they should not occur) to be consistent with a Sangamonian Interglacial to Illinoian Glacial age. Because of their abundance, wide distribution, small size, and short life span, diatoms leave us with a good record of their environmental conditions when and where they were alive, as previously shown by many investigators, including VanLandingham (2000, 2004) in the Valsequillo region.

The Irwin-Williams artifact bearing units (C, E, and I) exposed at Hueyatlaco underlie (are older than) a stack of sediments including three small, local stratigraphic units of very restricted outcroppings which include: (1) Buena Vista Lapilli, (2) Hueyatlaco Ash, and (3) unnamed beds of sand grading laterally into clay (Fig. 2). The last unit has abundant diatom fossils of Sangamonian age through most of its 140 cm thickness (samples VL2260 through VL2270), which overlies unit B (Figure 2). Also, Sangamonian diatoms were described by VanLandingham (2000, 2004) from the Hueyatlaco Ash and from what was then thought to be the Buena Vista Lapilli but which is now considered to be the closely related H-2 andesitic ash (Group 1, sample VL2083, see Fig. 2). Since all three of these small, younger stratigraphic units (which overlie the artifact-bearing units) have diatoms which are of Sangamonian age and since the diatom paleoecology of the older, artifact-bearing units of Sangamonian (to Illinoian) age indicates relatively still water (i.e., lacustrine) deposition (with little or no chance of waters swift enough to cause the displacement of artifacts as large as those at Hueyatlaco), a Sangamonian (to Illinoian) age for the artifacts is warranted (VanLandingham 2004).

Acknowledgments The author is very grateful to Virginia Steen-McIntyre for comments, observations, literature search, encouragement, support, and for acting as a repository for the core samples, field samples, notes, records, correspondence, etc. of several investigators (including H. E. Malde, C. Irwin-Williams, and herself) from several years of field work in the Hueyatlaco/Valsequillo region. Aid by her and Mexican colleagues at INAH (Instituto Nacional de Antropología e Historia) and UNAM (Universidad Nacional Autonoma de México), including Ana Lillian Martin del Pozzo, Patricia Ochoa, Joaquín Arroyo, Adrian Baker, and Mario Perez Campa, on this Hueyatlaco archeological project has been very helpful. The author also wishes to thank H. E. Malde, Elisabeth Fourtanier, Robert McKinney, and Cyclone Covey.

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