The Sundance Energy Project Monitoring and Excavation Near Coolidge, Arizona

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APPENDIX C

C.0 Micropaleontology

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The goal of understanding human activity and environmental impact through time has encouraged interdisciplinary research that combines the efforts of archaeologists, geologists, and other scientists. Hohokam irrigation canals are important archaeological features because of their potential sociopolitical implications (Howard 1993; Wittfogel 1957). The physical and paleontological attributes of historical-period and prehistoric canals contribute to the understanding of the organization of this ancient group in central Arizona. Over the past 20 years, much progress has been achieved regarding the history of Hohokam canals through investigations that combined sedimentologic, stratigraphic, and paleontologic studies (Ackerly and Henderson 1989; Anderson et al. 1994; Howard and Huckleberry 1991; Masse 1981; Shaw 2001).

From the paleontological perspective, the presence of subfossils (organisms in the process of fossilization less than 10,000 years old) in the geoarchaeologic record is an important source of information that can be used to reconstruct ancient environments occupied or affected by humans. Among the most useful organisms found in geoarchaeological sites are ostracodes (microcrustaceans), mollusks, vertebrates, pollen, and botanical remains. Each one of these groups leaves an imprint in the record that may be deciphered to evaluate how humans used and affected the milieu. Ostracodes and mollusks are addressed in this study.

Palacios-Fest (1989, 1994, 1997a; Adams et al. 2002; Palacios-Fest et al. 2001) has extensively used ostracodes to reconstruct canal hydraulics, water chemistry, and likely seasonal operations. Ostracode research has proved to be a strong tool in understanding the dynamics of Hohokam irrigation systems. Through ostracode studies, it has been possible to estimate canal flow rates, length of canal operation, and effects of seasonal variation in water flow. For example, according to Delorme (1989), *Limnocythere taplini* is commonly found in fine sediments, suggesting slow-flow waters—either permanent or ephemeral—within a wide salinity range (euryhaline: 500–75,000 mg L^{-1} total dissolved salts [TDS]). *Candona atzcuaro* is more tolerant of coarser sediments (up to medium sand), suggesting medium flow waters, and is somewhat tolerant of moderate salinity (euryhaline: 200–5,000 mg L^{-1} TDS) but requires longer water permanence than *L. taplini*. *Cypridopsis idua* and *Ilyocypris bradyi* are also euryhaline (100–4,000 mg L^{-1} TDS) species. The first is associated with seepage or flowing waters. The second, common in fluvial environments, is tolerant of relatively fast streamflow. *Cyprinotus glaucus* is also euryhaline (100–10,000 mg L^{-1} TDS) and is limited to slow-flow to stagnant waters. These three species are common in a broad range of sediments, from clay to medium sand (Palacios-Fest 1997a).

Mollusk analyses are also a powerful tool in reconstructing historical-period and prehistoric canals in the Southwest. Bequaert and Miller (1973) provided a detailed species list of gastropods that indicates the species distribution from Texas to California. Miksicek (1989, 1995) and Vokes and Miksicek (1987) have described the mollusk population of Hohokam canals and its autoecology to evaluate the impact of human activity on the environment in central Arizona. More recently, Adams et al. (2002), in a modern analog study conducted along the middle Gila River (Sacaton, Arizona), established the modern presence of mollusks in natural and man-made settings. For example, *Helisoma tenue*, an aquatic planorbid, is currently present at relatively high elevations (2,000–3,000 m) but is assumed to have been common at lower elevations in the past. This species inhabits standing waters and fine sediments and is tolerant to relatively long periods of desiccation (up to 2 months). *Physa virgata*, a pulmonate, is a widespread species present in all types of sediments but is more common in fine sediments (silty clay and clay). It also prefers standing waters and tolerates long periods of desiccation. These two species are formed either in permanent or ephemeral water bodies.

The purpose of this study was to analyze the faunal relationship between two different invertebrate groups (crustaceans and mollusks) and to determine how their respective signatures can be used to understand Hohokam canal hydraulics and periodicity of operations.

C.1 Study Locale

The Canal Casa Grande system was fed by the Gila River, which is characterized by a broad concentration of TDS ranging between 300 mg L^{-1} to more than 3000 mg L^{-1} throughout the year (Hem 1985). Water follows Types 1 and 2 of Eugster and Hardie's (1978) pathways. That is, water chemistry fluctuates from dilute (Ca^{2+}, [Mg^{2+}], and HCO_3^--dominated water; typically freshwater or very low salinity conditions) to Ca^{2+}-enriched/HCO_3^--depleted water (additionally containing Na^+, Mg^{2+} and SO_4^{2-}, or Na^+, Mg^{2+} and Cl^-; ranges from low salinity to hypersaline conditions). The Na^+, Mg^{2+}, and Cl^- pathway dominates the Gila River stream (Hem 1985).

C.2 Materials and Methods

Nineteen sediment samples from strata associated with three canals and nine distinct channel episodes were studied (Table C.1). Samples collected from specific points at four profile locations (1, 3, 4, and 5) and bulk samples from three strata were processed for ostracode and mollusk analysis. The samples represented three of the eight prehistoric channels identified in the field: Canals 1, 2, and 5. Samples were processed following the freeze-thaw technique standard for this analysis (Forester 1988) and washed in a set of three sieves (>1 mm, >106 µm, and >63 µm). A simple particle-size analysis was conducted after this procedure to determine sediment behavior and microinvertebrate response to physical properties of canal streamflow.

Sediment residuals (>1 mm to >63 µm) were analyzed under a low-power stereoscopic microscope. Routine micropaleontological analysis was performed to determine fossil content and faunal assemblages. Total and relative abundance were recorded. Because flowing systems usually hold small sample sizes, it is appropriate to include taphonomic features like fragmentation, abrasion, and the adulthood (adult/juvenile: A/J) and disarticulation (carapace/valve: C/V) ratios to determine the origin of specimens (Adams et al. 2002; Delorme 1989; Forester 1988). For paleoenvironmental interpretation, the samples were arranged by canal and channel episode.

C.3 Results

C.3.1 Sedimentology

Based on Folk et al. (1970), dry sediment fractions from these canals mostly consisted of light brownish gray (10YR 6/2) to yellowish brown (10YR 5/4) sandy silt to silty clay and clay (Table C.2). Sediment fractions recovered (fine sands coarser than 63 µm) showed some degree of correlation among samples within a channel. Three units (PPS 94, PPS 190, and PPS 185) representing two channel episodes of Canal 1 were selected for this study. The units were "unfossiliferous" clay, indicating slow flow to standing waters (see Table C.2). Sample PPS 185 represents the oldest channel episode, Channel 1a, among these samples. The two strata represented by PPS 94 and PPS 190 are the same depositional event at the base of Channel 1b.

Table C.1. Stratigraphic and Archaeological Context of Micropaleontology Samples

Channel Episode	Sample	Stratigraphic Interval	Stratum/PD	Field Characterization of Sediment Texture
Channel 1a	bulk	IIa	185	clay
Channel 1b	bulk	IIb	94	silty clay
Channel 1b	bulk	IIb	190	clay
Channel 2a	PPS 74	IIb/IIc	333	fine-sandy loam to silty loam
Channel 2a	PPS 78	IIb/IIc	335/129	fine-sandy loam/clay
Channel 2a	PPS 80	IIb/IIc	337	clay
Channel 2b	PPS 72	IIb/IIc	331	fine-sandy loam
Channel 2d	bulk	IIb/IIc	124	fine-sandy loam to fine sand
Channel 2e	PPS 58	IIb/IIc	323	fine-sandy loam
Channel 2e	PPS 60	IIb/IIc	325	silty loam
Channel 2g	PPS 54	IIb/IIc	119	fine-sandy loam
Channel 2g	PPS 69	IIb/IIc	329	clay
Channel 2h	PPS 65	IIb/IIc	326	fine-sandy loam
Channel 2h	PPS 67	IIb/IIc	110	silty loam
Channel 5d	PPS 25	IIb	296	silty loam to fine-sandy loam
Channel 5d	PPS 26	IIb	295	silty loam
Channel 5d	PPS 28	IIb	230	fine-sandy loam
Channel 5f	PPS 23	IIb	131	silty loam to fine-sandy loam
Channel 5f	PPS 24	IIb	226	fine-sandy loam to loamy fine-sand

Note: PPS=point-provenienced sample.

Table C.2. Results of Simple Particle-Size Analysis of Sediment Samples

Sample ID (PPS)	Profile Location	Stratum/PD	Channel	Level (cm bgs)	Bulk Weight (g)	>63 µm Weight (g)	>1 mm (g)	1mm–106 µm (g)	106 µm–63 µm (g)	<63 µm (g)	>1 mm (%)	1mm–106 mm (%)	106 µm–63 µm %)	<63 µm (%)	Textural Class	Color Name	Munsell Color (dry)
23	1	131	5f	11–27	100.0	48.3	1.9	30.3	16.1	51.7	1.9	30.3	16.1	51.7	sandy silt	yellowish brown	10YR 5/4
24	1	226	5f	41–53	99.4	47.8	0.9	31.2	15.7	51.6	0.9	31.4	15.8	51.9	sandy silt	light brownish gray	10YR 6/2
25	1	296	5d	58–61	100.3	46.4	3.5	27.5	15.4	53.9	3.5	27.4	15.4	53.7	sandy silt	light brownish gray	10YR 6/2
26	1	295	5d	67–69	98.5	43.1	5.4	25.1	12.6	55.4	5.5	25.5	12.8	56.2	sandy silt	yellowish brown	10YR 5/4
28	1	230	5d	77–88	100.4	65.6	12.5	43.8	9.3	34.8	12.5	43.6	9.3	34.7	gravelly silty sand	brownish yellow	10YR 6/6
65	4	326	2h	23–33	100.1	17.3	0.2	6.0	11.1	82.8	0.2	6.0	11.1	82.7	silty clay	light brownish gray	10YR 6/2
67	4	110	2h	35–42	100.9	18.9	0.1	10.0	8.8	82.0	0.1	9.9	8.7	81.3	silty clay	yellowish brown	10YR 5/4
54	3	119	2g	48–53	100.2	46.1	0.3	25.1	20.7	54.1	0.3	25.0	20.7	54.0	sandy silt	light brownish gray	10YR 6/2
69	4	329	2g	57–66	100.2	16.5	0.1	8.6	7.8	83.7	0.1	8.6	7.8	83.5	silty clay	yellowish brown	10YR 5/4
58	3	323	2e	58–61	100.0	14.6	0.1	2.5	12.0	85.4	0.1	2.5	12.0	85.4	silty clay	yellowish brown	10YR 5/4
60	3	325	2e	63–68	100.4	17.8	0.1	9.9	7.8	82.6	0.1	9.9	7.8	82.3	silty clay	yellowish brown	10YR 5/4
124	none	124	2d	67–71	100.7	19.4	0.2	4.9	14.3	81.3	0.2	4.9	14.2	80.7	silty clay	yellowish brown	10YR 5/4
72	4	331	2b	72–78	100.1	52.6	1.2	39.3	12.1	47.5	1.2	39.3	12.1	47.5	silty sand	light brownish gray	10YR 6/2
78	5	129/335	2a	44–55	100.3	4.2	0.1	1.0	3.1	96.1	0.1	1.0	3.1	95.8	clay	yellowish brown	10YR 5/4
80	5	337	2a	61–64	100.1	3.8	0.0	2.2	1.6	96.3	0.0	2.2	1.6	96.2	clay	yellowish brown	10YR 5/4
74	4	333	2a	83–84	100.2	62.4	1.3	42.5	18.6	37.8	1.3	42.4	18.6	37.7	silty sand	brownish yellow	10YR 6/6
94	none	94	1b	26–31	100.5	10.7	0.7	6.9	3.1	89.8	0.7	6.9	3.1	89.4	clay	yellowish brown	10YR 5/4
185	none	185	1a	115–120	100.2	9.3	0.6	6.3	2.4	90.9	0.6	6.3	2.4	90.7	clay	yellowish brown	10YR 5/4
190	none	190	1b	90–98	100.8	2.6	0.1	1.6	0.9	98.2	0.1	1.6	0.9	97.4	clay	dark grayish brown	10YR 4/2

Note: PPS=point provenienced sample.

Canal 2 consisted of eight episodes (a–h), six of which were analyzed for microfossils (a, b, d, e, g, and h). Channel 2a consisted of upwardly fining sediments (see Table C.2). Channels 2b and 2d were represented by single strata, whereas Channels 2e, 2g, and 2h consisted of two strata each. The sedimentary composition alternated from silty sand to silty clay or clay, indicating moderately slow to standing waters.

Channel 5 consisted of six episodes (a–f). Three sediment samples from Channel 5d and two more from Channel 5f were analyzed. The uppermost stratum associated with Channel 5f (Unit 131, PPS 23) is a "capping" episode marking the end of the sedimentary sequence in Canal 5. Fining upwards, the units range from gravelly sandy silt to sandy silt, indicating a moderately fast flow (see Table C.2).

The sediments contained abundant quartz, feldspars, biotite and muscovite, natural glass, and undetermined rock fragments. Charcoal, authigenic carbonates, and organic remains (shells) were also common; other minerals were rare (Table C.3).

C.3.2 Micropaleontology

Tables C.4–C.6 present the micropaleontological content and taphonomic features characterizing each sample. Poor abundance and diversity were recorded in the eleven "fossiliferous" samples. Total and relative abundance were recorded for mollusks and ostracodes. Fossil content ranged from extremely rare to very rare. Relative abundance categories are: extremely rare (< 5), very rare (> 6< 20), rare (> 21< 50), moderately abundant (> 51< 100), abundant (> 101< 500), very abundant (> 501< 1000), and extremely abundant (> (1001), (see Table C.4). The taphonomic parameters used to determine the origin of the sediments are also listed in Table C.4. Fragmentation and abrasion ranged from low (5 percent) to moderately high (30 percent). No evidence of encrustation, coating, or stains (redox index) was observed in the shells (mollusks and ostracodes). Shells were very well preserved (clear or white).

C.3.2.1 Ostracodes

Table C.5 summarizes the absolute and relative abundance and the adulthood (A/J) and disarticulation (C/V) ratios by species. Four species were present in these canal channels: *Candona patzcuaro, Ilyocypris bradyi, Cypridopsis vidua*, and *Cyprinotus glaucus*. *Cyprinotus glaucus* was the most abundant species; other species were only recorded from Canal 5 (PPS 23 and PPS 28), where *C. glaucus* appeared once. All fossiliferous samples were characterized by a very small population (0.01–0.11 individuals/g of sediment) and low diversity (1–4 species). Poor population appeared to be the result of the streamflow, as suggested by the moderately high fragmentation (10–30 percent) and abrasion (5–10 percent) rates recorded, at least for part of Canal 5. However, this does not explain their absence in finer sediments that certainly reflect slow flow to stagnant waters. Taphonomic properties indicate that microinvertebrates were introduced in the early stages of canal operation (Adams et al. 2002; Delorme 1969, 1989; Forester 1988; Palacios-Fest 1997a).

C.3.2.2 Mollusks

Table C.6 summarizes the absolute and relative abundance of the gastropod species present in the sampled Canal 1 channels at Canal Casa Grande. Two species, *Helisoma tenue* (planorbid) and *Physa virgata* (pulmonate), were extremely rare (0.01 individuals/g of sediment in the three samples containing mollusks). The taphonomic features (fragmentation and abrasion) indicated the specimens were reworked as juveniles.

Table C.3. Mineral Composition of Sediment Samples

					Mineralogy														
Sample ID (PPS)	Profile Location	Stratum	Channel	Level (cm bgs)	Quartz	Schist	Feldspars	Basalt	Granite	Rhyolite	Biotite	Muscovite	Garnet	Natural Glass	Clay Chunks	Calcareous Masses	Charcoal	Shell Fragments	Ostracode Fragments
23	1	131	5f	11–27	X		X		X		X	X		X		X	X	X	X
24	1	226	5f	41–53	X	X	X			X	X	X		X		X	X	X	X
25	1	296	5d	58–61	X	X	X				X	X		X		X	X	X	X
26	1	295	5d	67–69	X		X			X	X	X	X	X		X	X		
28	1	230	5d	77–88	X	X	X				X			X		X		X	
65	4	326	2h	23–33	X						X	X					X	X	
67	4	110	2h	35–42	X					X	X	X			X		X		
54	3	119	2g	48–53	X		X			X	X	X		X			X	X	
69	4	329	2g	57–66	X						X	X			X			X	
58	3	323	2e	58–61	X						X							X	
60	3	325	2e	63–68	X		X	X			X	X					X	X	
124	none	124	2d	67–71	X		X				X	X		X			X	X	X
72	4	331	2b	72–78	X		X				X	X		X	X		X	X	
78	5	129/ 335	2a	44–55	X						X				X	X	X		
80	5	337	2a	61–64	X						X				X			X	
74	4	333	2a	83–84	X					X	X	X		X		X	X		
94	none	94	1b	26–31	X						X			X	X		X		X
185	none	185	1a	115–120	X		X							X				X	
190	none	190	1b	90–98	X										X				

Note: PPS=point-provenienced sample.

Table C.4. Micropaleontological Content and Taphonomic Characteristics of Sediment Samples

Sample ID (PPS)	Profile Location	Stratum	Channel	Level (cm bgs)	Fossils:		Taphonomy of Ostracodes and Mollusks					
					Ostracodes	Mollusks	Fragmentation	Abrasion	Encrustation	Coating	Redox Index	Color
23	1	131	5f	11–27	3	1	30	10	—	—	—	clear
24	1	226	5f	41–53	7	—	10	5	—	—	—	clear
25	1	296	5d	58–61	3	—	5	5	—	—	—	clear
26	1	295	5d	67–69	1	1	—	—	—	—	—	clear
28	1	230	5d	77–88	—	—	—	—	—	—	—	
65	4	326	2h	23–33	—	—	—	—	—	—	—	
67	4	110	2h	35–42	—	—	—	—	—	—	—	
54	3	119	2g	48–53	—	—	—	—	—	—	—	
69	4	329	2g	57–66	—	—	—	—	—	—	—	
58	3	323	2e	58–61	2	—	—	—	—	—	—	clear
60	3	325	2e	63–68	—	1	—	—	—	—	—	white
124	none	124	2d	67–71	2	—	10	—	—	—	—	clear
72	4	331	2b	72–78	4		10	10	—	—	—	clear
78	5	129/335	2a	44–55	—	—	—	—	—	—	—	
80	5	337	2a	61–64	11	—	15	10	—	—	—	clear
74	4	333	2a	83–84	2	—	—	10	—	—	—	clear
94	none	94	1b	26–31	1	—	10	10	—	—	—	clear
185	none	185	1a	115–120	—	—	—	—	—	—	—	
190	none	190	1b	90–98	—	—	—	—	—	—	—	

Note: PPS=point-provenienced sample.

Table C.5. Ostracode Specimens Recovered

Sample ID (PPS)	Profile Location	Stratum	Channel	Level (cm bgs)	Bulk Weight (g)	>63 µm Weight (g)	Ostracodes	Ostracodes /Gr	*I. bradyi*			*C. vidua*			*C. glaucus*			*C. patzcuaro*		
									n	A/J[a]	C/V[2]	n	A/J[a]	C/V[b]	n	A/J[a]	C/V[b]	n	A/J[a]	C/V[b]
23	1	131	5f	11–27	100.0	48.3	3	0.03	1	—	—	1	—	—	—	—	—	1	—	—
24	1	226	5f	41–53	99.4	47.8	7	0.07	1	1	—	2	—	—	4	0.5	—	—	—	—
25	1	296	5d	58–61	100.3	46.4	3	0.03	1	—	—	1	—	—	—	—	—	1	—	—
26	1	295	5d	67–69	98.5	43.1	1	0.01	1	1	—	—	—	—	—	—	—	—	—	—
28	1	230	5d	77–88	100.4	65.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
65	4	326	2h	23–33	100.1	17.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—
67	4	110	2h	35–42	100.9	18.9	—	—	—	—	—	—	—	—	—	—	—	—	—	—
54	3	119	2g	48–53	100.2	46.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
69	4	329	2g	57–66	100.2	16.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—
58	3	323	2e	58–61	100.0	14.6	2	0.02	—	—	—	—	—	—	2	—	—	—	—	—
60	3	325	2e	63–68	100.4	17.8	—	—	—	—	—	—	—	—	—	—	—	—	—	—
124	none	124	2d	67–71	100.7	19.4	2	0.02	—	—	—	—	—	—	2	0.5	—	—	—	—
72	4	331	2b	72–78	100.1	52.6	4	0.04	—	—	—	—	—	—	4	0.5	—	—	—	—
78	5	129/335	2a	44–55	100.3	4.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—
80	5	337	2a	61–64	100.1	3.8	11	0.11	—	—	—	—	—	—	11	0.27	0.18	—	—	—
74	4	333	2a	83–84	100.2	62.4	2	0.02	—	—	—	—	—	—	2	1	—	—	—	—
94	none	94	1b	26–31	100.5	10.7	1	0.01	—	—	—	—	—	—	1	—	—	—	—	—
185	none	185	1a	115–120	100.2	9.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—
190	none	190	1b	90–98	100.8	2.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Note: PPS=point-provenienced sample

[a] A/J is Adult / Juvenile.

[b] C/V is Carapace / Valve.

Table C.6. Gastropod Specimens Recovered

Sample ID (PPS)	Profile Location	Stratum	Channel	Level (cm bgs)	Bulk Wt. (g)	> 63 µm Weight (g)	Mollusks	Mollusks (g)	*Physa virgata*		*Helisoma tenue*	
									n	%	n	%
23	1	131	5f	11–27	100.00	48.30	1	0.01	1	100	—	—
24	1	226	5f	41–53	99.40	47.80	—	—	—	—	—	—
25	1	296	5d	58–61	100.30	46.40	—	—	—	—	—	—
26	1	295	5d	67–69	98.50	43.10	1	0.01	—	—	1	100
28	1	230	5d	77–88	100.40	65.60	—	—	—	—	—	—
65	4	326	2h	23–33	100.10	17.30	—	—	—	—	—	—
67	4	110	2h	35–42	100.90	18.90	—	—	—	—	—	—
54	3	119	2g	48–53	100.20	46.10	—	—	—	—	—	—
69	4	329	2g	57–66	100.20	16.50	—	—	—	—	—	—
58	3	323	2e	58–61	100.00	14.60	—	—	—	—	—	—
60	3	325	2e	63–68	100.40	17.80	1	0.01	1	100	—	—
124	none	124	2d	67–71	100.70	19.40	—	—	—	—	—	—
72	4	331	2b	72–78	100.10	52.60	—	—	—	—	—	—
78	5	129/335	2a	44–55	100.30	4.20	—	—	—	—	—	—
80	5	337	2a	61–64	100.10	3.80	—	—	—	—	—	—
74	4	333	2a	83–84	100.20	62.40	—	—	—	—	—	—
94	none	94	1b	26–31	100.50	10.70	—	—	—	—	—	—
185	none	185	1a	115–120	100.20	9.30	—	—	—	—	—	—
190	none	190	1b	90–98	100.80	2.60	—	—	—	—	—	—

Note: PPS=point-provenienced sample.

C.3.3 Interpretation

The grain-size analysis reflects the depositional patterns throughout the history of these canals (see Table C.2). The fine sediments (clay) at Canal 1 indicate slow flow or standing water conditions during deposition. A single juvenile valve of *C. glaucus* recovered from PPS 94—in addition to the fragmentation and abrasion indices—show the specimen was introduced with streamflow.

Three samples from Channel 2a yielded the richest ostracode record. No mollusks were recovered from this profile. The grain-size data indicate decreasing streamflow through time (see Table C.2). Samples PPS 74 (Stratum 333) and PPS 80 (Stratum 337) contained ostracodes (*C. glaucus*). The taphonomic parameters (fragmentation and abrasion) suggested the specimens were introduced into the system; the adulthood and disarticulation ratios were consistent with this hypothesis. Stratum 337 probably represents the ending episode of a water flow cycle indicated by Stratum 338. The abrupt change in lithology from a fine sandy loam (see Stratum 338 in Table D.1, Appendix D) to a clay (see Table C.2) indicates that the canal flow was fast (Stratum 338) and abruptly terminated, allowing the fine sediments and a larger number of shells to accumulate (Stratum 337).

Sample PPS 78 probably represents the ending episode of a water-flow cycle similar to sample PPS 80. The characterization of Stratum 335 as clay in Table C.2, however, conflicts with the field characterization of this stratum as fine-sandy loam (see Table D.1). This discrepancy is explained as follows. When Profile Column 5 was originally recorded, Strata 335 and 129 were considered a single depositional unit. After sampling, the upper clay deposit was designated as a distinct unit (Stratum 129). The field description is based on the bulk of the unit (Stratum 335), but the materials submitted for micropaleontology studies obviously derived from the final clay unit (Stratum 129).

Absence of microfossils in the sample PPS 78 may have resulted from one of two situations. Again, unsaturated water may explain the loss of organisms. A second hypothesis is rapid desiccation of the deposits. Presence of calcareous masses may rule out the first alternative.

A sample from Channel 2b had an extremely poor ostracode population; no mollusks were recovered. Four specimens of *C. glaucus* were introduced into the system by a moderately slow streamflow. The taphonomic parameters are consistent with this interpretation. Channel 2d, also represented by a single sample, was equally poor in abundance and diversity. Two valves of *C. glaucus* were reworked by a slow streamflow. Again, the taphonomy indicates an allochthonous presence of microfossils.

Two samples from Channel 2e yielded an extremely poor microinvertebrate record as well, despite the favorable conditions indicated by the grain-size data (see Table C.2). Slow flow characterized the strata. A shell of *P. virgata* (gastropod) was the only specimen found at the lower stratum. Two valves of the ostracode *C. glaucus* were collected from the upper stratum. Taphonomic features indicated good preservation, but the species were unable to settle.

Channels 2g and 2h consisted of two "unfossiliferous" samples each. Absence of microinvertebrates in these two episodes is troublesome. Fine-grain sediments (silty clay) are among the richest in micropaleontological content. The more likely explanation is that at this time, canal waters were HCO_3^--depleted (Type 2 pathway) to the extreme of diluting existing carbonates. Because both ostracodes and mollusks are provided with a calcium carbonate skeleton, the shells were the only potential source of carbonate to approach ionic equilibrium in solution. Table C.3 shows absence of calcareous masses in these strata.

The lowermost stratum in Channel 5d contained no fossils, owing to a moderately fast flow as indicated by the large medium sand fraction (see Table C.2). Two other samples from Channel 5d contained a few microfossils. *Ilyocypris bradyi*, *Cypridopsis vidua,* and *Candona patzcuaro* (ostracodes) and *Helisoma tenue* (snail) were extremely rare. Specimens were introduced by streamflow and unable to settle a community. Streamflow was still moderately fast, as shown by the grain-size data (see Table C.2).

Channel 5f, represented by two strata (131, sample PPS 23, and 226, sample PPS 24), yielded a few more specimens and the greatest diversity within a single phase. The lower stratum (226) contained three ostracode species: *I. bradyi, C. vidua,* and *C. glaucus,* but no mollusks. The upper stratum (131) contained the ostracodes *I. bradyi, C. vidua, and C. patzcuaro,* as well as the gastropod *Physa virgata.* Despite the slightly richer and more diverse ostracode fauna, the specimens recovered do not reflect a biocenosis (a local community). *Cyprinouts glaucus* was the most abundant species. However, given its habitat preferences, it is unlikely the species reflected a local population. *I. bradyi* and *C. vidua* appeared once in Stratum 226; in addition, *C. patzcuaro* appeared once in Stratum 131 (see Table C.5). Similarly, *Physa virgata* appeared once at Stratum 131 (PPS 23). Streamflow was a major factor, limiting microinvertebrates to establish a community in Phase 5f. Grain-size data indicate a moderately fast flow (see Table C.2). The microfauna were reworked by streamflow.

C.3.4 Discussion and Conclusions

The combined sedimentological and micropaleontological analyses provided a resourceful strategy for understanding the history of canals at AZ AA:2:30 (ASM). The particle-size analysis indicated that these canals were characterized by episodes of varying streamflow. A similar trend was recorded from previous sites along the middle Gila River (Pecos Road site GR-556; Palacios-Fest 1997b) and the Santa Cruz River (Las Capas site AZ AA:12:111 ([ASM]); Palacios-Fest et al. 2001; Whittlesey et al. 2008). In contrast with these studies, the canals in the current project were extremely poor in microinvertebrates. Some canals along SR 87 in Safford, Arizona, and the Zuni Wetlands in Zuni, New Mexico, were worse than Canal Casa Grande (Palacios-Fest 2001, 2002b), but other than these, no other studies yielded a record this poor.

Despite the poor micropaleontological record, the degree of preservation of shells indicated that, in most cases, specimens were introduced and did not establish a population, or if so, the unsaturated waters diluted them during burial. At this time, it is not appropriate to attempt a hydrochemical reconstruction of the canal waters because the faunal composition does not warrant the analysis.

The four ostracode species present in the several channel episodes fit the water chemistry and TDS reported for the Gila River (300–3000 mg L^{-1}; Hem 1985). However, the poor record did not allow further elaboration on the issue. Most ostracode species present have a minimum salinity tolerance greater than 100 mg L^{-1} TDS and a maximum between 4000 and 5000 mg L^{-1} TDS, except for *C. glaucus*, which is able to tolerate a salinity as high as 10,000 mg L-1 TDS. Based on previous reports from the Phoenix and middle Gila River areas, it is unlikely that the Canal Casa Grande waters exceeded a salinity greater than 1000 mg L^{-1} that may be harmful to cultigens (Palacios-Fest 1997b, 2002a).

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