

Urban Geo-archaeology in Medieval Alzira (Prov. Valencia, Spain)

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Alzira is situated in a cut-off meander loop of the Rio Júcar. Geo-archaeological study shows that the Islamic city wall was built during the second quarter of the 11th century AD, at a time when the river had a low-amplitude and low-energy flood regime. After mid-century, overbank silts began to invade the city as peak flood discharge increased, with a spate of destructive floods reflected by high-energy deposits during the late 11th century. Urban expansion within the city wall is dated to the later 11th or early 12th century, interrupted by local abandonment and moderate-energy flood silts. Major construction during the mid-12th century was followed by protracted abandonment (after a siege in AD 1171?) and further, moderate-energy flood silts that redistributed occupation and collapse debris. Reoccupation, during the late 14th century, was terminated by catastrophic floods in 1517 and 1571, after which much of the western end of Alzira was not rebuilt. Following further flood catastrophes during the 17th century, parts of the central walled city remained abandoned until the 19th century, with new occupation atop flood sands of yet another disaster in 1864. The change in flood regime after 1150 was a result of deforestation of the watershed, but progradation of a downstream tributary fan after 1517 created an unstable, aggrading floodplain increasingly prone to severe flooding. Climatic anomalies were responsible for periods of recurrent severe floods, archaeologically verified during the 11th and 12th centuries, and historically documented, beginning in 1318. The geo-archaeological methodology illuminates the constructional and settlement history of Alzira, allows distinction of fluvial and cultural components, and provides the necessary microstratigraphic detail and dating control to document the true complexity of alluvial processes during the last 1000 years.

Keywords: ALZIRA, FLOODS, FLUVIAL AND URBAN SEDIMENTATION, GEO-ARCHAEOLOGY, HISTORICAL FILLS, MEDIEVAL ARCHAEOLOGY, SPAIN.

Introduction

The potentials of urban geo-archaeology were first demonstrated by Davidson with examples of prehistoric Greek tells (Davidson, 1973, 1976; Davidson *et al.*, 1976), that

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he studied in terms of vertical grain-size change and phosphate levels, form evolution, and post-depositional sediment dispersal. McIntosh (1977) has provided a complementary, ethnoarchaeological perspective that focuses on the processes of sediment accumulation in and around West African houses. Butzer (1981a) uses the example of Axum to show how landscape degradation and constructional history can be identified and inter-related by geo-archaeological techniques (see Butzer, 1982: chaps. 3–8). However, the full range of possibilities remains to be explored with some urgency, because countless urban sites continue to be excavated without any geo-archaeological attention.

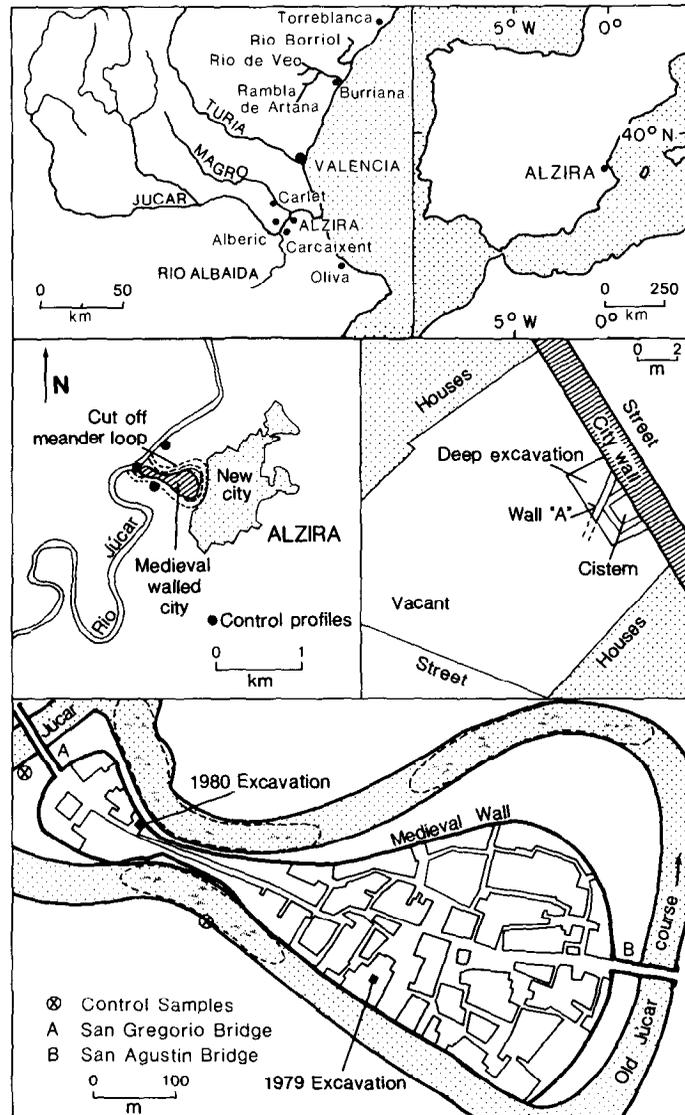


Figure 1. The setting of Alzira and the cut-off meander loop of the Júcar River, with location of the 1980 excavation. The city plan is based in part on Bazzana *et al.* (1980)

The present report explicates one such study, designed to illustrate some of the possibilities of interpreting sedimentation processes within an historical city, in terms of settlement and landscape changes through time. The case is that of Alzira, a site in the Júcar floodplain of Valencia Province that attained considerable prominence during Islamic times, especially during the 10th to 13th centuries. The city grew between the loops of a cut-off meander (Figure 1), as suggested by its Arabic name Al-Yazirat Shukr, *the Júcar island*. The date of this cut-off is unknown, but the 11th century author Al-Udri specifies that Alzira was surrounded by a wall and by the river, on all sides (Castrillo, 1970), while the first Christian land deeds of 1242–1244 already make clear reference to a stone bridge across the Júcar at that point, the site of the Medieval San Gregorio bridge (Pelufo, 1934). But major floods, such as that of 20 October 1982, have repeatedly broken through the former oxbow lake and penetrated the city, which consequently provides an unusual sediment trap.

A first archaeological exploration in 1979 by Bazzana *et al.* (1981) formulated many of the basic problems investigated in this paper. They identified a basal deposit of at least 2.5 m, described as a reddish clay of colluvial or fluvial origin, upon which the city was built during the 14th and 15th centuries, according to pottery dating of the bottom of the oldest fill. The basal clay has late 9th or early 10th century pottery inclusions, and is correlated with post-Roman or early Medieval sterile clays or clayey sand identified under other sites of eastern Spain: Burriana, Oliva, and the nearby Camí del Plà site. Complex occupational levels follow, at Alzira dated through to the late 16th century, when several lenticles of flood sands were interbedded with rubble or fill of the late 16th and early 17th centuries. A break follows, with late 19th to early 20th century occupation debris in the foundations of the present buildings. Bazzana *et al.* (1980) posit that the early Medieval clay buries older, Roman settlement vestiges at Alzira, and they consider that this deposit forms part of an extensive coastal alluviation related to soil erosion in the Spanish interior. They also raise the question of the significance of 16th–17th century flooding for urban adaptations.

Since no geo-archaeological examination was available to confirm these thoughtful inferences, a second exploration in 1981, under the direction of Ismael Miralles, was undertaken adjacent to the old city wall, to test and possibly to verify Bazzana's hypotheses. A 2 × 4 m square was dug to a maximum depth of 5.6 m, near the western end of Alzira and close to the abandoned meander loop (Figure 1).

Description of the 1980 Alzira Excavation Profile

The 1980 excavations of Miralles and his team provided broad exposures, the stratigraphy of which is generalized in Figure 2. Archaeological levels are used, counted from top to bottom and subdivided in cases of microstratigraphic complexity.

A total of 21 sediment samples from the 1980 profile, together with 10 further "control" samples from the Júcar floodplain near Alzira and Alberic (Alberique), were analyzed at the University of Chicago. Even the modern flood silts showed incipient calcite crystallization under the microscope, so that all samples were decalcified in hydrochloric acid prior to further processing. The residual was peptized in a sodium hexametaphosphate solution, processed by the hydrometer method, and then calibrated by dry-sieving with a Ro-Tap apparatus and standard mesh sieves (37, 63, 105, 210, 595 μm; 2, 3.35, 6.4 and 20 mm). Textual classes follow those of Link (1966), with standard pedological terms given in parentheses; the granulometric indices are those of Folk (1966): mean size (Mz), sorting (σ), skewness (Ski), and kurtosis (Kg). Colors are from the Munsell Soil Color Charts (dry state), pH values were determined for aqueous sediment pastes, and the calcium carbonate equivalent (CCE) approximated from bulk loss in acid. The laboratory data are presented in Figure 2 as well as in the geo-archaeological description that follows.

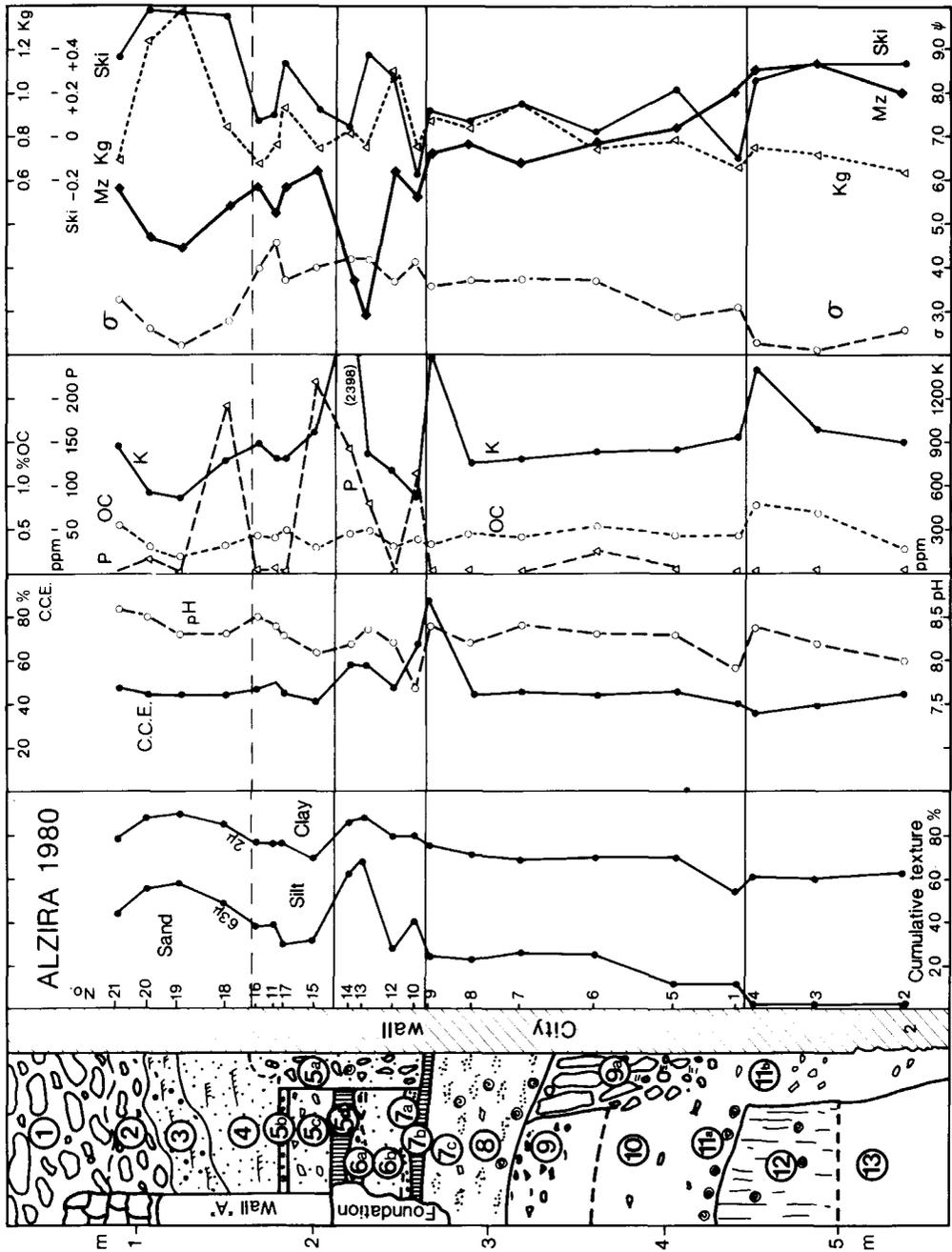


Figure 2. Profile of the 1980 Alzira excavations, shown schematically as abutting the City Wall, with corresponding sedimentological data.

Level 1. 0–85 cm

Fresh, construction rubble, largely derived from razing of houses, but in part representing basement fillings of decomposing mortar, brick fragments and land snails. The younger, poorly-cemented rocks of Wall "A" (Figure 1) extend up as far as –60 cm, and at the southern edge of the excavation a brick-floored, slab-covered drainage ditch (20 cm wide) ran roughly perpendicular to Wall "A".

Level 2. 85–120 cm

Older construction rubble of limestone blocks and decomposing mortar, with a matrix of calcified, partly oxidized (light yellowish brown, 10 YR, mottles), light grey (10 YR) clayey silt-sand (loam), poorly sorted (sample No. 21). The top of the older, well-cemented part of Wall "A" is at –112 cm; 46 cm wide, both its faces are plastered. Another structure appears at this level a plaster-lined *aljibe* (cistern), abutting the City Wall (Figure 1), with three brick walls, 30 cm thick and enclosing an irregular area of about 1.0 × 1.3 m. The metre of sediment within this cistern was not analyzed but includes a cap of gravelly, clayey silt-sand (equivalent to Level 3) over debris, comprising limestone rock, roof tiles, brick, mortar, potsherds, and some animal bone. Basal contact outside of the structures is irregular and abrupt.

Level 3. 120–155 cm

Undulating lense of 5–45 cm, oxidized (light yellowish brown, 10 YR mottles), light grey (7.5 YR–2.5 Y) clayey silt-sand (sandy loam), laminated, with dispersed fine quartz and quartzite pebbles, and animal bone. Pockets of calcified, current-bedded, silty sand appear to have been eroded elsewhere and redeposited. Overall this sediment is moderately sorted, highly leptokurtic, and strongly positively skewed (Nos 19–20). Basal contact is wavy and clear.

Level 4. 155–180 cm

Thick (10–65 cm) lense of pink (7.5–10 YR) clayey silt-sand (loam), laminated or current-bedded, moderately sorted and strongly positively skewed (No. 18). Includes animal bone and phosphates. Basal contact straight and abrupt.

Level 5(a).

Artificial fill in a 1 m deep "cut", with clean vertical faces, that intersects the western corner of the excavation (Figure 2): pink to very pale brown (7.5–10 YR) clayey silt-sand (loam) very poorly sorted (Nos 11, 16), with abundant limestone rubble, mortar debris, potsherds, animal bone, and large land snails (*hellicellidae*).

Level 5(b). 180–185 cm

Discontinuous lense of pink to white (7.5 YR), calcified clayey sand-silt (loam), poorly sorted (No. 17), with mortar-coated fine quartz and sandstone pebbles. This reworked mortar (1.2% opaline silica) grades laterally into clean pebbles within a sandy matrix.

Level 5(c). 185–210 cm

Pink (7.5 YR), sandy clay-silt (clay loam), poorly sorted (sample 15); the abundant phosphates and potassium, together with dispersed roof tiles, brick, rock, mortar debris, animal bone, and charcoal, represent occupation residues.

Level 5(d). 210–220 cm

Discontinuous lense of 10–20 cm thick, light grey to white (10 YR) decomposing mortar, with a residue of very poorly sorted, clayey silt-sand (sandy loam) (No. 14). The potas-

sium and phosphorus levels suggest that plant remains and bone meal were incorporated in the cement. Further, the low carbonate and opaline silica values (59% and 0.1%, respectively) indicate the use of an impure and incompletely "burnt", crushed lime. This mortar defines a cultural surface at the same levels as base of Wall "A" and the cistern behind it (-210 cm).

Level 6(a). 220–230 cm

Lense of light grey to white (10 YR), calcified, silty sand (sandy loam), very poorly sorted (No. 13); with much rounded and fine to medium-grade gravel of quartzite, quartz, and limestone, together with brick debris. This represents a prepared base to the "floor" of 5(d), secondarily cemented during the laying of that mortar.

Level 6(b). 230–250 cm

Very pale brown (10 YR), clayey sand-silt (silt loam), poorly sorted and leptokurtic (No. 12); with mortar debris, terrestrial snails, animal bone, and potsherds.

Level 7(a). 250–255 cm

Light grey to white (10 YR), calcified, clayey silt-sand (loam), very poorly sorted, negatively skewed (No. 10), with abundant fine to medium-grade, limestone and quartzite pebbles, as well as phosphates and potsherds.

Level 7(b). 255–265 cm

White (10 YR), good-quality mortar (5–10 cm thick, 89% CCE and 3.0% opaline silica) with a residue of poorly sorted sandy clay-silt and dispersed, medium-grade quartz pebbles (No. 9), representing "filler" derived from 7(c). The high potassium levels suggest decomposed plant material. This mortar was laid on an abrupt and straight surface dipping 2° (WNW); the filled trench 5(a) terminates at the top of 7(a) (see Figure 2 column).

Levels 7(c), 8. 265–310 cm

Pink (7.5 YR), compact sandy clay-silt (clay loam), poorly sorted (Nos 7, 8); with small lenses of fine quartz and quartzite pebbles dipping 2–5° (NW); dispersed rock, roof tile, charcoal fragments, animal bone, land and aquatic snails (*Rumina decollata*, *Cepaea nemoralis*, helicellidae, *Melanopsis dufouri*), and potsherds. Foundations of Wall "A" extend down to -280 cm (Figure 2). Base wavy and abrupt, dipping 8° (NW).

Level 9. 310–360 cm

Pink (7.5 YR), compact, sandy clay-silt (clay loam), poorly sorted (No. 6); with a localized concentration of mortar debris, animal bone, charcoal, and potsherds. Dip 8–10° (NW) to abut an 80 cm wide trench adjacent to the City Wall that is filled with rock and an incomplete, very pale brown matrix (Level 9(a) (Figure 2).

Levels 10, 11(a). 360–440 cm

Pink (7–5 YR), compact, partly oxidized (brownish, 10 YR mottles), sandy clay-silt (silty clay loam), moderately sorted (No. 5); with dispersed rock, animal bone, pottery, land snails (small helicellidae) and concentrations of aquatic shell (*Melanopsis*) along the wavy and abrupt base. Laterally the rubble trench, with a laminated matrix due to intrusive, throughflow deposition, continues along the City Wall, terminating at -430 cm (Figure 2).

Level 11(b).

Continuation of level 11(a) in northeastern part of excavation, where it fills an artificial

cut of 60 cm width next to the City Wall, extending down to at least –565 cm. The sediment is a pink (7.5 YR), partly oxidized, sandy silt clay (silty clay), moderately sorted and negatively skewed (No. 1); dispersed rock, brick, roof tiles, mortar debris, and traces of potsherds. The mortar finish of the inside of the City Wall terminates at –510 cm, confirming the impression that level 11(b) was partly excavated during building of the wall foundations (Figure 2).

Level 12. 440–500 cm

Pinkish grey (7.5 YR), partly oxidized (brownish, 10 YR mottles), humic, clayey silt (silty clay loam), moderately sorted (Nos 3–4); high organic carbon and potassium levels, and dispersed *Melanopsis* shell. Archaeologically sterile. Basal contact wavy and gradual.

Level 13. 500 cm to below 540 cm (water table)

Pink (7.5 YR) clayey silt (silty clay loam), moderately sorted (No. 2). Archaeologically sterile.

Pottery Chronology and Occupational History

A basic chronology for the Alzira excavation profile is provided by the pottery, which can be summarized in broad units, beginning with the earliest horizons.

Levels 10 and 11. There is a range of characteristic Caliphal items, including one sherd with a thick, green varnish line, one with white interior and exterior slip covered with thin clear varnish, one with greenish yellow (galena) varnish and blackish maroon decor (*alcofol*), three green-and-maroon sherds, a piece of impressed wall tile with a black (reduced) interior, and a number with dark green varnish or with parallel manganese lines on slip. Except for the green monochromes, which diffused widely after AD 1050, these features are characteristic of the late Caliphal period, c. AD 950–1030 (Bazzana, 1980).

Level 9. An impressed, *cuerda seca* rim fragment, an *ataifor*-style pot, a dark green bowl, and manganese decoration of *taches en virgule* are diagnostic of the flourishing arts of the Taifa period, which effectively extended from AD 1021 to AD 1172 in the Valencia area.

Levels 8 and 7. Taifa elements such as *cuerda seca*, *ataifor* decoration, dark green varnish, and manganese decor (parallel lines, striae, *taches en virgule*) remain prominent, while there are pots with honey-colored varnish and a large jar with sinuous incisions below the rim.

Levels 5 and 6. Characteristic are *cuerda seca*, dark green varnish, manganese decor (parallel lines, *taches festonnées*), sinuous incisions as well as cordiform relief on rim bases. In addition to this Taifa pottery there is an Almohad *esgrafiado* sherd (after AD 1172), exact provenience uncertain.

Level 4 and base of Aljibe. A mass of nondiagnostic pottery, lacking Islamic elements, indicates a major occupation break, made more precise by an early Manises blue-on-white dish and candle holder (at 140–190 cm), within the aljibe. This implies that characteristic pottery from the 13th and early 14th centuries is totally absent.

Levels 2 and 3. The external deposits here include only reworked Muslim material but, within the aljibe, Level 3 includes a cylindrical jar, a jug and a bowl with honey varnish, as well as a candle-holder stem of early 16th century type.

Level 1. The youngest rubble includes modern varnished sherds and a blue-on-white tile of the 19th century.

The construction and occupational history of the excavation area can now be summarized. This part of the cut-off meander was unoccupied until the city wall was con-

structed towards the middle of the 11th century, presumably by the first Taifa king of Valencia. Direct settlement at this site did not follow, although the sediments of levels 8 to 11 include silkworm eggs (white, ellipsoidal forms of 200–500 μm size with characteristic “styrofoam” texture), a fragment of an apparent cocoon wall, and silk fiber, in addition to reworked occupation rubble. Intensive construction was delayed until the final decades of the 11th century, or a little later, at which time Wall “A” and thealjibe were built. The abandonment of either occupation 7(a) or 5(d) may reflect on events during or after the siege of Alzira in 1171. Level 5 probably represents clean-up debris from the time the house was built during the second half of the 14th century. After the house was abandoned, the site remained unoccupied until the 19th century.

Table 1. Sediment parameters for Júcar control samples

Number	Sand/silt/clay (%)			σ	Mz (phi)	Ski	Kg	CCE (%)	Munsell color
Post-1941 flood silts (Alzira)									
25	67	25	8	2.1	3.8	0.53	1.72	38	7.5/10 YR 6.5/3.5
1864 Flood Silts and old Floodplain Surface (Alberic bridge)									
31	48	38	14	2.8	4.6	0.38	1.21	25	7.5/10 YR 7/3
32	16	62	22	2.7	6.4	0.56	0.77	52	10 YR 8/3
7m floodplain facies (downstream of Alzira)									
26	11	59	30	2.8	7.3	0.18	0.78	42	7.5 YR 7/4
28	71	21	8	1.6	3.6	0.39	2.30	43	7.5 YR 7/4
30	89	7	4	1.4	2.3	0.55	5.82	38	7.5 YR 6/4
27	54	21	25	3.5	5.5	0.64	0.63	40	7.5 YR 6.5/4
29	38	40	22	3.2	6.1	0.32	0.75	30	7.5 YR 6.5/4
Oxbow bank (Alzira)									
24	4	44	52	2.8	8.0	0.17	0.59	44	7.5/10 YR 7/3
22	2	43	55	2.6	8.8	-0.32	0.64	40	7.5 YR 7/3.5
23	25	49	26	2.5	5.8	0.56	0.67	43	7.5/10 YR 7/3

Analogue Study of Júcar Floodplain Sediments

To interpret the Alzira sedimentary suite it was necessary to study a suite of control samples from the modern Júcar floodplain. Since such external samples were not modified or dominated by cultural processes, they should permit diagnosis of cultural influences within the sedimentation patterns recorded by the Alzira profile. Further, control samples of bed and suspended load from the floodplain and channel margins of the Júcar should provide criteria for interpreting fluvial sedimentation modes.

A total of 10 such control samples were collected and studied, as summarized in Table 1. Mean grain size (Mz) is plotted versus sorting (σ) of all samples in Figure 3; similar plots of sorting versus kurtosis (Kg), and of sand fraction versus skewness (Ski), were made but are not shown. The control samples can be briefly described and compared with the sediments of the Alzira excavations.

(a) The Júcar channel was deepened in 1941 as a flood-control measure, leading to some downcutting at Alzira that left the floodplain 7–8 m above low water. Discontinuous channel-margin deposits have subsequently accumulated to a relative elevation of 1.5 to 2 m, and were sampled 100 m south of the modern Júcar highway bridge. This is a pink, weakly humified, silty sand (sandy loam), thin-bedded, moderately well sorted,

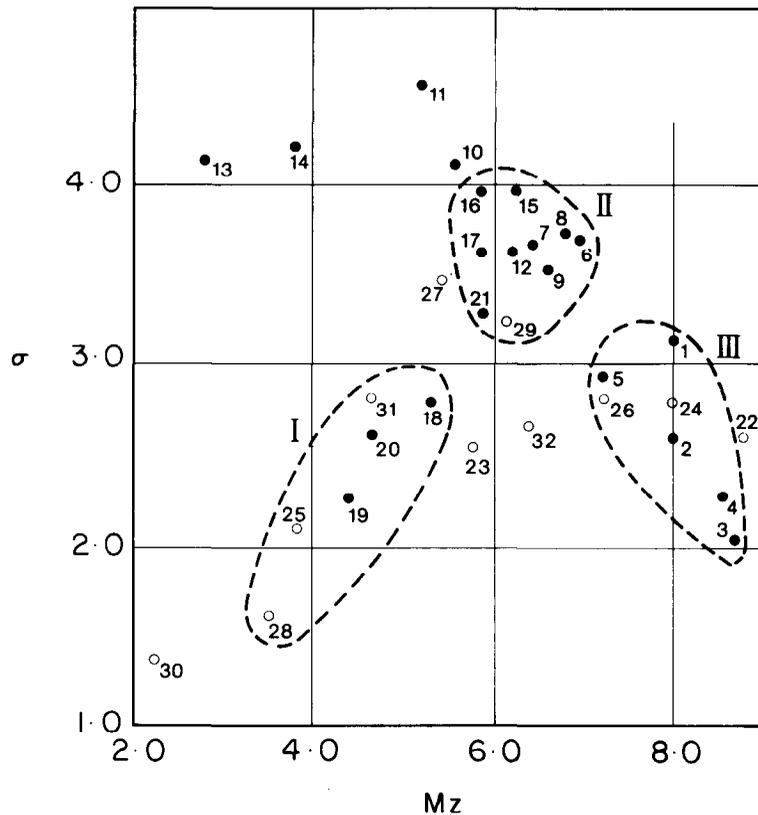


Figure 3. Mean grain-size (Mz) and sorting (σ) parameters for Alzira and Júcar sediment samples. For description of the individual samples and the three classes, see text. ●, Alzira samples; ○, Júcar samples.

strongly positively skewed, with charcoal powder and *Melanopsis* shell (No. 25). Comparison of all parameters showed very close similarities with Alzira samples Nos. 18–20 (Levels 3 and 4), identifying these as relatively high-energy fluvial beds, an interpretation consonant with the presence of small-scale, low-angle, planar crossbeds in both levels.

(b) The Júcar floodplain was devastated in 1864 by the most catastrophic inundation of the modern historical record. A metre and more of infertile sandy alluvium accumulated across the agricultural landscape (Bosch, 1866). This high-energy overbank deposit can be identified along the Júcar banks downstream of the Alberic–Pobla Llarga bridge, and it is a massive bedded to laminated, very pale brown, clayey silt-sand (loam), leptokurtic, with moderate sorting and traces of shell debris (No. 31). Again there are close affinities with Alzira Nos 18–20, except for the absence of strong stratification. The underlying, low-energy overbank sediment near Alberic is a sandy silt-clay (silt loam), mottled, with moderate sorting and strong positive skewing (No. 32). This has no counterparts in the Alzira column.

(c) A 4–5 sediment column is exposed along much of the Júcar right bank, downstream of Alzira. The top 1.6 m resemble the upper floodplain section near Alberic, but at –1.6 to –3.0 m there is a complex of alternating, fine and coarse beds, the latter with some crossbedding. Two are well-sorted, leptokurtic bedload deposits, namely a coarse

sand (No. 30) and a silty sand (sandy loam) (No. 28); only the latter has affinities to the Alzira column, namely with No. 19. Another is a pink, massive bedded, fine-sandy silt, moderately sorted and with *Melanopsis* shell (No. 26); this channel-near flood silt has strong similarities with No. 5, and more general affinities with Nos 1–4.

A weak, sandy floodplain soil (No. 27) gives a light brown, silty clay-sand (sandy clay loam), strongly positively skewed, that has no close analogues in the Alzira column.

Finally, the lower 1.7 m of the Júcar bank consist of pink, massive-bedded, clayey sand-silt (loam) (No. 29)—a channel-near flood silt interbedded with sand lenses; there are strong similarities with Nos 6–9, 12, 15–17, and 2 (matrix only) of the Alzira column.

(d) The last control section was selected on the bank of the abandoned meander loop south of Alzira. The dominant facies here is a very pale brown, weakly humic silty clay, massive-bedded and moderately sorted (No. 24). Two distinct interbeds were also sampled. One is a 7.5 cm lense of conchoidal, pink silty clay with moderate sorting and negatively skewed (No. 22). The second is a 10–15 cm lense of laminated, very pale brown, sandy clay-silt (silt loam), also with moderate sorting and strongly positively skewed (No. 23). None of these facies have any cultural rubble. Whereas the interbeds (Nos 22, 23) have no counterpart in the Alzira excavations, the dominant, slack-water silt/clay (No. 24) provides a consistent analogue for samples 2–4 and it can probably be correlated with the buried soil represented by Level 12.

(e) Some general characteristics of the Júcar control samples, and of their closest counterparts in the Alzira excavation profile, can be enumerated at this point. Sands are overwhelmingly quartz, but also include reddish or light grey quartzite sands, some white limestone, and occasional haematitic concretions in the 0.5–2.0 mm fraction; the coarser grains are subrounded to well rounded, and a proportion of the finer to medium-grade sands show films of reddish soil plasma. Occasional grains of hexagonal quartz are present, with a trace of muscovite in the fraction under 75 μm . The suspended silt and clay have a reddish tone and, combined with penecontemporaneous calcium carbonate precipitates (accounting for some 40% of most samples by weight), they give finer sediments a pink color. These characteristics identify the source area of the sediment—*terra rossa* soils and sediments of the hilly, limestone watershed of the upper Júcar and Albaida rivers—transported and deposited by waters supersaturated with calcium bicarbonate.

(f) Finally, several samples from the Alzira excavations can be singled out as lacking appropriate Júcar analogs. These are all very poorly sorted and include: the occupation residue Level 7(a) (No. 10) on top of the mortared floor of Level 7(b); the mortar and prepared base of Levels 6(a) and 5(d) (Nos 13, 14); and the lower two-thirds of the artificial fill of Level 5(a) (No. 11). Two obviously cultural deposits are not included, the mortar residues of Level 7(a) (No. 9)—obtained from underlying fluvial sediments of Level 7(b), and the fine matrix of the old basement rubble in Level 2 (No. 21)—which evidently includes a dominant flood silt component.

The thirty-two samples can be separated into three facies classes (Figure 3) and one “non-class” of atypical or artificial sediments, on the basis of mean size (Mz), sorting (σ), sand content, skewness (Ski), and kurtosis (Kg).

Class I: well-stratified channel or high-energy overbank deposits—include Nos 18–20, 25, 28 and 31.

Class II: massive-bedded, intermediate-energy, channel-margin flood silts—include Nos 6–9, 12, 15–17, 21 and 29.

Class III: slack-water, low-energy clays—include Nos 1–5, 24 and 26.

A non-class of miscellanea, including 10, 11, 13, 14, 22, 23, 32.

These groups were computer-tested by the SPSS discriminant-function program [as

applied to sediment "populations" by Butzer (1981*b*)]. The test identified all 23 samples of groups I, II and III as correctly classified, but it also placed No. 10 within class II.

Interpretation of the sedimentary facies is complemented by the faunal sample retrieved from the 1980 excavations, and studied by R. G. Klein. This fauna includes 32 identifiable bones of sheep and goat, 12 of domestic cat, six of red deer (*Cervus elaphus*), four of cattle (*Bos taurus*), two of a probable chicken, and one of rabbit or hare. All the deer and the cat bones appear to come from single animals, in terms of age/size, fossilization, and surface condition (Klein, pers. comm.). Yet the deer bones, which are heavily mineralized and end-rolled, were recovered from units 5(a), 3 and inside wall "A". The cat bones, with a brownish patina, were found in units 5(a), 4 and 3. The latter may have been dispersed within a burrow, but more probable is that much of the bone of levels 3 and 4 was reworked from lower beds by flood action. This interpretation is strengthened by an unusual pot, with deep, vertically incised lines, individual pieces of which were recovered from levels 5(a), 3 and 2. These anomalies underscore the high-energy nature

Table 2. *Facies identification of the Alzira excavation strata*

Level 1 (no sample)	Modern cultural rubble.
Level 2 (No. 21)	Cultural rubble (basement fillings), with matrix of coarse flood silts.
Levels 3, 4 (Nos. 18-20)	Partly crossbedded, commonly laminated, high-energy, channel-margin or overbank fluvial deposits, possibly sand-splays, incorporating derived cultural debris.
Level 5(a) (Nos. 11, 16)	Cultural debris (pit filling), with matrix of coarse flood silts near top.
Levels 5(b) 5(c) Nos. (15, 17)	Primarily massive-bedded, channel-margin flood silts, stratified at top, incorporating reworked cultural debris.
Levels 5(d) 6(a) (Nos. 13, 14)	Mortared floor and prepared base.
Level 6(b) (No. 12)	Massive-bedded, channel-margin flood silts.
Level 7(a) (No. 10)	Occupation residue on top of prepared floor.
Level 7(b) (No. 9)	Mortared floor, incorporating much coarse flood silt.
Levels 7(c), 8 (Nos. 7, 8)	Partly stratified, channel-margin flood silts, interbedded with small sand lenses of channel type and with aquatic shells near base; incorporates some reworked cultural debris.
Level 9 (No. 6).	Mainly massive-bedded, channel-margin flood silts, with varying concentrations of reworked cultural debris. Subsequent trench rubble (Level 9b) entirely artificial.
Levels 10, 11(a) (No. 5)	Massive-bedded, slack water silt/clay with freshwater snails and dispersed, reworked cultural debris.
Level 11(b) (No. 1).	Flood infilling of trench cut during wall construction by new slack-water silt/clay, mixed with cultural debris and reworked deposits from Level (12).
Level 12 (Nos. 3, 4)	Massive-bedded, slack-water floodplain surface of silt/clay, with freshwater snails, ultimately representing protracted period of slow or interrupted sedimentation with development of hydromorphic soil (entisol).
Level 13 (No. 2)	Massive-bedded, slack-water silt/clay.

of the flood deposits, and draw attention to the capacity of streams to redistribute supposedly diagnostic artifacts, not only on a channel bar but even inside a walled city.

Geo-archaeological Interpretation of the Alzira Profile

The available empirical and comparative data now allow specific facies identification of the Alzira excavation units, as presented in Table 2. Consequently, together with the pottery chronology and construction history outlined previously, the 1980 excavation profile can be comprehensively interpreted in Table 3.

The record of floods and occupations exposed in the 1980 profile is complemented by that of the Bazzana *et al.* (1980) excavations. A 25 cm fluvial sand lense and a 20 cm flood silt lense are found above the 15th century occupation horizon, interbedded at the base of a major settlement phase with lustreware of the 16th or 17th century. Two further silt/clay lenses and a sand lense, each 10–15 cm thick, rest on or are interbedded with the top of this meter-thick occupation level. Finally, there is a 10–15 cm sand lense directly

Table 3. River and settlement history documented by the Alzira profile

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1. Marshy, slack-water micro-environment adjacent to the abandoned meander of the Júcar, characterized by an equitable flood regime with very slow sedimentation and without severe floods. No evidence of adjacent settlement (Levels 12, 13). Represents five centuries or more prior to AD 1021.
 2. Construction of city wall, with excavation into floodplain soil to prepare foundations; backfill includes settlement debris obtained at no great distance (Level 11(b)). Probably between AD 1021 and about AD 1050.
 3. Flood silt and clay is now deposited regularly behind the city wall, but severe floods are not in evidence. Settlement nearby (Levels 10, 11). Mid-11th century.
 4. Moderate-energy overbank silts begin to invade the enclosed city, marking an increase in peak flood discharge and sedimentation. Settlement nearby (Level 9). Fresh trench dug along city wall may reflect on repair work (Level 9(a)). Mid-11th century.
 5. High-energy overbank and channel deposits periodically pass through the enclosed city, reflecting destructive floods. Settlement nearby (Levels 7(c), 8). Late 11th century.
 6. Construction on top of the excavation site, with intensive occupation (Levels 7(a), 7(b)). Late 11th or early 12th century.
 7. Moderate-energy overbank silts cover the now-abandoned occupation surface as flooding resumes (Level 6(b)). Early 12th century.
 8. Major construction of a house (Wall A) andaljibe (Levels 5(d), 6(a)). Mid-12th century.
 9. Moderate-energy overbank silts cover the abandoned house floor as flooding resumes and redistributes the occupation and collapse debris (Levels 5(b), 5(c)). Between late 12th and early 14th centuries.
 10. Reoccupation of house with partial removal of debris, and cutting of pit (5(a)). Late 14th century.
 11. Catastrophic flood or floods sweep through house, subsequently abandoned (Level 4). Major destruction probable within the walled city 16th century.
 12. Catastrophic flood, as great as any experienced before or after (Level 3). 17th century.
 13. Re-occupation of western end of walled city, with foundation debris including penecontemporaneous, moderate-energy overbank silts, indicative of destructive flood(s) (Level 2). 19th century.
 14. Local razing of houses (Level 1). 1970s.
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at the base of the late 19th century settlement soil and atop the debris of the 16th–17th century horizon. The flood lenses above the 15th century level evidently correlate with event 11 in Table 3, while those following the 16th–17th century occupation probably included event 12 of Table 3. The striking 19th century flood horizon in the Bazzana excavations can be linked with that of event 13 in Table 3.

The historical inventory of Júcar floods at Alzira and nearby Carcaixent (Carcagente) (Bosch, 1866; Anon., 1935; Fogues, 1931; Marti, 1960; Oroval, 1974; Casey, 1979:75; Mateu, 1983) includes, between AD 1300 and AD 1900, some 84 years characterized by one or more notable inundations; of these, 18 were sufficiently severe to flood the center of Alzira and Carcaixent, causing considerable and sometimes major damage. Yet only three levels of the 1980 excavation, and six lenses in the Bazzana *et al.* (1980) profile, document major flood events during the same 600 years. This suggests that only the most violent floods have left a record, and that some of the individual flood strata may record two or more events.

Four calamitous floods are documented between AD 1300 and AD 1600. That of 22 October 1406, destroyed an extramural sector of Alzira, while on 30 November 1473, 900 houses were destroyed in the city. On 27 September 1517, several floodplain villages and the extramural parts of Alzira were severely damaged, while on 17 November 1571, the river undercut a chapel next to the San Gregorio bridge. Archaeological dating of event 11 (Table 3), in both the Miralles and Bazzana excavations, points to the 16th century, i.e. either the flood of 1517 or of 1571, or both. Subsequently, the river crested almost 10 m above its banks in 1632 and caused damage comparable with that of 1517, while in late 1672, the Júcar burst its banks 11 times in 3 months. Other floods damaging public buildings within Alzira include 4–5 October 1779; 14 November 1805 (when the San Agustín bridge collapsed); 21 October 1843; and the great disaster of 3–5 November 1864. Event 13 of Table 3 must equate with the 1864 flood, while the flood events encapsulated in event 12 probably include those of 1632 and 1672.

Discussion and Conclusions

The geo-archaeological record of Alzira provides invaluable insights as to the history of the Júcar River since the early Medieval period.

(a) Prior to the early 11th century AD, the hydrological regime of the Júcar appears to have been different from that of more recent times. Discharge peaks were more subdued and severe floods essentially unknown, at least in the urban context of Alzira.

(b) A change of regime was inaugurated during the mid-11th century; flood amplitudes increased systematically, until a series of violent floods wreaked destruction during the last quarter of the 11th century. Major floods continued to affect the walled city well into the 12th, possibly the 13th century.

(c) Only isolated but truly catastrophic floods subsequently left sedimentary evidence: 1517 or 1571, probably 1632 and 1672, and certainly 1864. The geo-archaeological record suggests that the floods of the late 11th century, and of the 16th and 17th centuries, were no less destructive than those of 1864. The recent disaster of 20 October 1983, can be measured against these historical events.

(d) The impact of repetitive severe to catastrophic floods on Alzira, as well as on the productive agricultural lands of the Júcar floodplain, is historically documented. During the 16th century, when the population of other Valencian towns was rising or stable (Casey, 1979: 10–14), that of Alzira declined 12.5% between 1510 and 1609, and then another 17.2% by 1646 [see García (1976) and Halperin (1980) for census figures], while the geo-archaeological record shows that much of the walled city was abandoned after the disasters of the 17th century, remaining vacant until the 19th century. On the flood-

plain itself, some 10 villages were repeatedly destroyed and ultimately abandoned by successive floods between 1517 and 1779 (Escolano, 1610: 907, 967, 974; Cavanilles, 1795: 196–198; Mateu, 1983). No trace remains of them today, their foundations buried by several meters of later alluvium as, for example, represented by the top 3 m of the right-bank Júcar profile below Alzira, or the meter of 1864 overbank deposits near Alberic.

(e) The historical records suggest a change in flood frequencies. From 1740 to 1814 and from 1833 to 1924, destructive floods recurred with a frequency of greater than once per decade. Previously, such floods tended to be clustered, e.g. 1318–1329, 1472–1477, 1589–1632, 1683–1690, and 1709–1716. The implication is a long-term trend after 1740, continuing into the 20th century.

The question remains whether the flood problem of Alzira and its floodplain is a result of climatic anomalies or human impact on the Júcar watershed.

Already in 1635, the Jesuit Pablo de Racsas (document dated 24 April, Archivo Municipal de Alzira) attributed the Júcar flood hazard to an unstable floodplain (a low-gradient, narrow river, actively aggrading) in combination with human modifications (subdivision of the floodplain by irrigation barriers and high canals not only impeded the Júcar from flooding into its natural basins, but also closed the once free-draining convergent streams of the floodplain; additionally, sediment was trapped within the channel by cane breaks of *Arundo donax*). Bosch (1866:356) implicated progressive deforestation in the increased frequency and elevation of Júcar floods, but also cited the negative impacts of irrigation structures.

The present study, and Mateu's (1980) investigation of the tributary valley of the Magro, place the Júcar flood problem in a more complex perspective.

(a) The poorly-drained, clayey floodplain prior to AD 1000 was created by a river mainly carrying clay and silt, deposited during sustained floods but with relatively low peak discharges. This infers a different rainfall pattern, with more frequent but lower intensity precipitation, or a forested watershed, serving to equalize the hydrological regime, or both. The extreme scarcity of archaeological vestiges in eastern Spain that date *c.* AD 450–900 (Palol, 1966; Bazzana & Guichard, 1976) can only be interpreted by very low population densities, prior to the increasing prosperity of the Valencian area during the Taifa era, after 1021. This is confirmed by a dated pollen core from the coastal plain of Castellón, at Torreblanca (Figure 1) (see Menéndez & Florschütz, 1961); here grasses, sedges and disturbed vegetation declined dramatically between about the 2nd and 11th centuries, while oak and pine woodland expanded. The shift to briefer but more violent floods during the 11th century was not unique to Alzira. It can also be observed in the Turia floodplain, under the city of Valencia (excavations of J. V. Lerma in the Calle del Mar), where the major Islamic occupation (11th–13th centuries) begins on top of flood sands and gravels that cover a dark 50–80 cm hydromorphic soil, developed on thick overbank deposits. Although the contemporaneous, 11th century flood horizons in Valencia and Alzira suggest a climatic anomaly, the flood regime never reverted to its original lower-energy pattern. This long-term shift to intermediate or high-energy floods can best be explained in terms of regional settlement expansion and extensive deforestation of the Júcar–Albaida watershed. This would tally with the influx of oxide-stained sand grains, derived from red hill soils of the upper catchment.

(b) During the 16th and 17th centuries, the Magro River deposited some 3 or 4 m of coarse alluvium within its channel and prograded a broad sand/silt fan at its confluence with the Júcar (Mateu, 1980). This alluvium includes bricks, roof tiles, and intact 11th century pots as well as sherds of 16th or 17th century Manises pottery. This debris, in the channel below Carlet, suggests rapid bed-load accumulation in the wake of a catastrophic

flood of the Magro, in 1517, that destroyed 100 houses in that small town. Growth of the downstream fan eventually constricted the Júcar channel and, in turn, promoted active alluviation along the meander belt and convex floodplain of the Júcar between Alzira and Alberic. Significantly, whereas Medieval sites upstream of the Magro confluence are mantled by 1–3 m of recent alluvium, downstream Roman sites are not buried under silt. By stimulating upstream aggradation, the Magro fan created an environment highly susceptible to flood damage, evident in the trend to increasing flood frequency after 1740.

(c) The marked clustering of destructive floods between 1300 and the early 18th century, and the recurrence of as many as 22 flood episodes within a single year (in 1589–1590), testify to climatic anomalies. This is supported by modern observations that floods derived from storms over the upper Júcar watershed normally coincide with sustained, torrential rains across the coastal lowlands (Rosselló, 1972), clearly documented for the disaster of 1864 by Boix (1865) and Bosch (1866). A climatic impetus is also suggested by the clustering of severe flood years in five episodes between 1318 and 1716, not only along the Júcar, but also in the Turia floodplain near Valencia. After 1740, flood events also show cluster patterns, of once every 5 years or less, for 1740–1754, 1773–1808, 1833–1843, 1852–1864, 1879–1884, 1891–1899, and 1906–1924.

In sum, it appears that upstream deforestation during the 11th century, together with progradation of the Magro confluence fan during the 16th and 17th centuries, created an increasingly unstable floodplain, prone to high-amplitude response in regard to extreme rainfalls. Against this background, the direct impetus for periods of recurrent severe floods was given by the frequency of aberrant climatic patterns. Thus, a combination of changing land-use, geomorphologic change, and climatic anomalies must be invoked to provide a full explanation for the behavior of the Júcar River at Alzira during the past millennium.

Returning to the initial premises of this study, the geo-archaeological methodology developed here illuminates the constructional and settlement history of Alzira, and it allows a replicable distinction of fluvial and cultural components by sedimentological criteria. This record also corroborates the historical evidence that catastrophic floods periodically devastated the city, but further shows that settlement was, at least locally, interrupted for long spans, apparently after major flood destruction. Much of the walled city was evidently unoccupied during most of the 13th and 14th centuries, and again from the early 1600s until the late 1800s. Rapid growth of Alzira from 691 households in 1646 to 2100 in 1792 (Cavanilles, 1795:283) was restricted to the “New City” east of the meander (Figure 1). The reasons for this shift of site are probably complex and remain to be examined on the basis of the municipal archives.

Finally, the microstratigraphic detail and dating control of the two test excavations in Alzira, in combination with the historical documentation, serve to illustrate the true complexity of alluvial history, sometimes down to the level of specific flood events, from AD 1000 to the present. This flood record can be explained by watershed deforestation (since the 11th century), floodplain aggradation upstream of the Magro confluence-fan (since the 16th century), and the recurrence of extreme flood events probably reflecting climatic anomalies.

Acknowledgements

Richard Klein (Chicago) kindly identified the Alzira fauna. Illustrations were drafted by Elizabeth Brooks. The 1980 excavations were made possible by a grant from the Diputación Provincial de Valencia, while the laboratory analyses were supported by Lichstern funds of the University of Chicago. But the excavation would not have been possible

without the participants: Augustín Ferrer, Juan Matoses, José Perepérez, Asunción Perepérez and José Aparicio.

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