Calcareous dunes of the United Arab Emirates and Noah’s Flood: the postglacial reflooding of the Persian (Arabian) Gulf

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Abstract

Aeolian dunes cover most of the United Arab Emirates and a large part of the eastern Arabian Peninsula. Although these sands, as well as older aeolianites, are largely composed of quartz, there is a high percentage of detrital carbonate in them south of the Persian (Arabian) Gulf for more than 40 km; this percentage decreases inland. These carbonate grains consist mainly of marine bioclastic fragments and calcareous ooids, and were derived from the floor of the Persian Gulf, which was exposed during low sea level of the last glacial period.

The postglacial rise in sea level rapidly reflooded the floor of the Persian Gulf, cutting off the source for these aeolian sediments. Between 12 and 6 ka, the sea transgressed more than 1000 km, inundating the extended route of the Tigris–Euphrates River and forcing people living on the exposed floor of the Gulf to abandon their settlements. Because of the varying rate of eustatic sea level rise, these waters at times flooded across the flat floor of the Persian Gulf at more than a kilometer per year. We proposed that the stories of a great flood, recorded in the Bible as Noah’s Flood and in Babylonian history on clay tablets (excavated in the Tigris–Euphrates delta) as the Epic of Gilgamesh, are a record of this rapid postglacial flooding of the floor of the Persian Gulf. © 2000 Elsevier Science Ltd and INQUA. All rights reserved.

1. Introduction

The Persian Gulf is a shallow basin with an average depth of 35 m and a maximum depth of about 100 m (Fig. 1) (Purser and Seibold, 1973); waters in this large basin are also referred to as the Arabian Gulf. The basin is bounded on the north by the Zagros Mountains of Iran and on the south by the eastern Arabian Peninsula. The modern waters of this basin extend for nearly 1000 km southeast from the Tigris–Euphrates–Karun fluvial system of Iraq to the Arabian Sea and Indian Ocean, to which this epeiric sea is linked through the Straits of Hormuz (Fig. 1). The average salinity of the Gulf is 37–40\textsuperscript{0}o/oo which is high relative to the ocean because of the high evaporative rate over this restricted basin; values of 40–50\textsuperscript{0}o/oo or higher are reached in shallow waters along the United Arab Emirates (UAE) coast (Purser and Seibold, 1973).

Runoff into the Persian (Arabian) Gulf comes from rivers draining the Zagros Mountains to the north and from the Tigris, Euphrates, and Karun Rivers, which enter at the western end of the basin in Iraq and drain the region as far west as Syria and Turkey and the western part of the Zagros Mountains of Iran. Together these form the Shatt-al-Arab River. Virtually, no runoff is received from the arid Arabian Peninsula, where precipitation is very low (< 100 mm/yr) and daily temperatures average from 18°C in winter to about 35°C in summer (United Arab Emirates University, 1993).

Fringing the southern side of the Persian Gulf are coastal islands, coral reefs, tidal channels, tidal flats, raised beaches, and coastal sabkhas (e.g. Kendall and Skipwith, 1969; Purser, 1973). Inland from this for about 1000 km is a large area of aeolian dunes called the Rub‘al Khali, which covers much of the Arabian Peninsula, including most of United Arab Emirates and eastern Saudi Arabia (Fig. 2). These dunes, many of them large, can be divided into a number of distinct morphological regions that are interpreted as being related to varying wind-flow patterns associated with changing Quaternary climate. In many areas, active dunes overlie older dunes...
and aeolianite, and are interpreted as having been derived partly from the older sands. The origin of aeolian sands in the UAE is mainly from alluvial sediments derived from the uplands of Saudi Arabia to the west, as well as from the floor of the Persian Gulf (Glennie, 1994). Net wind transport is in a generally southerly direction as is reflected by dune morphology and trends in mineralogy.

This paper describes the linkage of the last phase of calcareous dune construction in the Emirates with the availability of these marine components when the floor of the Persian Gulf was exposed to wind deflation. We also advance the hypothesis that the rapid rate at which the floor of the Persian Gulf was reflooded at the end of the Last Glacial Maximum (LGM), which brought calcareous dune accumulation to an end, is the flood recorded in Babylonian history and in the Bible as Noah’s Flood.

2. Calcareous dunes and the Persian Gulf

2.1. Introduction

It has long been realized that the floor of the Persian Gulf was exposed during the Last Glacial Maximum (LGM) (e.g. Sarnthein, 1972; Kassler, 1973) and that it was the source for the calcareous sands in dunes of the adjacent Arabian Peninsula (Kassler, 1973; Glennie, 1998). The floor of the Gulf is very flat, and bathymetric maps show most of the basin to be covered by < 70 m of water, with a large area along the UAE coast where waters are < 20 m deep today (Fig. 1) (Purser and Seibold, 1973); only in the eastern end, where the paleo-Tigris and Euphrates River system entrenched its channel during interglacials to reach the Arabian Sea (Kassler, 1973; Lambeck, 1996), do water depths exceed 90 m. Thus, during the LGM, about 21–18 ka, when sea level was at −120 m, the entire floor of the Persian Gulf was exposed. Leading up to the LGM from the last interglacial (Stage 5e) there was a long period of retreating sea water from the basin as high-latitude ice sheets thickened on the continents. Following the LGM, sea level transgressed back into the basin, reaching a maximum of 1–3 m above its modern level about 4–6 ka, as reflected by dated terraces and marine sediments in many areas along the southern shore of the Gulf (Al-Asfour, 1978; Felber et al., 1978; Uchupi et al., 1996; Lambeck, 1996).

2.2. General morphology of dunes

At least six generations of dunes can be identified on satellite images of the United Arab Emirates (Glennie,
Some of the largest and most widespread dunes are the roughly west–east oriented 50–100-m-high complex linear dunes that are found throughout the northern and eastern part of the UAE, as well as in the southeastern part of the country and adjacent areas of Oman and Saudi Arabia (areas B and C in Fig. 4). Dunes of this type are spaced 2–5 km apart and are clearly visible on satellite images. Crescentic dunes are superimposed on these linear features in the northern and eastern regions, and star dunes on those in the southeastern region. Within about 50 km of the coast, these linear features are today being reworked by northwesterly winds into crescentic dunes and into obliquely oriented small linear dunes that are superimposed on the large linear dunes. In area D (Fig. 4) linear dunes are overlain by simple and compound crescentic dunes with a spacing of less than 300 m. In the Liwa area (E, Fig. 4), very large (100- to 150-m-high) compound barchanoidal (crescentic) dunes are migrating very slowly across inland sabkhas where the groundwater table lies near the surface and interdune sediments are being cemented by gypsum. To the east of this, the large crescentic dunes of the Liwa area merge
with the west–east oriented complex linear dunes of area B. To the northwest, dunes are successively overlain by two younger generations of small crescentic dunes, and by north–south oriented simple linear features. Modern dunes close to the coast are mainly crescentic forms that migrate to the southeast and invade areas of older linear dunes.

2.3. Composition of the dunes

The dunes in the Emirates are comprised mainly of fine-grained sand composed of varying amounts of quartz, feldspar, calcite, dolomite, heavy minerals, anhydrite and gypsum, and lithic fragments. Detailed studies of the grain characteristics and mineralogy of dune sands have been made by Pugh (1997) and Hadley et al. (1998) in central UAE, by Ahmed et al. (1998) and Alsharhan et al. (1998) in eastern UAE, and by El-Sayed (1999) in southeastern UAE. Pugh (1997) concluded that most quartz and feldspar in the dunes of central UAE were derived from Pliocene and younger alluvial sediments; these have been supplemented by marine carbonates, evaporites, and other continental lithoclasts and grains.

The relative proportion of siliciclastics to detrital carbonates in the dunes is variable, with lower calcareous percentages inland. Pugh (1997) shows a carbonate decrease in the modern dunes in central UAE from 70% in the coastal region to 30% 70–100 km inland; Hadley et al. (1998) show a similar progression, with carbonates decreasing below 30% about 40 km inland. Our observations are that south of about 40–50 km from the coast, modern dunes contain <10% carbonate; this limit may reflect the southernmost extent of aeolian sands that were derived from marine sediments deposited in the coastal lowlands during the mid-Holocene high sea stand.

Aeolianites of older dunes (Fig. 3) also show this progressive decrease to the south, but contain an average of 10–20% less detrital carbonate, which Pugh (1997) concludes is the result of either a more distant carbonate source on the floor of the Persian Gulf or is a function of the greater time that the older dune sediments have had for post-depositional dissolution of the more soluble carbonate grains. The progressive decrease inland of the clastic carbonates, especially the aragonitic shell fragments, both in the modern and ancient dunes, is the result of the down-wind destruction of these mechanically less durable grains, the addition of siliciclastics during transport and selective dissolution of these grains over time.

Ahmed et al. (1998) find the range of carbonate grains in dunes along a 120 km west–east transect between the cities of Abu Dhabi (on the coast) and Al Ain (see Fig. 4) to be from 43 to 61% (as determined by X-ray peak heights); they also found dolomite in the dunes with a range of 16–41%, but do not describe the nature of the dolomite nor its origin. Our preliminary analyses of the sand-sized fraction in this area indicates a much lower percentage of calcite and dolomite than those reported by Ahmed et al. (1998). Kirkham (1998, p. 27) notes that carbonate dunes along the coast in the Northern Emirates become more siliciclastic toward the northeast.
“partly because the offshore sea bed profile is steeper and offered a less extensive [and more distant] aeolian carbonate provenance during lower relative sea levels”.

According to Pugh (1997), bioclastic carbonate grains in the dunes of the central Emirates include (in order of abundance) coralline red algae, mollusks, miliolid foraminifera, echinoid spines, and calcareous worm tubes. Allochemical carbonate grains consist mainly of (1) ooids with cores of quartz (commonly reddish coloured) or occasionally aragonite or shell fragments that are coated by a thin layer of low-magnesium calcite, (2) ooids (pellets) of micritic calcite, (3) oolites, and (4) ooids that form “shells” around hollow centers. The latter are interpreted as the result of post-depositional solution of a more soluble aragonitic bioclast fragment; shell-cored ooids are common in the Holocene calcareous marine sands of the coastal lowlands, where conditions (and time) have not yet allowed the solution of these bioclast fragments.

2.4. Source of aeolian calcareous grains

Today, as in previous interglacial high sea level periods, the warm waters of the Gulf result in the production of calcareous bioclast grains and, in the shallower wave-agitated waters, oolite and ooid accretion. These sediments and their formative environment have been described by many (e.g. Emery, 1956; Kendall and Skipwith, 1969; Purser, 1973; Walkden and Williams, 1998). Detrital siliciclastics comprise a significant proportion of the sediments on and below the floor of the Gulf, as a result of runoff from the tectonically active
Zagros Mountains and the influx from the transgressing and regressing Tigris–Euphrates fluviodeltic system (Sarnthein, 1972; Baltzer and Purser, 1990; Walkden and Williams, 1998). Along the southern side of the Gulf is a shallow shelf (Fig. 1) where carbonates are forming; fringing the tidal zone is the well-known sabbaha flats of the United Arab Emirates (area A, Fig. 4) (e.g. Kendall and Skipwith, 1969). Modern beaches along this sabbaha are composed of very high percentages of bioclastic grains and ooids; however, no modern dunes appear to be accumulating inland from them, although there are active dunes composed of detrital carbonates on some of the nearshore islands that are today separated from the mainland by lagoons (e.g. Evans et al., 1973).

When sea level fell below about − 70 m during the last glacial period, nearly the entire floor of the Persian Gulf was exposed (Fig. 1). During the preceding regressive phase along the Emirates coast, shallow-water shells, ooids, and oolites, as well as allochthonous siliciclastics and other authochthonous chemical sediments such as gypsum and dolomite were exposed (cf. Kendall and Skipwith, 1969; Purser and Evans, 1973; Evans et al., 1973; Loreau and Purser, 1973), leading to the potential for deflation of these materials by the strong Shamal winds that blow from the northwest (Fig. 2). Sarnthein (1972) described and discussed areas of relict bioclastic and ooid-bearing sands across the floor of the Gulf at water depths below − 40 m (as well as at shallower depths), which originally formed in shallow water. He also reported relict oolitic sands at depths as great as − 101 m that must have formed in very shallow water. Kassler (1973) also reported oolitic sands at depths below − 80 m. In the northwestern part of the basin in 40–64 m of water, Sarnthein (1972) identified long linear dune features oriented northwest–southeast and composed of ooid sands, which he interpreted as relict seif dunes.

The greatest potential for wind deflation probably would have been shortly after these clastics were exposed by receding waters and before the sand-sized grains were stabilized by diagenesis (cf. Whittle et al., 1998; Evamy, 1973; Evans et al., 1973; Bush, 1973) or vegetative cover. For example, bioclastics and ooids deposited along the Emirates coast during the mid-Holocene high sea stand are now firmly cemented by calcite (Whittle et al., 1998), although previously deflated grains continue to migrate inland. Cemented bioclastic grains and ooliths (limestone) related to glacial low sea level are reported off the coast of the Emirates (Uchupi et al., 1996). Thus, the source of calcareous grains for the dunes of the Arabian Peninsula would have progressively retreated northward during the decline of sea level after Stage 5e.

2.5. Age of calcareous dunes

The age of dune activity in the Emirates, as determined by luminescence dates on quartz sand, reflects the long (but probably variable) deflationary stage between about 100 and 12 ka (see dates in Juyal et al., 1998; Pugh, 1997). Radiocarbon dates on aeolianites of the Aradah Formation range from 12–43 ka (Wood and Imes, 1995) and these sediments are considered by Hadley et al. (1998) to have been deposited during the last glacial, 12.2 to > 70 ka. Dates from “miliolites” (calcareous ooids and foraminifera) in dunes in the Emirates whose bedding extends below sea level suggest that dunes were forming 20–30 ka (Kassler, 1973). Aeolian dunes in the Northern Emirates have been dated at 9–20 ka (Dalangaeville et al. in Kirkham, 1998).

Two new radiocarbon dates on detrital calcite in aeolianites 30–40 km from the coast are also in this range: 21,710 ± 140 (just south of Gayethi; 23°48.96′, 52°49.73′E; Beta 130626) and 32,320 ± 370 (50 km south of Abu Dhabi; [A in Fig. 4]; 24°00.93′, 54°24.51′E; Beta 130627). The upwind source for these detrital carbonates cannot be the nearby raised-marine nearshore sands along the coastal sabbaha of the Emirates, because these clastics relate to the mid-Holocene high sea level that is dated at 4–6000 yr BP (Felber et al., 1978; Evans et al., 1969; McClure and Vita-Finzi, 1982; Bernier et al., 1995; Lambeck, 1996); new radiocarbon dates on carbonates in these raised bioclastic deposits (2–3 m above sea level) from west of Jebel Dhaana (J in Fig. 4) are 5520 ± 70 (23°56.26′, 53°09.22′E; Beta 130624) and 4170 ± 50 (23°56.98′, 52°08.39′E; Beta 130623). Therefore, the source for the detrital dune carbonate (aeolianite) must have been on the floor of the Persian Gulf when it was exposed during the last glacial episode. Kassler (1973) and Stoffers and Ross (1979) report relict shallow-water carbonates in relatively deep water areas of the Persian Gulf, with many ages comparable to those of the calcareous dunes of the UAE.

The roots of still older dunes are exposed in interdune areas and form the cores of some modern dunes. These aeolianites have been isotopically and radiocarbon dated at > 160 to 800 ka (Hadley et al., 1998).

3. Reflooding of the Persian Gulf

During the LGM, the Tigris and Euphrates Rivers extended across the subaerially exposed floor of the Persian Gulf (Sarnthein, 1972; Kassler, 1973; Lambeck, 1996; Glennie, 1998). A few studies have identified morphological or sedimentological traces of this ancient waterway, although no details are known. A marshy, lake-dotted environment comparable to that along the modern Tigris and Euphrates Rivers (Ionides, 1937) probably extended eastward along this ancient waterway for more than 1000 km to the Straits of Hormuz (Fig. 1). Between the last interglacial (Stage 5e) and the LGM at 18–21 ka, the main source for calcareous detritus for the dunes of the Emirates had grown more distant as Gulf
waters receded. By the time sea level had fallen to 
— 100 m, wind deflation of clastics on the Gulf floor may
have become difficult because sediments had been
cemented or stabilized by vegetation. The subsequent
postglacial rise in sea level flooded those sediments and
permanently eliminated them as a source for the dunes.
This explains why ages for detrital carbonate in the dunes
are mainly > 18 ka.

As sea level rose after the LGM, the ocean transgressed
back through the Straits of Hormuz and across the flat
floor of the Persian Gulf, inundating the floodplain of
the extended Tigris and Euphrates Rivers and (progressively)
drowning its lower reaches. Most of the Holocene se-
quence was deposited over a glacial hiatus (“acoustic
basement”) (Uchupi et al., 1996). Evans et al. (1969)
indicate that the sea transgressed over aeolian sands
along the UAE coast and Sarnthein (1972, p. 262) stated
that the rapid rise in sea level “left the Gulf bottom evenly
covered with polymict coquina sands”. Postglacial global
sea level appears to have risen without interruption until
about 6 ka, albeit somewhat irregularly (e.g. Fairbanks
et al., 1989; Lambeck, 1996).

By 14 ka, the ocean had begun to enter the Gulf
through the Straits of Hormuz, and by about 12 ka
a narrow waterway extended several hundred kilometers
to the west (Fig. 2). The most rapid postglacial rise in sea
level occurred between 12 and 8 ka (e.g. Bard et al., 1990;
Lambeck, 1996). If sea level flooded across the 1000 km
length of the Persian Gulf from the Straits of Hormuz to
the Tigris–Euphrates delta in 7000 years (between 13 and
6 ka), then the average rate would have been 140 m per
year. Sarnthein (1972) estimated that the sea transgressed
across the Gulf floor at an average rate of 100–120 m per
year, although he felt that there were stillstands in the rise
(at depths of 61–64 m, 40–53 m, and 30 m) (Fig. 1), as well
as periods of more rapid transgression. Kassler (1973)
describes stratigraphic and morphological evidence for a
fluctuating rise in sea level across the Gulf floor, with
relatively rapid rises occurring between about 12–11 ka,
9.5–8.5 ka, and around 7.0 ka. Fairbanks (1989), based
on the Barbados coral record, concluded that rising glo-
bal sea level was marked by two rapid increases in
meltwater influx, the first increase was from — 100 m to
— 70 m at about 12–11.5 ka (meltwater pulse 1A), the
second from about — 50 m to — 30 m at 9.5 to 8.5 ka
(meltwater pulse 1B). The sea level curve of Bard et al.
(1990) shows two abrupt rises in sea level superposed on
the overall rise during the last deglaciation, one about
12 ka (14,000 BP calendar years) and another about
9.5 ka (11,000 BP calendar years). Blanchon and Shaw
(1995) used corals to conclude that more than half of the
global sea level rise around 12 ka (13.5 m) occurred in
< 290 years.

Using a “glacio-hydro-isostatic model”, Lambeck
(1996) plotted the postglacial rise in sea level across the
floor of the Persian Gulf. He noted that this rise is not
spatially uniform and “will differ substantially from the
eustatic sea level curve” (p. 44), although it is consistent
with the eustatic curve of Fairbanks (1989). Because of
eustatic unloading of the Persian Gulf basin during the
last glaciation, its floor was more elevated at the start of
the postglacial transgression, resulting in a delay in the
re-flooding of the Gulf floor (Lambeck, 1996). Although
the marine arm extended west across the floor of the
basin by 10 ka, large areas of the southern and western
parts of the basin still would have remained dry (Fig. 2)
(Lambeck, 1996).

Combining various interpretations of postglacial sea
level rise, we conclude that the transgressing shoreline of
the rising waters must at times have exceeded one kilo-
meter per year. This is especially likely along the deeper
axis of the basin and across the very flat central part,
where there is only an 18 m rise in elevation across a
distance of about 500 km (Fig. 1, but see large detailed
bathymetric map in Kassler, 1973). Using the eustatic sea
level curve of Fairbanks (1989, his Fig. 2) and Bard et al.
(1990, his Fig. 1), this part of the basin would have been
reflooded around 12 ka during meltwater pulse 1A
(Fig. 2). Adjusting this for Lambeck’s (1996, Fig. 5) delay
in the early re-flooding of the basin, this rapid marine
incursion may have been closer to 11 ka. Fairbank’s
(1989) sea level rise from — 100 m to — 75 m at
12–11.5 ka would have caused waters of the Persian
Gulf to flood westward along the axis of the basin
from the Straits of Hormuz (57°E) to at least
52°E, a distance of about 500 km in 500 years, or
1 kilometer per year. Depending on the details of the
bathymetry of the Gulf basin around 52°E, this ex-
pansion may have been closer to 700 km, meaning
a 1.4 km per year transgression during this period.
Similarly, using the rapid rise of 13.5 m around 12 ka
identified by Blanchon and Shaw (1995), transgression
along the axis of the eastern Gulf basin over this period
probably would have exceeded 1 km per year for three
centuries.

During the subsequent rapid rise in sea level of 20 m,
about 9.5 to 8.5 ka (Fairbanks, 1989), which Bard et al.
(1990) placed at 9.5 ka, waters would not have expanded
as rapidly, perhaps transgressing across the shallow shelf
of the northwestern and southern basin at 100–150 m per
year (cf. Lambeck, 1996, Fig. 7; Kennett and Kennett, in
press). Blanchon and Shaw (1995), however, identified
a very rapid sea level rise of 7.5 m (from about — 55 to
— 49 m) for a short period just after 10 ka (possibly
meltwater pulse 1B); with their interpretation, transgres-
sion across the Gulf floor may again have exceeded 1 km
per year at this time. Furthermore, the Persian Gulf at
one time extended west of 260 km farther to the north-
west to about the now-abandoned city of Ur in Iraq
(once a seaport) (e.g. Cooke, 1987; Sanlaville, 1992), and
the modern shoreline and bathymetry in the shallow
northwestern end of the Gulf (Fig. 1), have changed in the
past several thousand years because the Tigris–Euphrates–Karun delta has been prograding. When that
is taken into consideration, the rate of transgression into
the northwestern end of the basin may have been even
more rapid during the last eustatic rise into the shallow
northwestern end of the basin.

Thus, at several times during the postglacial period,
humans living on the exposed floor of the Arabian Gulf
would have witnessed rapid inundation along the leading
edge of the transgressing sea in only a few decades. Large
areas became salinized and submerged within a person’s
lifetime; settlements, pasture, and cultivated land would
have to have been abandoned, navigation along the ex-
tended course of the ancient Tigris and Euphrates Rivers
changed, and civilization in the region was forever
dislocated.

4. Noah’s Flood?

Although the chronological details of sea level rise are
not yet clearly defined in terms of a human lifetime, there
is enough evidence to suggest that at times the transgres-
sion margin of the ocean would have produced a very
notable rate of reflooding across the low-gradient Per-
sian (Arabian) Gulf floor during the last deglaciation.
The rate of reflooding was variable and may have been
punctuated by very rapid sea level rises such as those of
meltwater pulse 1A and 1B (Fairbanks, 1989), or possibly
as a result of the abrupt release of large volumes of
subglacial or proglacial meltwater (e.g. Blanchon and
Shaw, 1995).

We believe humans residing on the flat floor of the
Persian Gulf — to the east of what is regarded as the
center of some of the earliest human activity in the
Middle East (in Mesopotamia) — would have been
impressed by this flooding. Stories of the continuing event
(or of one of the specific rapid rises in sea level) would
have been told, and probably embellished. Such stories
may have originated from a particularly flat area on the
Gulf floor where the rate of transgression was especially
rapid, or from an area where influential story tellers lived
and whose tales survived; one descriptive story may have
merged with other related stories during successive gen-
erations. Eventually, when picture writing was replaced
by the cuneiform script in the 4th millennium BC (e.g.
May, 1984) long after most sea level rise had occurred,
the Sumerians recorded this event.

Most scholars suggest that the Biblical account of
Noah’s Flood must have been derived from Mesopota-
mian legends, specifically from the Epic of Gilgamesh
(e.g. King, 1918; Magnusson, 1977; Keller, 1981), which
was recorded during the Old Babylonian Period about
1800 BC. The Flood, as told in the Bible, cannot be
assumed to reflect a single “40-day and 40-night event”.
Complicating all accounts is the fact that floods along the
Tigris and Euphrates Rivers are common, and abrupt
shifts in the routes of these rivers across the delta have
been common (Agrawai and Evans, 1994). Therefore, the
stories of big floods may not all refer to “the” big flood,
nor even to the same flood.

In addition to the flooding of the Persian Gulf floor by
postglacial sea level rise, there may have been an increase
in precipitation during the early Holocene, perhaps in
part as a result of a shift in the monsoon belt (e.g. Sirocko
et al., 1993; Naidu and Malmgren, 1996; cf. Hötzl et al.,
1984; Yan and Petit-Maire, 1994). In fact, the dune sys-
tems of part of the Arabian Peninsula became stabilized
and lakes filled some interdune depressions at this time
(e.g. McClure, 1976, 1978, 1988; Sanlaville, 1992; Glennie,
1998). Hötzl et al. (1984) discuss the widespread evidence
for wetter conditions on the Arabian Peninsula 6–9000
years ago, and Hadley et al. (1998) suggest that paleo-
dunes in the UAE were cemented at this time, coincident
with rising groundwaters. A series of sediment lobes in
the northern Gulf basin were deposited by rivers draining
southwestern Iran (Uchupi et al., 1996). The increase in
runoff through the ancient Tigris and Euphrates system
and from the Zagros Mountains to the north may have
compounded the real or perceived “cataclysmic” impact
of the transgressing Persian Gulf waters. Glennie (1997,
p. 26–27) paints the following scenario in relation to the
Biblical story: “Noah’s family possibly lived in the
drier environment of a gentle rise to escape the effects
of a rainfall that was considerably higher than any ex-
perienced today. As sea level rose in the Gulf, Noah’s
pasturage would have been cut off from the mainland
and ...[would have become progressively smaller],
leading to the need for a boat or barge if he and his
family and flocks were to survive the encroaching
sea”.

Thus, during the last deglaciation, humans residing on
the subaerially exposed floor of the Persian Gulf were
forced to abandon their land and to “flee” in front of
rising waters. Some may have chosen to move south on
to the semiarid Arabian Peninsula, which probably was
vegetated at that time (Potts, 1997; McBrearty, 1999), or
north into the Zagros Mountains, where sparse evidence
suggests that people were there 8–10,000 years ago (e.g.
Potts, 1992; Nützel, 1979). However, we believe it is
logical that many migrated to the west, probably along
the ancient course of the Tigris and Euphrates River,
eventually re-settling in Mesopotamia where conditions
would have been comparable to those of the region they
were forced to abandon. This migration no doubt was
incorporated into legend, and may be the source of the
stories about a deluge that are found in a number of
cultures. Most scholars believe that flood stories pre-date
the rise of the great empires of the Middle East and
also occurred before the flowering of the dynasties in
Mesopotamia that led to the Sumerian and Babylonian
Empires.
5. The human record in the region

5.1. A brief overview of the Holocene

The record of human history around the modern Persian Gulf is complex and far beyond the scope of this paper. Archaeological records are very scattered and incomplete for the first half of the Holocene, and chronological resolution of human events during the time when sea level transgressed across the Gulf floor and reached its maximum extent (i.e. prior to about 6 ka) is poorly known. The best records come from Mesopotamia (now mainly Iraq) at the western end of the Persian Gulf. However, frequent shifts in the routes of the distributaries of the Tigris and Euphrates Rivers and the progradation of their fluviodeltaic sequence into the Gulf, as well as normal flooding by these rivers, has buried and destroyed much of the late Holocene record there (Cooke, 1987; cf. Larsen and Evans, 1978). Kennett and Kennett (in press) provide an excellent review of the human history of the region at the western end of the Gulf that describes the relationship of people to rising Holocene sea level. It seems likely that early people had settled on the exposed floor of the Gulf and were driven west as the Tigris and Euphrates systems retreated during sea level transgression (J. Kennett, personal communication, 1999). Ancient floods in the Near East that had catastrophic results are described in a number of cultures (e.g. King, 1918; Cohn, 1996; Hoerth, 1998). However, many would place The Flood described in Genesis (Chapters 7 and 8) and in the Old Babylonian Epic of Gilgamesh (written on twelve clay tablets about 1800 BC and uncovered near Ur in the Tigris–Euphrates delta; Steibing, 1976; Keller, 1981; Kovacs, 1989; Lambert and Millard, 1970) prior to 6000 yr BP, probably in the Neolithic (about 5500–8000 yr BP) or Mesolithic Period (about 8000–10,000 yr BP). The latter was a time of food-gathering, animal domestication, and scattered village development in the region, whereas the Neolithic Period saw the rise of village life and development of agriculture (Potts, 1997). Perhaps the flood legend had its beginning in the Paleolithic Period before 10 ka (8000 BC). Potts (1990) says that stone tools from sites in Kuwait, Saudi Arabia, and Qatar have been assigned to the Middle Paleolithic by a number of scholars. Civilization in the borderland of Kurdistan and the Zagros Mountains is known to have begun by about 9–10,000 years ago (Nützel, 1979).

Bibby (in Ridley and Seeley, 1979) indicates that the Ubaid people were the first agricultural settlers to move into the lower Tigris and Euphrates valleys around 7000 years ago, where the Epic of Gilgamesh is likely to have originated (Keller, 1981). Kennett and Kennett (in press) hypothesize that the development of complex state-level societies in southern Mesopotamia was partly stimulated by eustatic sea level rise (and the eventual stabilization of sea level) in the region between 7.5 and 5 ka; this, combined with higher rainfall, provided special environmental changes that led to the “earliest known development of cities and complex hierarchical societies anywhere in the world” by about 5.5 ka (the late Ubaid Period; Kennett and Kennett, in press). Eventually, the Sumerian culture became established in Mesopotamia by about 5 ka; Genesis (11:2) says that these people came from the east. The oldest written records known from this region date to the 4th millennium BC, which is the time of the first cuneiform script (May, 1984).

5.2. Living conditions on the Gulf floor

During the early Holocene, conditions on the exposed floor of the Persian Gulf are likely to have been favorable to life, including people, probably being similar to those along the modern Tigris and Euphrates Rivers; as noted before, there is evidence to suggest that the region may have been somewhat cooler and wetter than today. During unfavorable times, nomadic groups would have been able to retreat north into more livable conditions in the Zagros Mountains (Nützel, 1979). Of course, the ancient Tigris and Euphrates Rivers would have provided fresh waters both for the nearby ecosystem and for humans; as well, this river system would have provided a transportation route for people between the Mediterranean–Near East region and the Indian Ocean–Far East. Settlements, nomadic or otherwise, likely would have been along this paleo-river system (Nützel, 1979; Lambeck, 1996). Lambeck (1996) suggests that fresh water lakes may have existed on the floor of the basin, both along the central part near the river and along the southern side.

No records of early civilization on the now-drowned floor of the Persian Gulf have been discovered. However, because all early biblical stories have a Mesopotamian background (e.g. Keller, 1981; May, 1984), accounts of Noah’s Flood in early chapters of Genesis are believed to have had their origin in the region around the Persian Gulf, almost certainly in the lower Tigris and Euphrates River valleys as recorded in the Epic of Gilgamesh (e.g. King, 1918; Keller, 1981). It is possible that the affected peoples lived far east of the present mouth of this river along its extended route in the deepest part of the basin (Nützel, 1979). Archaeological records to the north and south of the Persian Gulf basin indicate that people were present there by 8–10,000 years ago (Potts, 1992; Nützel, 1979). Pottery of the Ubaid type was present in many coastal sites in the UAE, Saudi Arabia, Qatar, Bahrain, and the islands of Kuwait by 7000 years BP, indicating contact with people from southern Mesopotamia (Potts, 1992, 1997).

Did the Ubaid people, the earliest settlers along the lower Tigris and Euphrates Rivers and precursors of the Sumarians who built advanced cities at the western end of the Persian Gulf, first live on the now-submerged floor
of the Gulf? Were these people forced to migrate upslope into what would become Mesopotamia, as rapidly rising sea level flooded their settlements? Would this forced displacement lead to stories, then legend, then gospel about this natural flood?

Although several have suggested that the postglacial rise in sea level in the Persian Gulf basin may have become incorporated into legends about a Deluge and even the Biblical Flood (e.g. Fairbridge, 1960; Boulton, 1993; Lambeck, 1996; Glennie, 1997, 1999; Teller et al., 1999), none are known to have elaborated on the possible linkage. In part, this may have been because the time frame for the most rapid marine transgression pre-dates the generally accepted age of Noah’s Flood. Importantly, however, it may have been an underestimation of the actual rate of sea level transgression across the Gulf floor and a failure to realize that the extended Tigris–Euphrates River valley would have been a likely place for people to have lived. We believe that hundreds of meters of shoreline encroachment each year would have made a major impact on peoples of the region and would have initiated stories that probably would have “evolved” during the Holocene into what eventually became recorded in script as The Flood.

6. Summary and conclusions

The dunes of the United Arab Emirates contain up to 70% carbonate bioclastic grains, ooids, and oolites in the northern area closest to the Persian (Arabian) Gulf; this calcareous detritus decreases downwind until dunes 50–100 km inland contain mainly quartz. Because the bioclastic and ooid grains must have formed in shallow marine waters, the source for these materials was the exposed floor of the Persian Gulf. Radiocarbon dates on these carbonates and luminescence dates on associated quartz grains indicate that these sediments were deflated from the floor of the Gulf during low sea level of the last glacial period, about 100–12 ka.

Transgressing waters into the subaerially exposed Persian Gulf basin at the end of the LGM cut off the supply of calcareous grains to these dunes; many of these glacial-age dunes are now stabilized by calcite cement, perhaps resulting from slightly wetter conditions in the region during the early Holocene.

The rate of the marine reflooding of the Persian Gulf basin was very rapid at times. Notable rapid eustatic rises occurred around 12–11.5 ka and 9.5–8.5 ka. Combined with the extremely flat floor of the Gulf, marine waters would have transgressed an average of > 100 m per year; at times of rapid eustatic rise this transgression probably exceeded a kilometer per year. Early people who were living on the riverine plain along the extended Tigris and Euphrates Rivers on the floor of the Persian Gulf would have been displaced by rising waters. The rapid submergence of their land and villages continued for many generations and dramatically impacted on their lives. Stories of this forced migration must have been told and passed on to succeeding generations. We propose that this postglacial reflooding of the floor of the Persian Gulf is the flood event recorded in the Epic of Gilgamesh after the first cuneiform script was invented and as Noah’s Flood in Genesis 7–8 of the Bible.

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References


