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CHAPTER ONE

PHYSICAL GEOGRAPHY

Jennifer R. Pournelle

Of all the natural factors that impact (or are impacted by) human activity, to fully understand the multi-millennial settlement history of ancient Sumer (and – perhaps more importantly – to understand what of that history is archaeologically visible), it is crucial to understand the dynamic interplay of water and sediments through rivers and marshes, levees and plains, lagoons and estuaries, and, finally, the sea. For without these elements, much of what came to be distinctly “Sumerian” simply would not have been.

THE LAY OF THE LAND

The physical stage on which the drama of Sumer’s rise was played was set toward the end of the Pleistocene epoch. As the earth warmed, vast rivers fed by melting ice and heavy rains carved their way through the earlier sediments that had infilled the alluvial basin between the Zagros Mountains of Iran and the Arabian plateau. They dumped those sediments into the Shatt al Arab valley, creating the floor of what is now the Arab-Persian Gulf. Throughout the early Holocene, even newer sediments then infilled those channel scours. For the most part, this re-leveled the basin floor – in some places burying the earlier surface beneath tens of meters of alluvial sands and silt; in others leaving older remnants exposed, like turtles’ backs rising above the still waters of a pond. Over time, the interplay of tectonic uplift and subduction with rising and falling sea levels, rivers and floods, and wind-born sand scouring its way across that silty plain shaped and re-shaped optimal zones for a variety of biological (including human) activities.

An unstable foundation

Water drainage throughout southern Iraq is controlled by a great downward flexure that results from slippage of the Arabian plate beneath the upward-thrusting Iranian Zagros Mountains. This slippage forms an unstable shelf upon which Quaternary alluvial sediments were deposited (Aqrawi, Domas, and Jassim 2006) (Figure 1.1a). The topology of this warped bedrock ultimately influences not only hydrology, but also sedimentation, marine incursion, marsh formation, and the likelihood of archaeological sites being preserved and visible at the surface.

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While the *entire* Mesopotamian zone tips slightly from the northwest (at Samarra) to the southeast (at Basrah), its plane is also *twisted* northeast toward the Zagros as it is subducted below the great mass of those mountains. Between Najaf and Kut, it further twists west to east along an oblique fault zone. It then turns southeast to follow the course of the Samarra–Amara divide. Finally, near Zubair (old Basra), it assumes a uniform, north-to-south trend (Figure 1.1b).

Thus, waters of the Tigris, down-cutting as they drop onto the alluvium at Samarra, tend to flow south-southeast, always seeking the lowest ground along the base of the Zagros piedmont. Waters of the Euphrates tend to flow west to east, eventually joining those of the Tigris. Both rivers then empty into the Shatt al-Arab estuary, and continue southwards until encountering the Gulf. The combined outflows, passing southward, are slowed by the Zubair sill, behind which fresh water tends to pond, and to which tidal action extends.

A narrow exit

To the west, the alluvial shelf is defined by an abrupt rise in elevation of 10–20 meters to a Miocene limestone plateau, punctuated by small step faults that are most easily visible on the surface at Hit (Buday and Jassim 1987). During wetter periods and seasons, those faults funnel intermittent streams falling from the plateau, creating sediment fans below their nick points, as is clearly visible for the Wadi al-Khar near Hit (Figure 1.1c). The most dramatic of these fans is that of the Plio-Pleistocene Wadi Batin fluvial cone. During dryer periods and seasons, windborne sand pours down from the plateau, forming dune fields that are pushed south-westward ahead of prevailing winds (Al-Dabi et al. 1997) (Figure 1.1d). In aggregate, these sediments constrain southerly flow of water, reinforcing the Euphrates' easterly trend in its search for an outlet to the Gulf (Aqrawi, Domas, and Jassim 2006).

The Mesopotamian Zone's eastern boundary is sharply demarcated by the folded uplands of the Zagros piedmont. Piedmont sediments, carried downstream during pluvial periods, have deeply buried that boundary in a series of merged alluvial fans that tend to push Tigris waters southward from their southeast-trending flow (Mashkour et al. 2004; Baeteman, Dupin, and Heyvaert 2004/2005). Thus, as the Shatt al-Arab crests the Zubair sill en route to the Gulf, it passes through a sediment-framed bottleneck, where much mixing, scouring, and re-leveling of sediment occurs during river floods and marine incursions.

Alluvial waters and the prograding delta

Understanding the deep structural effects of this twisted bedrock on hydrology and sediment deposition is fundamental to understanding the processes of the twin rivers' metamorphoses through time. From the eighth millennium BC, at their point of emergence onto the alluvium, the Tigris and Euphrates appear *always* to have had anastomosing and significantly intermingled flows. Attempts to reconstruct portions of the major fluvial systems from Samarra to Sippar (Northedge, Wilkinson, and Falkner 1989), from Sippar to Kish and Babylon (Cole and Gasche 1998), in the vicinity of Abu Salabikh (Wilkinson 1990), from Isin and Mashkan-Shapir to Ur (Stone 2002), in the vicinities of Nippur and Wasit (Hritz 2010), and from Nippur and Mashkan-

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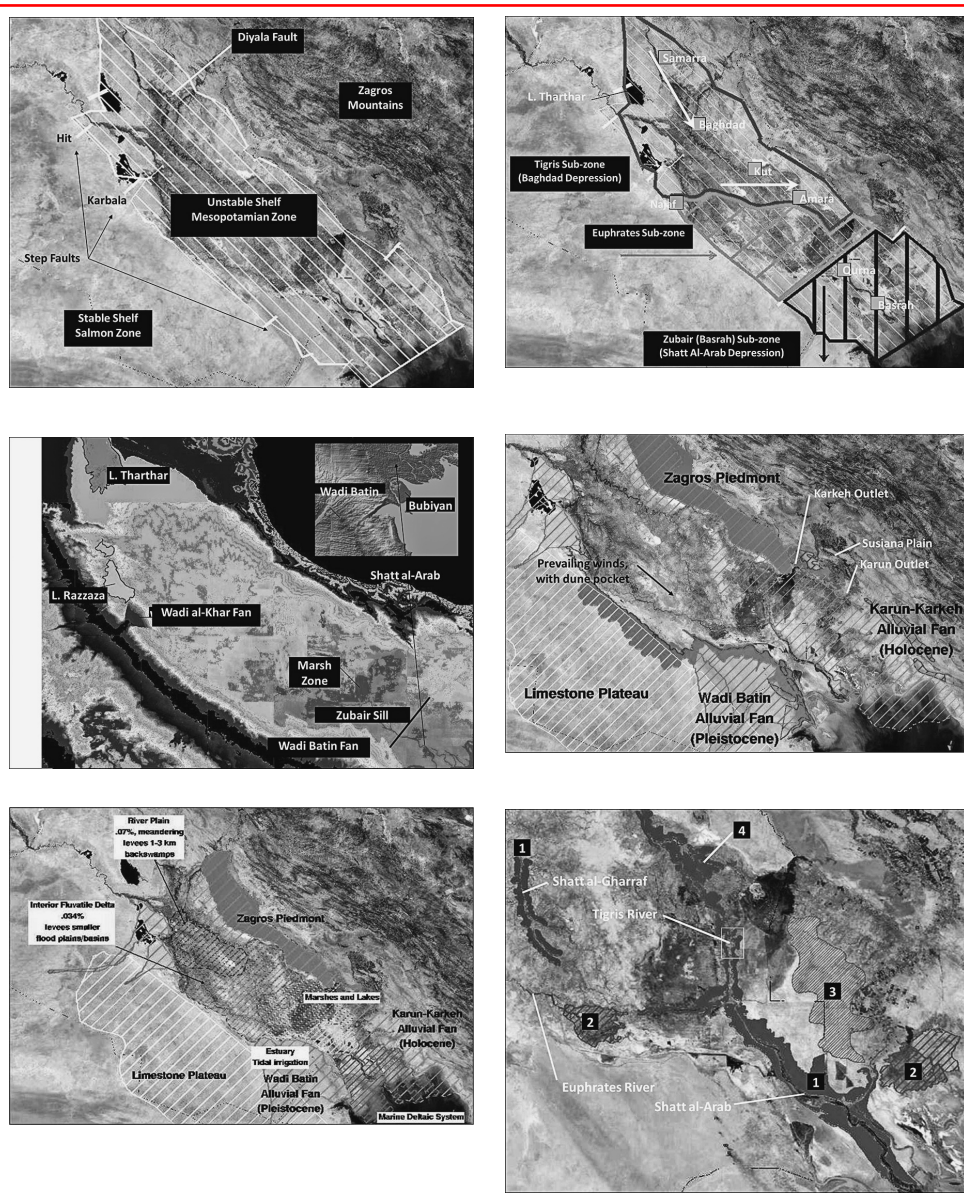


Figure 1.1 (a) The Mesopotamian Zone geosyncline (white hachure) forms where the Arabian plate is forced below the Zagros Mountains. Image: NASA 2001b MODIS. (b) Mesopotamian Zone tectonic subunits. Arrows, hachure indicate tilt direction. (c) Mesopotamian alluvial topology, showing sharp drop to the unstable shelf, and southeast trend tilted toward the Zagros from L. Tharthar to the Gulf. The Wadi al-Khar's alluvial fan tends to push Euphrates water eastward. Fresh water ponds behind, and tidal flushing extends inland to the Zubair sill (black bar). Manually retouched mosaic of NIMA DTEDo 1° quadrangles, with ENVI(tm) 3.5 linear stretch (16:243) applied. (d) Boundary uplands. (e) The Shatt al Arab deltaic system. After Verhoeven 1998, Sanlaville 2003. (f) Contemporary (1) Levees, (2) Crevasse splays, (3) Alluvial soils, (4) Bird's foot delta. Box: see Figure 1.2 Figure 1.2a.

small cap

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Shapir to Uruk (Steinkeller 2001) do not indicate the *proportion* of the Tigris' overall contribution to alluvial settlement and irrigation before the third–second millennium BC. However, there is no evidence that *either* river established its present meandering channel beds at the latitude of Felluja and Baghdad before the early second millennium (Verhoeven 1998: 160; Heyvaert and Baeteman 2008). Even then, at least one branch of the Euphrates still flowed eastward to the Tigris (Gasche and Tanret 1998). How then should we interpret physical evidence for hints of the rivers' earlier evolution?

space

As the surface slope of alluvial channels levels off – either because the land itself levels, or because their channels empty into a large body of water – river beds undergo threshold changes from braided, to meandering, to straight or sinuous, with the latter in some cases assuming multi-channel, anastomosed patterns (Baker 1986: 257–259 and figs. 4–5; Schumm and Khan 1972). Thus, in Mesopotamia, braided channels are typical of the arid uplands, where the Tigris and Euphrates are deeply incised into the Syrian and Arabian plateaus. However, on dropping from those stable shelf lands into the alluvium, the slope abruptly diminishes to less than 1 percent. There, the rivers assume meandering courses through the river floodplain, within fairly stable banks (Figure 1.1e).¹ Over time, as they alternately carve through and re-deposit silts, sands, and gravels, these meanders leave fossil traces up to several kilometers wide, characterized by concentric stripes on their crests (Gasche and Tanret 1998: 5–7). Those contours can be preserved for millennia, due in part to their durable function in shaping subsequent agricultural systems, as they delineate systems of irrigation dikes and levees that both trap silt and demarcate field and crop boundaries. Down the upper Mesopotamian alluvium, such relict meandering systems are visible within the relatively narrow belts of their archaic floodplains (Pournelle 2003a and in press).

This leaves in question whether, where, and to what extent it is possible to associate any relict channels with earlier periods. The Ur III period Tigris/Euphrates admixtures mentioned above could have existed in substantially the same beds for millennia. Conversely, subsequent sediments and channel migrations may have obliterated any (surface) remains. To assess which of these scenarios is more likely, we must first note that, on passing from the slightly tilted Tigris sub-zone to the nearly flat Euphrates sub-zone, the slope falls to less than 0.5 percent. There, along the transecting slip faults, the Tigris and Euphrates rivers tend to branch into multiple, sinuous distributaries with weak banks. From this point southeastward, channels leave few (if any) relict meander scrolls. Instead, connectivity among levees, avulsive splays, and deltaic mouths must be used to chart relict river systems.

Most sediments are dropped in flood deposits along river distributaries, over time building broad, weak levees. Today, the largest of such alluvial levees lines the Shatt al-Arab, where the conjoined rivers form an estuary once famed for its millions of date palms (since destroyed during the Gulf Wars) (Figure 1.1f). Because alluvial soils comprise the best-drained agricultural soils (Buringh 1960; Wirth 1962), direct association of these levees with past agricultural activity is common (Wilkinson 2003) (Figure 1.2a and **b**). Chains of sites situated along their tops can indicate the system date, as for those of the second millennium BC systems of the Third Dynasty of Ur analyzed by Hritz (Hritz and Pournelle in press).

wf

Where weak levees break (or are broken by human intervention), avulsions can become the source of new or diverted main channel flows (Figure 1.2c). However, just as often, the sudden fanning drops sufficient silt that the natural levees reestablish

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when floodwaters recede. Sites located at the *head* of floodplays, where dramatic annual flooding would make permanent habitation hazardous and unlikely, can serve as a *termini post quem* for active inundation from the breach, and thus the system of which they form a part. However, sites located *within* such splays are ideally situated to take advantage of floodbasin cultivation and pasturage (Pournelle and Algaze in press) (Figure 1.2d).

Finally, as rivers abruptly slow on encountering slack water, they dump their remaining sediment loads, resulting in the multiple, bifurcating channels of a “bird’s foot” delta, with newly deposited sediments becoming webs of marshland between the toes (Figure 1.3a). This can be seen at Warka (Uruk), where satellite photos reveal the city’s placement not so much *on* the river as *in* it: the city’s walls are clearly surrounded by a relict bird’s foot delta extending into spring 1968 Euphrates floodwaters (Figure 1.3b).

Through time, this process of channel bifurcation, sediment dumping, and channel extension builds sediment lobes that infill older channels around *turtlebacks* (the isolated fragments of older surfaces that protrude above the floodplain) and contribute to channel-flipping (as distributaries become blocked by their own sediments). To better understand this dynamic interaction of water and sediments over time, we must consider the profound effects of sea level on the hydrological regime.

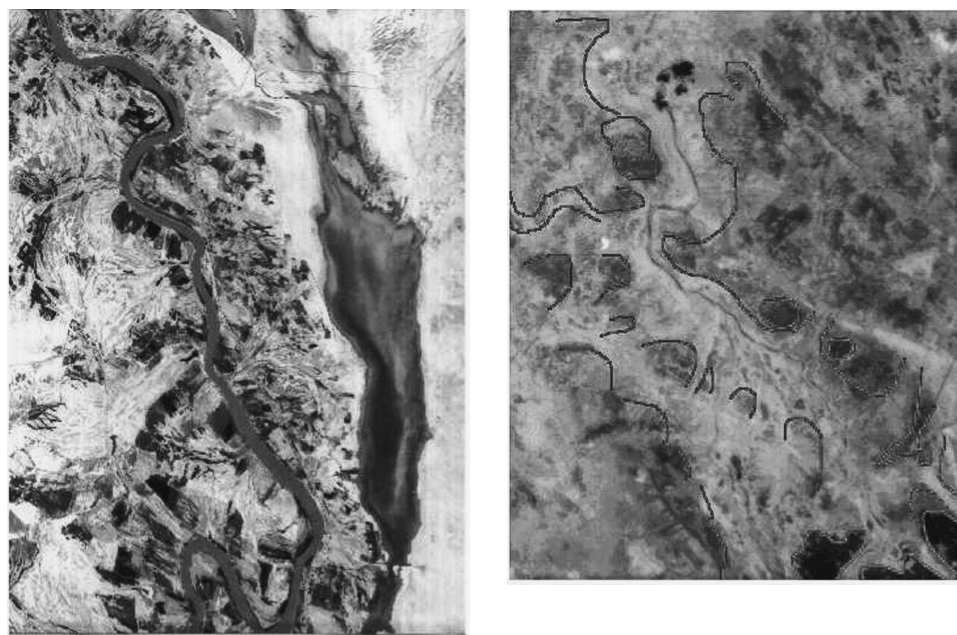
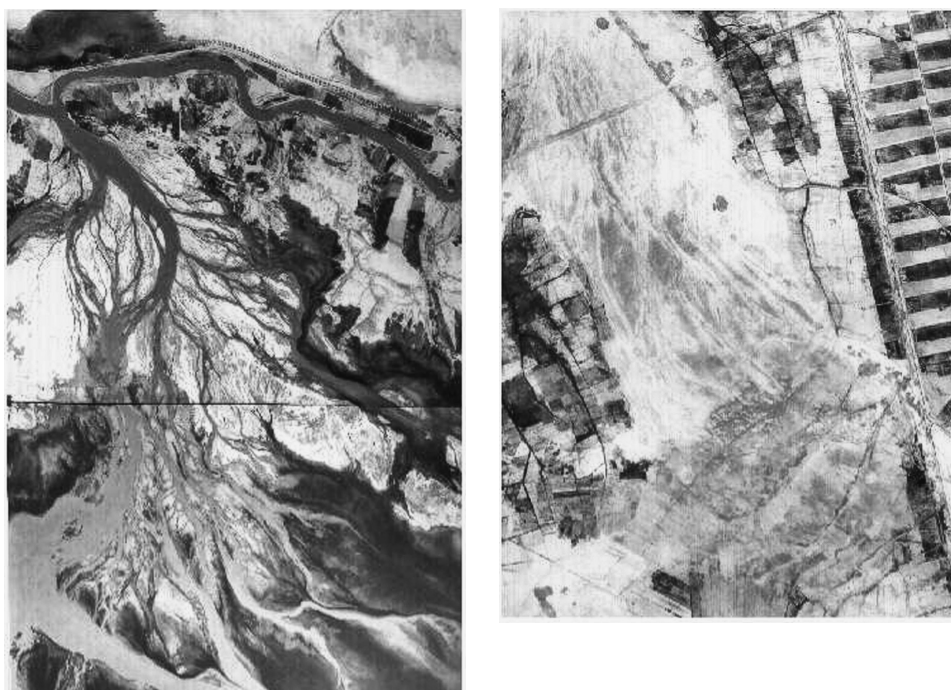


Figure 1.2 (a) Tigris south of Amara (Qalat Salih–al-Azair). The cultivated agricultural zone extends outward from the water channel along the levee system. Excess water drains through light-colored tails of smaller canal levees into seasonal back swamps visible as silty, dark grey bodies. Only two centuries ago these rice fields were year-round marshlands (Westphal-Hellbusch and Westphal 1962: 39–40). (b) Outlines demarcate relict levee between sites WS375 and WS400. Better-consolidated levee soils are less waterlogged, and hence appear lighter in color. KH4B_1103-1A-Do41-055; KH4B_1103-1A-Do41-058 (May 1968).

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Figure 1.2 (continued) (c) The Kut barrage on the Tigris between Sheikh Sa'ad and Ali al-Gharbi drains floodwaters into Lake as Sa'adiya (Haur as Sa'adiya). The barrage maintains and augments a natural avulsion (floodsplay) (compare Buringh 1960: 181). As floodwaters recede, wetland villages (circles) stockpile fodder (reeds and grasses), and transhumant pastoralists graze livestock en route to the Zagros piedmont. (d) Flanked by modern fields, a relict avulsion south of

Wilaya is cross-cut by more recent Parthian–Sassanian canals associated with sites WS901 (Tell Abu Khay) and WS902, dated to the first–second century AD (Adams 1981). Sites (circled) within the splay are unsurveyed, but Stone (2002) dates the relict Tigris watercourse that fed it to Isin-Larsa/Old Babylonian (second millennium BC). CORONA KH4B_1103-1A-Do41-050/51; KH4B_1103-1A-Do41-052 (May 1968)

In describing the environmental setting wherein Sumer came to be, the significance of sea level rise is often misunderstood. Neither identifying “the” shoreline at a specific year nor deciding where sites and settlements might have been drowned is of paramount importance. In terms of human habitation and environmental exploitation, the ocean’s rise and fall is most significant in its see-saw effect on the rivers’ debouchment into the Gulf. When ocean levels drop, the rivers’ gradients increase and their water flow speeds up, leading to upstream downcutting, and downstream sediment dumping, that rapidly builds out (progrades) the rivers’ alluvial fans. When sea levels stabilize, head-to-tail slope levels off, and the rivers slow. As they do, more sediment accumulates within their floodplains, along their levees, and across their existing deltas, creating ideal conditions for formation of freshwater marshlands and brackish estuaries.

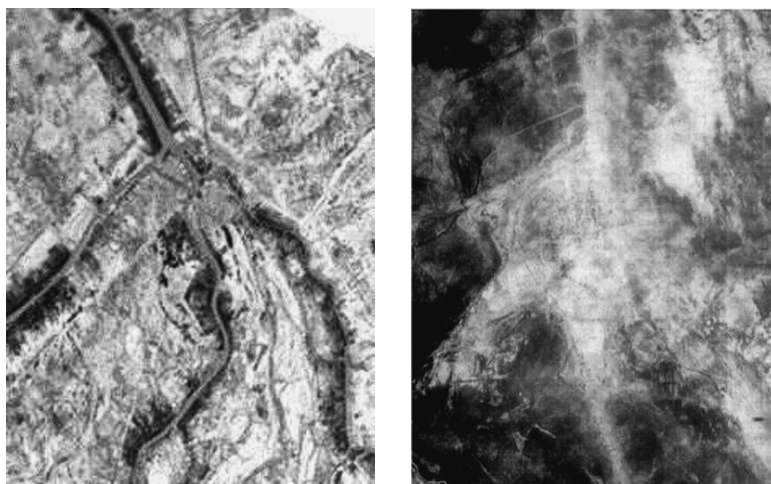
— *Physical geography* —

Figure 1.3 (a) Amara, straddling Tigris distributaries arrayed in a bird's foot delta extending into surrounding marshlands (Buringh 1960: 187). (b) Warka (ancient Uruk), straddling a relict bird's foot delta extending into spring Euphrates floodwaters (black). As late summer heat dries surrounding marshes and lowers the water table, lower areas and infilled drainage are marginally wetter, and therefore darker. Less permeable, higher, and dryer built-up areas, levees, and consolidated canal beds appear lighter in tone. CORONA KH4B_1103-1A-Do41-065 (May 1968); KH4B_1107-2170DA-139 (August 1969).

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Marine incursion, backswamps, marshes, and estuaries

From the early Holocene, after rising at a (geologically) “rapid” rate of about 1.8 cm per year for two millennia, by 6150 (cal) BC the head of the Arab-Persian Gulf reached approximately its current level. For the next three centuries, throughout the ‘Ubaid o, that rate slowed. At that time, ancient marshes extended as far southeast as Tello (Girsu), and the rivers laid down sediments in the Euphrates Valley from Ur to Fao (Bird et al. 2010; Aqrawi and Evans 1994; Aqrawi 1995; Hritz, Pournelle, and Smith 2012a). For the next four centuries, as sea level rise slowed to a near halt, the delta expanded, and marshes continued to form. Following this interim stillstand, by 5450 (cal) BC, sea level rise resumed at a rate of a half-meter per century (a half-centimeter per year), and continued to do so for the next millennium.

Through the remainder of the ‘Ubaid, the sea rose another 2–4 m, reaching a highstand of approximately 2.5 m above that of today. By 4550 (cal) BC, the sea had completely swamped the Euphrates Valley and the ancient marshes, and extended as far inland as Ur (Figure 1.4, Figure 1.7). Thus, at the dawn of the Uruk period, the Gulf having halted at its maximum level, the rivers began another round of marsh- and delta-building, stretching inland at least as far as the foundations of Uruk itself (Aqrawi 2001; Brückner 2003; Plaziat and Sanlaville 1991). Sea levels remained stable throughout the Uruk and Jemdat Nasr, regressed slightly at the beginning of the Early Dynastic, and then returned to their highstand. That eustatic stability over roughly two millennia had profound implications for that area called “the heartland of cities” by Robert McC. Adams in his definitive 1981 study (Adams 1981). Before Adams, the

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presumption that cities arose on the Mesopotamian alluvium *because of* mastery of irrigation technologies, with concomitant increases in grain (especially barley) production. Adams envisioned a more complex urban hinterland, comprising grain agriculture, livestock husbandry, and exploitation of marshes and backswamps, all important to urban survival, but in that relative order. Nevertheless, he opposed the more certain views of those who would, for the Sumerian case, reverse those relative roles, placing a *deltaic* heartland at the Sumerian core (e.g. Oates 1960).

Mighty winds: aeolian deflation and site visibility

Whence came this enduring presumption that irrigation went hand-in-hand with Sumer's emergence? Aside from the obvious (that early cities now lie scoured by arid winds in a desert landscape), undue reliance was placed on two bodies of evidence.

The first of these was textual. Because the earliest towns and cities were pre- or proto-literate, insight into their organization and social relations was sought in cuneiform texts from much later periods. Related to this, because early excavations were primarily concerned with delineation of architecture and recovery of objects, little or no environmental evidence was observed or recorded. Thus, any discrepancy between evidence for the physical environs of early Sumer, as compared to that a millennium or more later, went unnoticed. The second was the corpus of data derived from extensive archaeological surface surveys. Seeking to understand the origins and development of civilizations in the alluvial lowlands of the Tigris, Euphrates, and their tributaries, over the course of two decades scholars conducted broad-scale regional settlement surveys that located, recorded, and dated thousands of archaeological sites. Guided by the later texts, they then attempted to associate these to relict water courses that intricately lace the region (Adams 1981, 1965; Wright 1981; Adams and Nissen 1972; Gibson 1972; Ur, this volume). Prior to these studies, it had been generally thought that heavy alluvial deposits over the lower Mesopotamian alluvium would have made it impossible to determine the origins of deeply buried cities (Nützel 1978). However, the surface surveys showed that this was not necessarily the case. In some cases, wind erosion periodically re-exposed long-buried artifacts that, when systematically collected, dated, mapped, and plotted with reference to ancient canal traces, revealed a distinct pattern of urbanization and extension of irrigation technology over a period of five millennia.² The surveyors thereby constructed a broad view of long-term settlement patterns and demographic change in the Mesopotamian lowlands from the beginnings of settled towns to the present day. Adams' work is especially well known for its clarification of how the natural environment of the area affected human life, what changing strategies Mesopotamian societies used throughout history to adapt to that environment, how successive Mesopotamian societies transformed that environment, and what selective environmental pressures existed in the region that favored the development of the world's earliest urban societies (Adams 1981).

Nevertheless, the results of these efforts must be interpreted with care for several reasons. Most obviously, those surveys were conducted within bounded areas. Anything outside those boundaries remains, comparatively speaking, archaeological *terra incognita*. Second, following Jacobsen's attempt to reconstruct the main watercourses of ancient southern Mesopotamia from textual sources (Jacobsen 1958), and *presuming the necessity of irrigation*, Adams undertook his survey in large part *to identify* waterways

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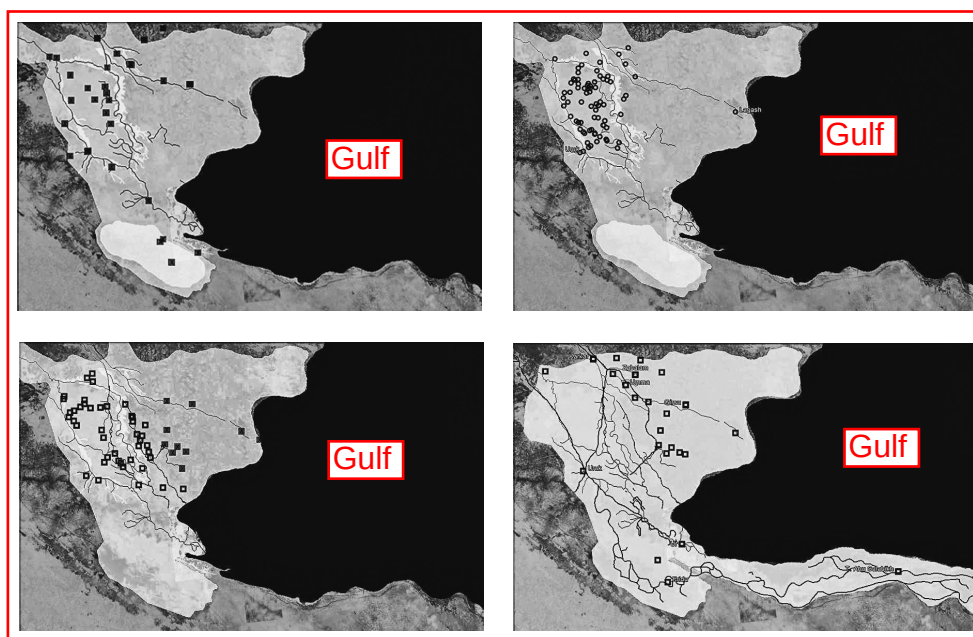


Figure 1.4 The Mesopotamian Delta, c.5000–3000 BC. (a) Maximum marine transgression coincides with the ‘Ubaid 4–Early Uruk transition c.4500 BC, leading to formation of a (freshwater) inner delta in the “heartland” basin, and freshwater lagoon in the Eridu basin, transitioning to a fresh–brackish mixing zone and outer delta in the East Gharraf basin. *Visible* sites of this era are situated either on turtlebacks, or within the deeply deflated areas of the “heartland.” (b) Sites newly visible as of the Middle Uruk. Sites are clustered where the rivers meet and freshwater marshes would become perennial. (c) Sites newly visible as of the Late Uruk–Jemdet Nasr. These follow the prograding delta to the southeast – up to the eastern margin of the surveyed zone. (d) Sites as of the Early Dynastic. The cluster to the northeast may indicate a new delta lobe. Any other sites to the east or southeast would fall outside of the surveyed area.

and canals, using extensive ground survey and aerial photography (Pournelle 2007). And, while in some areas he documented hundreds of deserted canals associated with archaeological sites, he merely *hypothesized* linear connections among many others – *especially for those of earlier periods, for which no direct evidence was visible*.³

Finally, even within the survey boundaries, *sites were unevenly exposed*. As noted, they are apparent at all because of aeolian deflation of later river and canal levees, which formed dune fields that then scoured their way across the plain. In some cases, this destroyed archaeological sites entirely. In others, it barely scraped the top of the surface, revealing more recent material, but leaving the older foundations buried. In still others, it buried sites utterly—or, alternatively, left archaeological features pedestaled above the deflated surface, standing on columns of sediments protected from deflation by archaeological debris (Wilkinson 2003; Pournelle 2003b).

Thus, while the corpus of archaeological survey data for Mesopotamia succeeded in adding a corrective rural and non-literate dimension to the predominantly urban, literate, elite focus of previous excavations and cuneiform texts – which texts themselves have long influenced interpretation of the archaeological data – we must now

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consider the implications of the facts that inside the “heartland” survey zone we are left with an uneven patchwork of exposures, while outside it we know only a few major mounds plotted by Iraq’s Department of Antiquities.

URBAN TRENDS

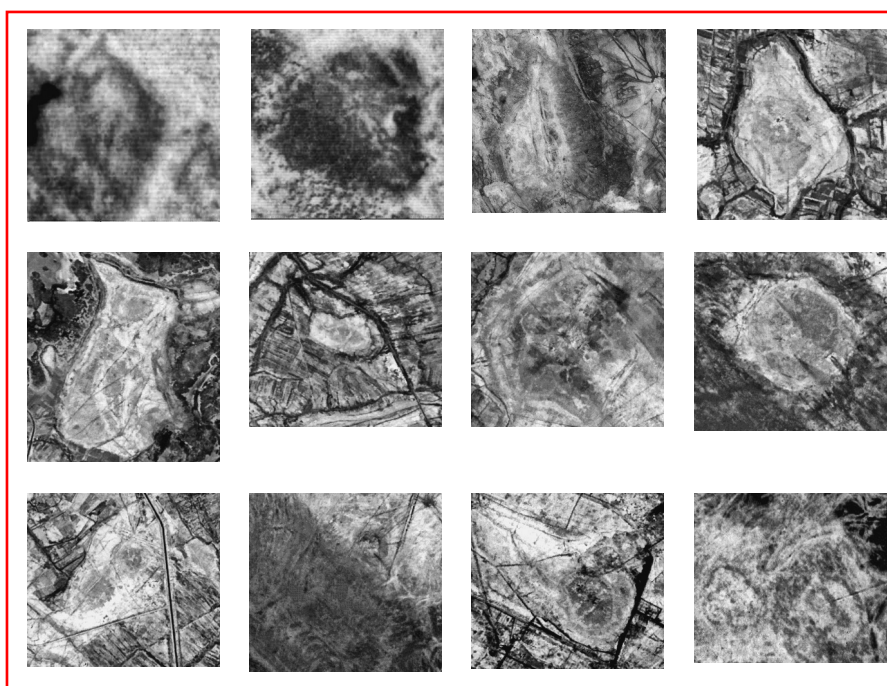
Early foundations: the ‘Ubaid

During the Neolithic Ubaid o (6500–900 BC), archaeologically visible early villages in the southern Mesopotamian alluvium were concentrated on river levees at locations bordering swamps and marshes. Many of these early sites continued to be occupied into the Chalcolithic Ubaid 4 (4900–3500 BC), accounting for half of the sites known in the Warka and Eridu survey areas for that period. Of the newly founded sites, all but one were situated on exposed surfaces of Pleistocene “turtlebacks” that once overlooked anastomosing distributaries subject to seasonal flooding. Innumerable smaller, scattered sites may be buried beneath the Holocene deposits. These Ubaid towns presaged an explosion of newly visible sites founded during the Early Uruk period, when virtually all identifiable turtlebacks became inhabited (Safar, Mustafa, and Lloyd 1981; Huot et al. 1981; Pournelle 2007) (Figure 1.4a, Figure 1.5).

4900 BC

4350 BC

Mustafa



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Figure 1.5 Sumerian cities founded within marshlands. Uruk straddles a bird’s foot delta; Bad Tibira fronts a marsh edge. The rest surmount turtlebacks. WS 125, Umma, WS230, ES156: USGS CORONA May 1968. All others: NIMA SPOT 1991. Scales approximate.

— *Physical geography* —**Urban emergence: Uruk and Jemdet Nasr**

Administrative texts from the earliest protoliterate lexical lists onward indicate that, for the vast majority of the working population, the primary dietary protein source was dried fish (Adams 1969: 48; Adams 1981: 142; Englund 1998: 94).

Two relict 5 km-wide levee systems extend through the now-arid plain north of Uruk (Figure 1.2c). One runs south-southeast to a series of distributaries dissipating into relict marshland.⁴ Particularly clear is a section showing relict back swamps and off takes for near-levee cultivation (Figure 1.2b). The thin, black line of the **Shatt al-Khar canal** is all that remains to indicate that a **once-mighty watercourse** – a channel the size of one of the marsh-feeding Tigris distributaries south of Amara (Figure 1.3a) – once flowed here. The second levee underlies the **Tullul al-Hammar/Banrat al-Hassan canal**; again, a waterway of historical date (and proportions) that could not have built the levee atop which it runs. This would appear to have been the main water supply into Uruk, conspicuous by its desiccation after Old Babylonian times, when the city fell into decline.⁵ Southeast of the city, they joined into a combined outflow, passing through an estuary zone or brackish marsh en route to the sea near Ur (Aqrabi 2001).

Along this building Uruk–Ur levee system, tidal flushing would have influenced cultivation regimes as far inland as Uruk itself, encouraging date palm and levee garden crop production. This would have been accompanied by at least seasonal marsh formation over all but the highest ground of the Warka and Eridu survey areas, as the outlets of the combined Tigris and Euphrates discharge became flooded, slowing drainage. However, intensification of cattle-keeping in riparian and littoral habitats also would have steadily degraded browse and the watershed, necessitating intensified fodder gathering and production (Belsky 1999).⁶

Late Uruk (Uruk IVA) seals, sealings, and tablets excavated at Warka depict palms, frogs, livestock emerging from reed byres, and hunting scenes with pigs stalked among reeds. Many tablets show the clear imprint of the reed mats upon which they lay as they dried (Boehmer 1999: 51–56, 66–67, 71–74, 90–104). Contemporary protoliterate lexical lists include dozens of ideographs for reeds and reed products, waterfowl, fish, dried fish, fish traps, dried and processed fish flour, as well as those for cattle and dairy products, and fifty-eight terms relating to wild and domestic pigs. The slightly later “professions” lists record offices including “fisheries governor” and “fisheries accountant” that endure one and one-half millennia (Englund 1998).

Ports and harbors: early dynastic

Beginning with the southernmost reaches of Sumer, broadly speaking, three urban zones frame the surveyed portions of the **Eridu basin** below the Euphrates: the temple complex at Eridu, the excavated port city of Ur, and **ES34**, an Isin-Larsa-Old Babylonian city. More precisely, Wright’s survey of the basin was circumscribed to the west by a remarkably well-preserved levee, topped with meander scrolls and channel bars etched in sharp relief, into one bend of which ES34 seems tucked away (Wright 1981). Clearly, this levee has a complicated history, as does the basin through which it wends. Pocketed with wadi sediments washed down from its ringing escarpment, scoured and layered with sands blown down from the Arabian shield, alternately flooded by winter rains, and parched by summer sun, the Eridu basin comprises a complicated patchwork of new sediments, old surfaces, and migrating dunes.

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Southeast of ES34, beside the fragments of older sediments, lies ES156, a city that appears to have prospered during the early third millennium (Figure 1.6a). On the mound itself, surface survey turned up Jemdet Nasr–Early Dynastic material, while surrounding lands were littered with flint sickles, once presumed to have been used for grain harvesting. Yet the configuration of this city’s hinterlands does not suggest anything like the regularity of plowed fields, nor communities dependent upon irrigated cultivation. Rather, the surrounding geography suggests the former marshy basin setting of Turaba–Abu Dakar in the al-Khuraib (East Tigris) marshes, with water that floods over and seeps through weak levees, slowly draining southward to eventually rejoin the fluvial system (Figure 1.6c). Closer views bolster this impression of former dendritic water channels infilled with dry sand (Figure 1.6b). At very high resolution, it suggests waterways connecting marshland towns to the clusters of houses and byres built by wetland cattle-keepers who harvest thousands of tons of reeds and rushes for mat-weaving, fodder, fuel, and construction material to meet both local need, and those of urban brokers on the marsh fringes (Figure 1.6d, e) (Salim 1962; Westphal-Hellbusch and Westphal 1962). No excavations have been conducted here, but at nearby Sakheri Sughir, *Phragmites* phytoliths have been recovered from contexts suggesting the use of this reed as livestock fodder during the Early Dynastic I period (Miller-Rosen and Weiner, 1994; Miller-Rosen 1995 and personal communication 2003, 2011).

Within the “heartland” north of Uruk, throughout the Early Dynastic, average aggregate site area increased, even as the number of settlements fell. This trend toward fewer, but bigger, settlements is explainable not only as a phenomenon of population being drawn in from immediately surrounding, drying wetlands, but as the visible part of the ongoing deltaic progradation cycle. Beyond the eastern limits of the survey area,



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Figure 1.6 (a) Hundreds of thread-like channels, 1.5–10 meters wide, extend between ES156 and surrounding desiccated wetlands, suggesting levee cultivation combined with intensive marshland exploitation.

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early sites become nearly invisible, buried beneath the unsurveyed sediments along the Shatt al Gharraf. What few are recorded suggest that this delta-following settlement process, with concomitant consolidation of urban centers behind the advancing band of smaller settlements, continues forward (Figure 1.4d). The advancing sediment lobe was bounded by what would in Old Babylonian times become a canal, following a sweeping arc from Bad Tibira to Larsa (Steinkeller 2001). At this earlier time, it would have facilitated boat traffic passing from settlement to settlement across the edge of the marshy zone. Later, once the climate dried, the sea level dropped, and the delta protruded further into the estuary zone, waterways extending southeastward maintained connections back to the urban core. As smaller settlements shifted southeastward, out

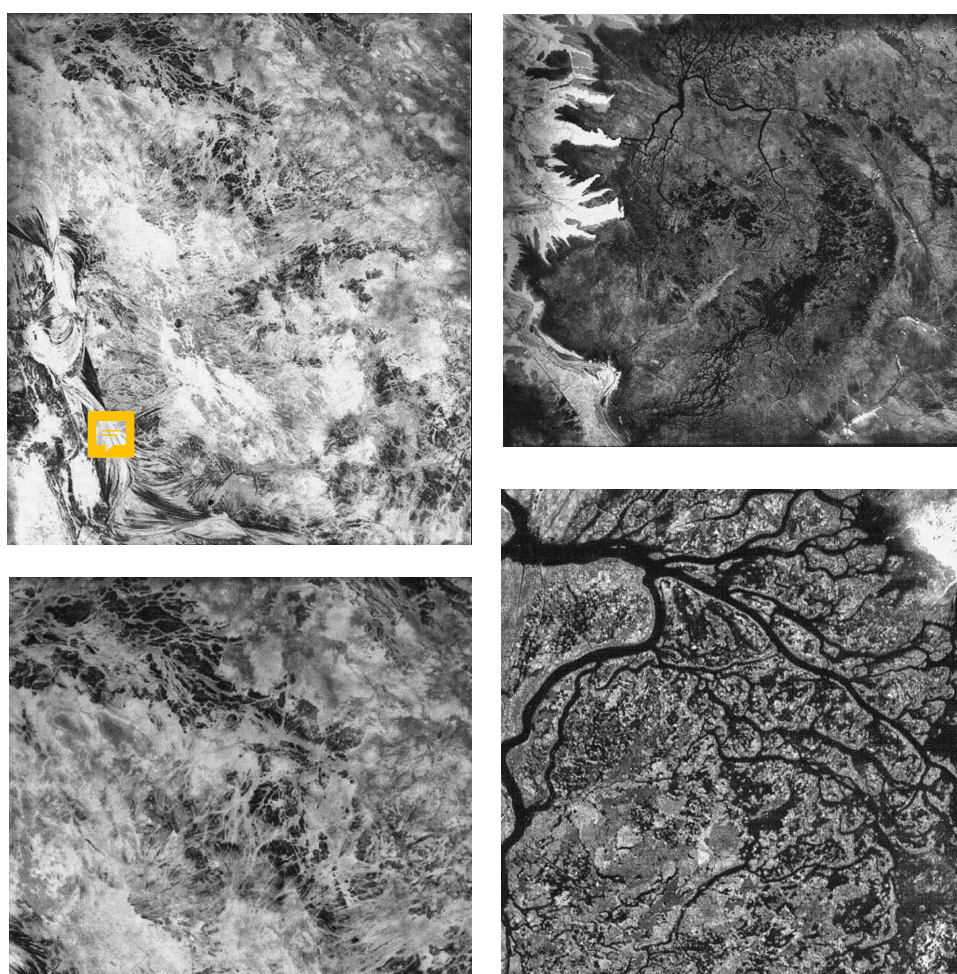


Figure 1.6 (continued) (b) ES156 in the Eridu Basin. (c) Abu Dakar in the al-Khuraib (Tigris) marshes south of Amara. Water overtops banks and leaks through weak levees, eventually rejoining the fluvial system (arrows). (d) Desiccated water channels (white) infilled with dry sand skirt EP156. (e) Dendritic water channels (black) through reed beds skirt Abu Tanam. CORONA May 1968.

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of the surveyed area, following the littoral zone, the integrated centers remained behind and grew, supplied by a forward-expanding hinterland. This model is consistent with calculations that show high rates of settlement founding and abandonment in the Uruk region for the Late Uruk, Jemdet Nasr, and Early Dynastic I periods (Pollack 1999: 73, Table 3.2).

East of the Warka survey area, an ancient levee, cut by modern canals, extends into a flooded marsh. To its south, each year Tell al-Hiba – ancient Lagash – becomes a seasonal island surmounted by multiple occupation mounds. Scattered with kiln debris are small rises on the western margins of “a large, roughly semicircular area that has the appearance of a dry lake bed . . . flooded at various times in the past by the marsh, and as a result covered with a thick layer of dried mud that buried most of the artifacts” (Carter 1990: 61). A deep sounding through this rise, much disturbed by later cuts and pits, found 7 meters of Early Dynastic I trash above the (obviously high) water table (Hansen 1978: 76). Later surface survey turned up a few upcast Uruk sherds, indicating the possibility of earlier occupation (Carter 1990: 61), but the lack of significant quantities of surface material older than late fourth millennium is consistent with a mid-Holocene marine transgression that either precluded permanent habitation altogether, or confined it to relatively small areas, not subject to seasonal inundation, now deeply buried beneath subsequent debris. Even

the extent of the Early Dynastic city is difficult to estimate. No city wall has been discovered, and a significant portion of the ancient ruins lie below the reed-covered marshlands that surround the site on three sides. The central area of the site extended west . . . but it is now covered by the marsh. One mound, now cut off from the rest of the site by water, was found to be covered with sherds of Early Dynastic date. Through most of its history, and particularly in the Early Dynastic period, Lagash, al-Hiba, had a flourishing ceramic industry. This was perhaps due to the proximity of fuel from the marshes.

(Carter 1990: 62)

During the historical Early Dynastic III period (2600–2350 BC), at the height of Lagash’s power, sea levels once again rose to one meter above present (Bird et al. 2010s, Sanlaville 1989, 2003; Potts 1997: 33). Scattered beach rock indicates proximity of a shoreline (Hritz, Pournelle, and Smith 2012b). Faunal remains included not only several species of mollusk shell used in jewelry manufacture, but also two of marine fish, as well as edible conches and bivalves, and six types of waterfowl including duck, flamingo, gull, coot, cormorant, and spoonbill – the latter three particularly preferring open marshes, shallow lagoons, and estuarine mud flats (Carter 1990; Kenoyer 1990: 67; Mudar 1982: 29–30, 33–34). Later third–second millennium BC (land) itineraries from Sumer to Susa run first northwest to the Diyala region, then southeast to their destination, suggesting a requirement to circumvent a marine incursion (Leemans 1960).

Among deltaic cities, Lagash – although probably well above the mean – was hardly unique in its littoral reliance. Among other finds indicating its importance as a port, cylinder sealings from the ED I Seal Impression Strata at Ur depict reed structures (Amiet 1980 [1961]: 333–344), cattle fed in and lead from reed byres (ibid.: 337, 342, 344); personages poled along fish-filled watercourses in high-prowed boats (ibid.: 300), fishing from small watercraft (ibid.: 310), and persons carrying tribute of fish and

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waterfowl (ibid.: 302, 303). ED III texts found in Girsu of the é-mi household, headed by the wife of the ruler of the state of Lagash, detail produce from a number of dependent laborers, including fishermen. Renamed the é-Bau under Urukagina of Lagash, of the approximately 1,200 members of the productive household, 100 were listed as fishermen, and another 125 as oarsmen, pilots, longshoremen, and sailors (Maekawa 1974; van de Mieroop 1987). Economic activities included fresh- and salt-water fishing, and fish and dried fish brought into the household were both deposited in the store-room and issued as purchase goods to merchants acting on behalf of the household (Postgate 1994: 114, 202).

This accumulated evidence suggests that, while palm groves, gardens, temples, kilns, and other institutions were consolidated on turtlebacks and levees away from seasonal inundation (by peoples well accustomed to thorough exploitation of wetlands), concomitant with intensified agricultural production, reed and other marsh products were also intensively harvested to underwrite urbanizing consumption. The multiple canal off-takes cutting through the relict levee abutting site ES156 clearly directed water flow into the alluvial basin adjacent to the site – but *not* into any apparent field irrigation system. Instead, the water flow seems designed to augment catchment into what is now a desiccated wetland. The surface morphology of the area is directly comparable to desiccated habitation areas on the seasonally inundated edges of massive, permanent marsh reed beds such as those of the al-Khuraib marsh south of Amara (Figure 1.6).

Separating the twins: UR III and beyond

By painstakingly reconstructing late third millennium BC travel and shipping itineraries from the city of Umma, Piotr Steinkeller has shown that a watercourse thought by textual scholars to represent “the eastern branch of the Euphrates” (Jacobsen 1960) was known at Umma as the Tigris (Idigna) – but the major channels of the twin rivers still flowed so closely together that direct interconnection was maintained, possibly just south of Mashkan-shapir (Steinkeller 2001).⁷ At Umma itself, texts show clearly the continuing importance of marshland resources like reeds (Steinkeller 1987), fish (Englund 1990), fowl, pigs, and even trees (Heimpel 2011). They also record quotas for production of marsh-based products like reed, bitumen, boats, mats, and standardized fish baskets (de Genouillac 1920: 603–606). However, upstream, the primacy of Isin, Kish, and Babylon during the early to mid-second millennium BC demarcates progressive westward (Euphrates) and eastward (Tigris) channel succession. As the climate dried and became more seasonalized, that succession privileged the (to those cities, proximate) Euphrates as a source of irrigation water, fostering the pearls-strung-through-the-desert view handed down through later historical periods (Figure 1.7a).

CONCLUSION

A hallmark of nineteenth-century beliefs about non-urban landscapes was that marshes are inherently diseased, sodden wastelands, and that the appropriate effort of good government was to transform them into cultivated agricultural land. This emphasis on the importance of transforming “waste” marshes for “useful” agricultural endeavor was especially operative during the formative period of Mesopotamian archaeology.

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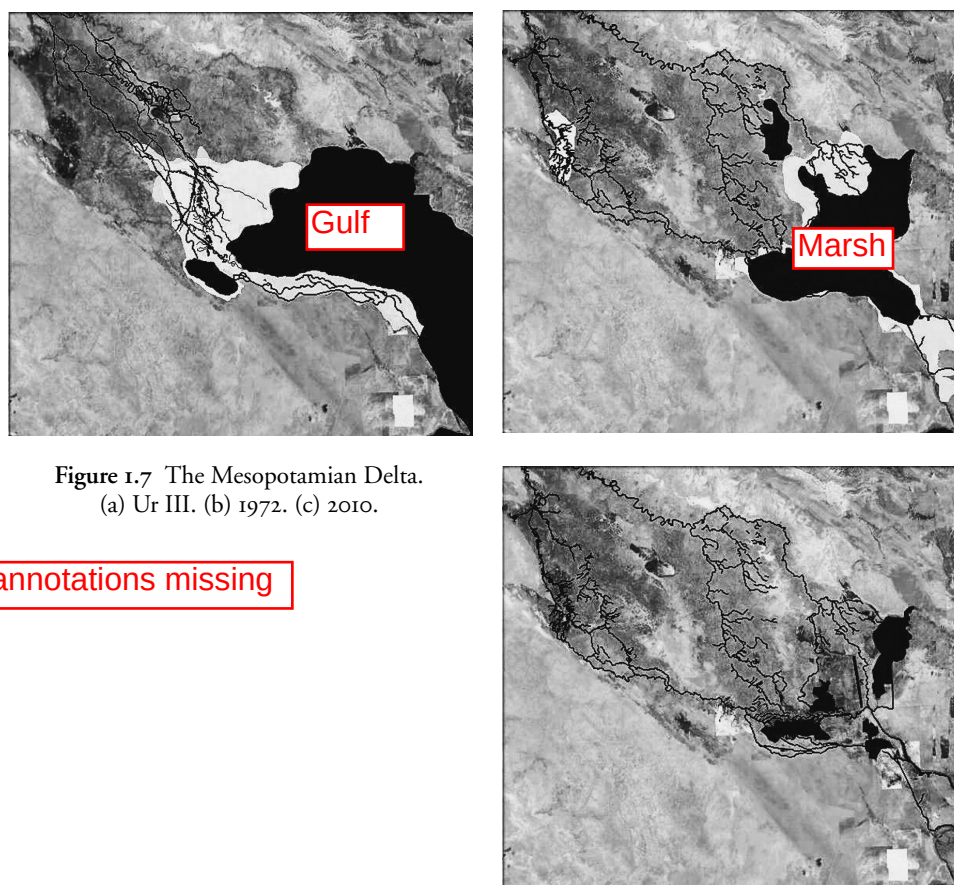


Figure 1.7 The Mesopotamian Delta.
(a) Ur III. (b) 1972. (c) 2010.

annotations missing

Through the mid-twentieth century, it was embedded in an outlook that viewed the birth of Mesopotamian civilization as inherently tied to the drying of primordial lands, accompanied by state (or temple, or household) administration of irrigation systems and plow agriculture. In Iraq, in the closing decade of the twentieth century, that belief played a major part in the destruction of nearly 20,000 km² of wetlands that for centuries prior had directly sustained between a quarter- and half-million people (and indirectly many times that number) – in exchange for a few poor years of agricultural output, now abandoned (IMOS 2006; Chen et al. 2010; Garstecki and Amr 2011) (Figure 1.7b and c).

However, as we see in this brief review, we cannot extrapolate the origins of Sumerian urban centers from an irrigated version of the modern desert landscape. Marshy deposits underlay or surrounded the earliest occupation layers of all early urban sites. Those cities are better imagined as islands embedded in a marshy plain, situated on the borders and in the heart of vast deltaic marshlands (Figure 1.5). Their waterways served less as irrigation canals than as transport routes. The essential nature of those wetlands in supporting and shaping the complex social institutions that underlay urbanization in southern Mesopotamia is evident from the earliest protoliterate accounts. For example, the predominance of reeds, reed bundles, and reed structures

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points to their significance to early Sumerian economies. Indeed, it may well yet be shown that reeds themselves had lasting importance, not only as a commodity per se, but also in the ways the demands of their production structured urban-centered labor control over their marshland hinterlands.

Thus, the image of urban beads strung along life-giving filaments of rivers and irrigation canals came later. The millennial-scale stability of the earliest centers was contingent upon the vicissitudes of human interaction with natural processes of deltaic progradation. The inner delta in which those cities first formed and grew moved on southeastward, following the drop in sea level (Figure 1.4). Collectively, urban residents had few choices. They could find new settlements, further afield, to extract wetland resources; they could invest in ever-more-extensive irrigation systems, in order to emulate that innate wetland productivity; or they could simply move on. It is a set of choices, and a set of processes, that endures to the present day.

NOTES

- 1 See Verhoeven 1998: 175 (fig. 3) on the interaction of sediment load with stream power, flow velocity, and gradient to determine channel pattern and stability.
- 2 Discussed in detail in Wilkinson, 2003, Chapter 5. See especially Figure 5.7.
- 3 Adams' original periodized maps must, therefore, be used with caution and detailed attention to the accompanying text. It is not always clear which lines are hypothetical, which observed on air photos, which observed on the ground and presumed associated with nearby sites, and which actually tested for association.
- 4 WS: Warka Survey (Adams and Nissen 1972); NS: Nippur Survey (Adams 1981); ES: Eridu Survey (Wright 1981).
- 5 Crucial to its dating is determining if and when it supplied water to the "northeast-southwest canal" through the city (Finkbeiner 1991: table 19), or to Uruk-period brick canals excavated in the Eanna precinct (Hemker 1993 I: 39–42; II: 138–146). That it is of at least second millennium BC date is suggested by Ur III itineraries linking Uruk to Shurrupak (Steinkeller 2001).
- 6 The riparian regime appears to have been relatively stable until at least the late third millennium BC, when the Euphrates bed appears to have flipped into the channel skirting the Eridu depression (Figure 1.4d). This channel, as well as the immense overburden of the Ur levee, could well obscure older sites.
- 7 Stone (2002) critiques details of Steinkeller (2001), but agrees that the "Eastern Euphrates" attested in third millennium BC texts was in fact a Tigris distributary.

REFERENCES

- Adams, Robert McC. 1965. *Land behind Baghdad: A history of settlement on the Diyala plains*. Chicago: University of Chicago Press.
- 1969. *The Evolution of Urban Society*. Chicago and New York: Aldine.
- 1981. *Heartland of Cities: Surveys of ancient settlement and land use on the central floodplain of the Euphrates*. Chicago and London: University of Chicago Press.
- Adams, Robert McC. and Hans J. Nissen. 1972. *The Uruk Countryside: The natural setting of urban societies*. Chicago and London: University of Chicago Press.
- Al-Dabi, H., M. Koch, M. Al-Sarawi, and F. El-Baz. 1997. Evolution of sand dune patterns in space and time in north-western Kuwait using Landsat images. *Journal of Arid Environments* 36: 15–24.
- Amiet, P. 1980 (1961). *La glyptique mesopotamienne archaïque*. Paris: Editions du CNRS.
- Aqrabi, A. 1995. Correction of Holocene sedimentation rates for mechanical compaction: the Tigris-Euphrates delta, lower Mesopotamia. *Marine and Petroleum Geology* 12 (4): 409–416.

— Jennifer Pournelle —

- Aqrawi, Adnan A. M. 2001. Stratigraphic signatures of climatic change during the Holocene evolution of the Tigris-Euphrates delta, lower Mesopotamia. *Global and Planetary Change* 28(1-4): 267-283.
- Aqrawi, Adnan A.M., and G. Evans, 1994. Sedimentation in the lakes and marshes (Awhar) of the Tigris-Euphrates delta, southern Mesopotamia. *Sedimentology* 41: 755-776.
- Aqrawi, Adnan A.M., J. Domas, and S. Z. Jassim. 2006. Quaternary deposits. In *Geology of Iraq*, ed. Saad Z. Jassim and Jeremy C. Goff, pp. 185-196. Prague: Dolin.
- Baeteman, C., L. Dupin, and V. Heyvaert. 2004/2005. Geo-environmental investigation. In *The Persian Gulf Shorelines and the Karkheh, Karun, and Jarrahi Rivers: A Geo-Archaeological Approach*. A Joint Belgo-Iranian Project. First Progress Report, ed. H. Gasche. *Akkadica* 125(2) : 141-215.
- Baker, Victor R. 1986. "Fluvial landforms". In *Geomorphology from Space: A global overview of regional landforms* (NASA-SP 486), ed. Nicholas M. Short and Robert W. Blair, pp. 255-315. Washington, DC: National Aeronautics and Space Administration Scientific and Technical Branch. <http://www.oercommons.org/courses/geomorphology-from-space-a-global-overview-of-regional-landforms/view> (2 February 2012).
- Belsky, Joy. 1999. Survey of livestock influences on stream and riparian ecosystems in the western United States. *Journal of Soil and Water Conservation* 54: 419-431.
- Bird, Michael, William Austin, Christopher Wurster, Keith Fifield, Meryem Mojtahid, and Chris Sargeant. 2010. Punctuated eustatic sea-level rise in the early mid-Holocene. *Geology* 38(9): 803-806. doi: 10.1130/G31066.1.
- Boehmer, Rainer Michael. 1999. *Uruk: früheste Siegelabrollungen*. Mainz: Phillipp von Zabern.
- Brückner, Helmuth. 2003. Uruk—A geographic and Paleo-archaeologic perspective on a famous ancient city in Iraq. *Geo-Öko* XXIV: 229-248. Bensheim: Georg-August University.
- Buday, Tibor and Saad Z. Jassim. 1987. *The Regional Geology of Iraq: Tectonism, magmatism, and metamorphism*. Baghdad: Government of Iraq, Geological Survey and Mineral State Establishment.
- Buringh, P. 1960. *Soils and Soil Conditions in Iraq*. Baghdad: Ministry of Agriculture Directorate General of Agricultural Research and Projects.
- Carter, Elizabeth. 1990. A surface survey of Lagash, al-Hiba, 1984. *Sumer* 46: 60-63.
- Chen, Z., M. Kavvas, N. Ohara, M. Anderson, and J. Yoon, 2010. Impact of water resources utilization on the hydrology of Mesopotamian marshlands. *Journal of Hydrologic Engineering*. [doi:10.1061/(ASCE)HE.1943-5584.0000208].
- Cole, S.W., and H. Gasche. 1998. Second-and first-millennium BC Rivers in Northern Babylonia. In *Mesopotamian History and Environment 5/1 – Changing Watercourses in Babylonia: Towards a Reconstruction of the Ancient Environment in Lower Mesopotamia*, ed. H. Gusche and M. Tanvet, pp.1-64. Ghent: University of Ghent.
- Englund, Robert K. 1990. *Organization und Verwaltung der Ur-III Fischerei*. Berlin: Berliner Beiträge zum vorderen Orient 10.
- 1998. Texts from the late Uruk period. In *Späturuk-Zeit und Frühdynastische Zeit*, ed. Pascal Attinger and Marcus Wäfler. Freiburg and Göttingen: Universitätsverlag and Vandenhoeck & Ruprecht.
- Garstecki, T. and Z. Amr. 2011. *Biodiversity and Ecosystem Management in the Iraqi Marshlands – Screening Study on Potential World Heritage Nomination*. Amman, Jordan: IUCN.
- Gasche, Hermann and M. Tanret (eds.). 1998. *Changing Watercourses in Babylonia. Towards a reconstruction of the ancient environment in lower Mesopotamia*. Ghent and Chicago: University of Ghent and the Oriental Institute.
- Gibson, MGuire. 1972. *The City and Area of Kish*. Miami: Field Research Publications.
- Genouillac, Henri de. 1920. *Texte cuniform d’Louvre*. Paris: Laroux.
- Finkbeiner, U. 1991. *Uruk Kampagne 35-37 1982-84: Die archäologische Oberflächenuntersuchung (Survey)*. German Archaeological Institute, Bagdad Division. Ausgraben in Uruk-Warka Endberichte, vol. 4, ed. Rainer Michael Boehmer. Mainz: Verlag Philipp von Zabern.
- Donald P. Hansen, Al-Hiba: A summary of four seasons of excavation: 1968-1976, *Sumer*, vol. 34, pp. 72-85, 1978

space

— Physical geography —

- Heimpel, Wolfgang. 2011. Twenty Eight Trees Growing in Sumer. In *Garšana Studies*, Cornell University Studies in Assyriology and Sumerology 6, ed. David I. Owen. Bethesda: CDL Press.
- Hemker, C. 1993. *Altorientalische Kanalisation. Untersuchungen zu Be- und Entwässerungsanlagen im mesopotamisch-syrisch-anatolischen Raum*. 1. Text. 2. Abbildungen. Abhandlungen der deutschen OrientGesellschaft 22. Munster: Agenda Verlag.
- Heyvaert, Vanessa and Cecile Baeteman. 2008. A Middle to Late Holocene avulsion history of the Euphrates River: a case study from Tell ed-Der, Iraq, Lower Mesopotamia. *Quaternary Science Reviews* 27: 2401–2410. doi : 10.1016/j.quascirev.2008.08.024.
- Hritz, Carrie. 2010. Tracing settlement pattern and channel systems in Southern Mesopotamia using remote sensing. *Journal of Field Archaeology* 35: 2.
- Hritz, Carrie and Jennifer Pournelle. In press (2012). Feeding history: deltaic resilience, inherited practice, and mllennial-scale sustainability in an urbanized landscape. In *From Field to Table: Historical Ecology of Regional Subsistence Strategies*, ed. David Goldstein. Columbia, SC: University of South Carolina Press.
- Hritz, C., J.R. Pournelle, and J. Smith. In press (2012a). Mid-Holocene Dates for Organic-Rich Sediment, Palustrine Shell, and Charcoal, Southern Iraq. *Radiocarbon*.
- . In press (2012b). Revisiting the Sealands: Report of Preliminary Ground Reconnaissance in the Hammar District, Dhi Qar and Basra Governorates, Iraq. *Iraq*.
- Huot, Jean-Louis, Yves Calvet, J. Chevalier, and Jean-Daniel Forest. 1981. II. Tell el 'Oueili. I. Rapport préliminaire sur la deuxième champagne, (1978). *Syria* 58 (1–2): 101–120. doi : 10.3406/syria.1981.8590.
- IMOS, 2006. Iraqi Marshlands Observation System – UNEP Technical Report 2006. http://postconflict.unep.ch/publications/UNEP_IMOS.pdf.
- Jacobsen, Thorkild. 1958. La géographie et les voies de communication du pays de Sumer. *Revue d'Assyriologie* 52: 127–129.
- . 1960. The waters of Ur. *Iraq* 22: 174–185.
- Kenoyer, Jonathon M. 1990. Shell artifacts from Lagash, al-Hiba. *Sumer* 46: 64–66.
- Leemans, W.F. 1960. *Foreign Trade in the Old Babylonian Period as Revealed by Texts from Southern Mesopotamia*. Leiden: Studia et documenta ad iura orientis antiquae pertinenta VI.
- Maekawa, Kazuya. 1974. The development of the é-mi of Lagash during the Early Dynastic III. *Mesopotamia* 8–9: 77–144.
- Mashkour, Marjan, Andrew Bauer, Tony Wilkinson, Nicholas Kouchoukos, and Abbas Alizadeh. 2004. Human-Environment Interactions on the Upper Khuzestan Plains, Southwest Iran. Recent Investigations. *Paléorient*, 30 (1): 69–88. doi: 10.3406/paleo.2004.4773.
- Miller-Rosen, Arlene. 1995. Analytical techniques in Near-Eastern archaeology, phytolith analysis. *Biblical Archaeologist* 58 (3): 170.
- Miller-Rosen, Arlene and S. Weiner. 1994. Identifying ancient irrigation – a new method using opaline phytoliths from emmer wheat. *Journal of Archaeological Science* 21 (1): 125–132.
- Mudar, Karen. 1982. Early Dynastic III animal utilization in Lagash: a report on the fauna of Tell al-Hiba. *Journal of Near Eastern Studies* 41: 23–63.
- Northedge, Alastair, T.J. Wilkinson, and Robin Falkner. 1989. Survey and excavations at Samarra. *Iraq* 52: 75–84.
- Nützel, Werner. 1978. To which depths are the “prehistorical civilizations” to be found beneath the present alluvial plains of Mesopotamia: A theoretical archaeology contribution. *Sumer* 34: 17–26.
- Oates, Joan L. 1960. Ur and Eridu, the prehistory. *Iraq* 22: 32–50.
- Plaziat, J.C. and P. Sanlaville. 1991. Données Recentes sur la sédimentation tardive dans la plaine de Larsa-Oueili. In *Oueilli: Travaux de 1985*, ed. J.-L. Huot. Editions Recherche sur les Civilizations. Paris: 342–343.
- Pollack, Susan. 1999. *Ancient Mesopotamia*. Cambridge: Cambridge University Press.
- Postgate, J.N. 1994 *Early Mesopotamia: Society and economy at the dawn of history*. London and New York: Routledge.

— Jennifer Pournelle —

- Potts, Daniel T. 1997. *Mesopotamian Civilization: The material foundations*. Ithaca: Cornell University Press.
- Pournelle, J.R. 2003a. The littoral foundations of the Uruk state: Using satellite photography toward a new understanding of 5th/4th millennium BCE landscapes in the Warka survey area, Iraq. In *Chalcolithic and early Bronze Age hydrostrategies*, ed. Dragos Gheorghiu, pp. 5–23. BAR International Series 1123. Oxford: Archaeopress.
- 2003b. *Marshland of Cities: Deltaic landscapes and the evolution of early Mesopotamian civilization*. Ph.D. dissertation, Department of Anthropology, University of California, San Diego. http://sc.academia.edu/JenniferPournelle/Papers/872585/Marshland_of_Cities_Deltaic_Landscapes_and_the_Evolution_of_Early_Mesopotamian_Civilization.
- 2007. KLM to Corona: a bird's-eye view of cultural ecology and early Mesopotamian civilization. In *Settlement and Society: Essays dedicated to Robert McCormick Adams*, ed. E. Stone, pp. 29–62. Los Angeles: UCLA Cotsen Institute of Archaeology, and Chicago: Oriental Institute.
- Pournelle, J. R. In press (2012). *Fluvial Landscapes and Civilizations in Mesopotamia. Proceedings of the American Geophysical Union Chapman Conference on Climates, Past Landscapes, and Civilizations*, Santa Fe, NM 21–25 March 2011.
- Pournelle, J.R. and G. Algaze. In press (2012). Travels in Edin: Deltaic resilience and early urbanism in greater Mesopotamia. In *Preludes to Urbanism: Studies in the late chalcolithic of Mesopotamia in honour of Joan Oates*, ed. H. Crawford, A. McMahon, and N. Postgate. B.A.R. International Series. Oxford: Archaeopress.
- Safar, F., M.A. Mustafa, and S. Lloyd. 1981. *Eridu*. Baghdad: Ministry of Culture and Information, State Organization of Antiquities and Heritage.
- Salim, S.M. 1962. *Marsh Dwellers of the Euphrates Delta*. London School of Economics Monographs on Social Anthropology. London: Athlone.
- Sanlaville, Paul. 1989. Considerations sur l'évolution de la Basse Mesopotamie au cours des derniers millénaires. *Paléorient* 15 (2): 5–27.
- 2003. The deltaic complex of the lower Mesopotamian plain and its evolution through millennia. In *The Iraqi Marshlands*, ed. Emma Nicholson and Peter Clark, pp. 133–150. London: Politico's Publishing.
- Schumm, S.A. and H.R. Khan. 1972. Experimental study of channel patterns. *Geological Society of America Bulletin* 83: 1755–1770.
- Steinkeller, Piotr. 1987. The foresters of Umma: Toward a definition of Ur III Labor. *AOS* 68: 73–115.
- 2001. New light on the hydrology and topography of southern Babylonia in the third millennium. *Zeitschrift für Assyriologie* 91: 22–84.
- Stone, Elizabeth. 2002. Whither the Tigris? Abstracts of the 103rd Annual Meeting of the Archaeological Institute of America 25: 58.
- Van de Mierop, M. 1987. Women in the economy of ancient Sumer. In *Women's Earliest records from Ancient Egypt and Western Asia*, ed. Barbara Lesko, pp. 53–46. Atlanta: Scholars Press.
- Verhoeven, K. 1998. Geomorphological research in the Mesopotamian flood plain. In *Changing watercourses in Babylonia. Towards a reconstruction of the ancient environment in Lower Mesopotamia*, ed. Hermann Gasche and M. Tanret, pp. 159–245. Ghent and Chicago: University of Ghent and the Oriental Institute.
- Westphal-Hellbusch, Sigrid, and Heinz Westphal. 1962. *Die Ma'dan. Kulture und Geschichte der Marschenbewohner in Sud-Iraq*. Berlin: Duncker und Humbolt.
- Wilkinson, Tony J. 1990. Early channels and landscape development at Abu Salabikh; a preliminary report. *Iraq* 52: 75–84.
- 2003. *Archaeological landscapes of the Near East*. Tucson: University of Arizona Press.
- Wirth, Eugen. 1962. *Agrargeographie des Irak*. Hamburger geographische Studien 13. Hamburg: Institut für Geographie und Wirtschaftsgeographie der Universität Hamburg; Cram de Gruyter & Co.
- Wright, Henry T. 1981. The southern margins of Sumer: Archaeological survey of the area of Eridu and Ur. In *Heartland of Cities: Surveys of ancient settlement and land use on the central floodplain of the Euphrates*, ed. Robert McC. Adams, pp. 295–338. Chicago and London: University of Chicago Press.