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by Jeffrey I. Rose

The emerging picture of prehistoric Arabia suggests that early modern humans were able to survive periodic hyperarid oscillations by contracting into environmental refugia around the coastal margins of the peninsula. This paper reviews new paleoenvironmental, archaeological, and genetic evidence from the Arabian Peninsula and southern Iran to explore the possibility of a demographic refugium dubbed the "Gulf Oasis," which is posited to have been a vitally significant zone for populations residing in southwest Asia during the Late Pleistocene and Early Holocene. These data are used to assess the role of this large oasis, which, before being submerged beneath the waters of the Indian Ocean, was well watered by the Tigris, Euphrates, Karun, and Wadi Batin rivers as well as subterranean aquifers flowing beneath the Arabian subcontinent. Inverse to the amount of annual precipitation falling across the interior, reduced sea levels periodically exposed large portions of the Arabo-Persian Gulf, equal at times to the size of Great Britain. Therefore, when the hinterlands were desiccated, populations could have contracted into the Gulf Oasis to exploit its freshwater springs and rivers. This dynamic relationship between environmental amelioration/desiccation and marine transgression/regression is thought to have driven demographic exchange into and out of this zone over the course of the Late Pleistocene and Early Holocene, as well as having played an important role in shaping the cultural evolution of local human populations during that interval.

> *For Dilmun, the land of my lady's heart, I will create long waterways, rivers and canals, whereby water will flow to quench the thirst of all beings and bring abundance to all that lives.* (The promise of Enki the Lord of Sweet Waters to Ninhursag the Earth Mother, from the Sumerian creation myth "Enki and Ninhursag"; Kramer 1945)

Introduction: Out of Africa and Into Arabia?

The investigation presented in this paper commences with the question of human expansion from Africa into Arabia during the Late Pleistocene (128,000–12,000 BP). Scholars often envision South Arabia as a population corridor, drawing on evidence from archaeozoology (Fernandes 2009; Tchernov 1992; Wildman et al. 2004), paleoanthropology (Lahr and Foley 1994, 1998; Stringer 2000), human genetics (Kivisild et al. 2004; Metspalu et al. 2004; Oppenheimer 2009; Quintana-Murci et al. 1999), computer modeling (Field, Petraglia, and Lahr 2007; Mithen and Reed 2002) and Paleolithic archaeology (Caton-Thompson 1957; Petraglia and Alsharekh 2003; Rose 2004, 2006, 2007; Whalen, Davis, and Pease 1990). Such studies are based on the supposition that South Arabia was an important conduit throughout the Pleistocene, facilitating the expansion and contraction of biota to and from East Africa. Hence, the Paleolithic archaeological record of Arabia can be used to assess the southern route of dispersal for populations expanding out of Africa.

Recent fieldwork conducted throughout the Arabian subcontinent indicates that human demography was far more complex than has been considered until now. Contrary to expectations of a well-trodden Stone Age highway, new data collected by archaeologists working in Yemen (Crassard 2009; Delagnes et al. 2008; Fedele 2009), Oman (Jagher 2009; Rose and Usik 2009), and the United Arab Emirates (UAE; Marks 2009; Uerpmann, Potts, and Uerpmann 2009) suggest that parts of the peninsula may have served as population refugia, enabling indigenous hunter-gatherers to survive in localized pockets during periodic climatic downturns (Rose and Petraglia 2009). Far from finding East African–derived lithic technologies spilling over into Arabia, freshly unearthed evidence points to a conspicuous lack of connection with African lithic industries following the last interglacial (Rose and Usik 2009). These industries tend to exhibit a distinct Arabian tradition, suggesting minimal demographic input from outside the peninsula. Thus, it is germane to consider the pos-

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sibility that humans have continuously occupied parts of Arabia for the past 100,000 years, if not longer.

The Arabian subcontinent houses a mosaic of microenvironments, some of which provided stable, predictable sources of food and freshwater even during the most hyperarid phases of prehistory. At times when glacial conditions led to increased aridity and widespread environmental degradation, reduced sea levels exposed large portions of the continental shelf and caused the formation of "coastal oases" fed by upwelling subterranean springs (Faure, Walter, and Grant 2002). Taking into account the concentration of freshwater resources in coastal and other low-lying areas, as well as annual rates of precipitation, figure 1 depicts three proposed refugia around Arabia: (1) the Red Sea basin and 'Asir-Yemeni highlands, (2) the southeast Arabian littoral zone, and (3) the exposed basin of the Arabo-Persian Gulf.[1]

This paper focuses on prehistoric occupation within and around the Gulf Oasis, posited to have been the primary refugium in Arabia. For the purposes of this study, the Gulf Oasis is defined as the shallow inland basin that was exposed throughout most of the Late Pleistocene and Early Holocene. It was bounded to the west by the sprawling deserts of the Arabian Peninsula, to the east by the towering peaks of the Zagros mountain range, and to the north by the Mesopotamian floodplain. From 74,000 BP to the final incursion of the Indian Ocean around 8000 BP, the Gulf Oasis formed the southern tip of the "Fertile Crescent" (sensu Breasted 1916). This presently inundated zone was once a low-lying floodplain beginning at the confluence of the Tigris and Euphrates Rivers in Mesopotamia, the Karun River draining off the Iranian Plateau, and the Wadi Batin River flowing across northern Arabia. Together, these systems joined together into the Ur-Schatt River Valley. Further downstream, the Ur-Schatt was fed by additional surface runoff from both eastern Arabia as well as the Zagros Mountains. Its deeply incised channel is still visible in the extant bathymetry (Seibold and Vollbrecht 1969). The Ur-Schatt catchment zone terminates at a large lake basin (>100,000 km^2) positioned in the heart of the Gulf some 140 m below current sea level (fig. 2). In addition to surface runoff, freshwater within the purported oasis was also supplied by upwelling springs, known as *khawakb* in Bahraini dialect, which are subterranean rivers linked to the Rub' Al Khali and Zagros aquifer systems. Even today, these springs deliver freshwater to the Gulf through fissures in the porous bedrock of the basin (Church 1996; Shiraz and Münster 1992; Sultan et al. 2008).

Consequently, as potentially one of the largest and most stable sources of freshwater in southwest Asia for the majority of the Late Pleistocene and the Early Holocene, it is germane to consider that the Gulf Oasis was home to a sizable human population. In suggesting autochthonous human groups that survived outside of Africa from 128 kya onward, the proposed model contradicts scenarios of modern human emergence that envision a more recent expansion from Africa during marine isotope stage 4 (MIS 4), between 74 and 60 kya.

This new iteration of the old "oasis hypothesis" also offers a novel perspective on the century-long discussion of Neolithization in southwest Asia (e.g., Bender 1975; Braidwood 1973; Childe 1928; Flannery 1969, 1973; Pumpelly 1908; Staubwasser and Weiss 2006), recently dubbed the "Neolithic demographic transition" (Bocquet-Appel 2008). The Gulf Oasis hypothesis proposes a heretofore undocumented indigenous community at the nexus of the ancient world, ground zero of the Agricultural and Urban revolutions. Not only does the proposed scenario introduce a new and substantial cast of characters to southwest Asia at the critical Pleistocene-Holocene boundary, it also supplies an ecologically driven mechanism—fluctuating landscape carry capacity within an isolated environment—that is thought to have played an important role in shaping cultural evolution throughout the region.

While the bulk of the archaeological record during the Terminal Pleistocene and Early Holocene lies submerged beneath the waters of the Arabo-Persian Gulf, there are more than 60 archaeological sites that suddenly appear along the newly established Middle Holocene shoreline, which evidence a prospering Neolithic population practicing a combination of fishing, date palm cultivation, and animal husbandry. Before the appearance of these sedentary/semisedentary villages, the few known Early Holocene archaeological sites in the region were characterized by sparse and ephemeral hunter-gatherer camp sites scattered along the coast. The Gulf Oasis model envisages that the wave of Middle Holocene settlements derive from an indigenous population displaced by the advancing shoreline. From that perspective, Terminal Pleistocene and Early Holocene sites around the Gulf represent but the more mobile, peripheral elements of a larger core group within the basin.

Archaeological remains recovered from these newly founded Middle Holocene sites exhibit a suite of characteristics demonstrating a high level of cultural complexity, including plant and animal domestication, aquatic subsistence, permanent structures, public architecture, pressure flaking, boat construction, a two-tiered settlement hierarchy, and extensive trade networks described as "mature, stable and structured" on their initial appearance in the archaeological record (Carter, forthcoming). By 7,000 years ago, settlements along the northern shoreline even demonstrate the first detectable use of lowland irrigation farming to carry out intensive agricultural production, an innovation that some have speculated was the catalyst for the Urban Revolution (Adams 1972; Helbaek 1972; Hritz and Wilkinson 2006; Pournelle 2003).

If a local community was displaced from the Gulf Oasis, triggering a wave of settlement activity around the post-8000-BP shoreline, this then leads to questions of cultural evolution

1. The author acknowledges that "Arabian Gulf" and "Persian Gulf" are more typically used to refer to this body of water; however, to avoid contention, this paper adopts the convention of hyphenating the two designations.

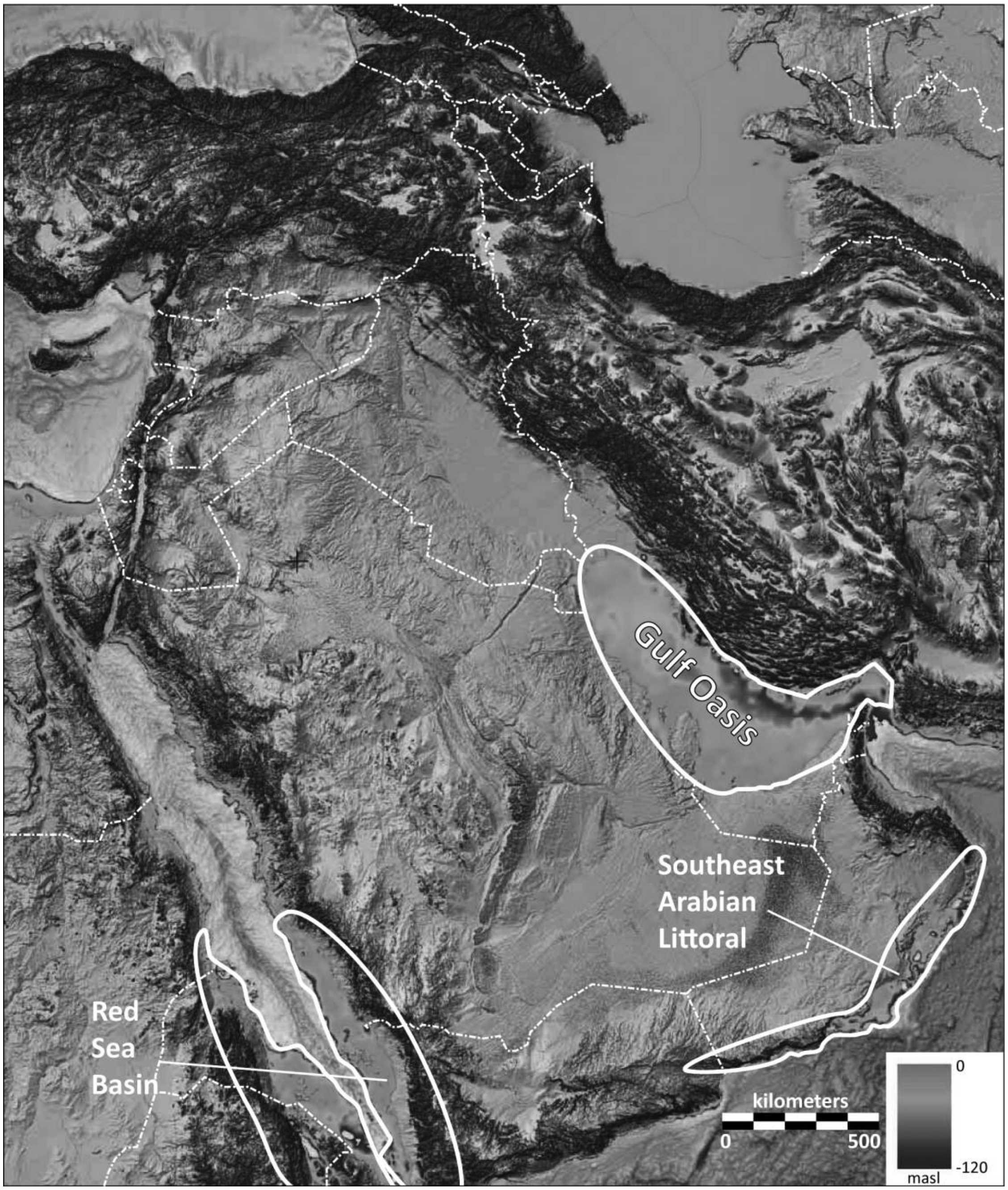
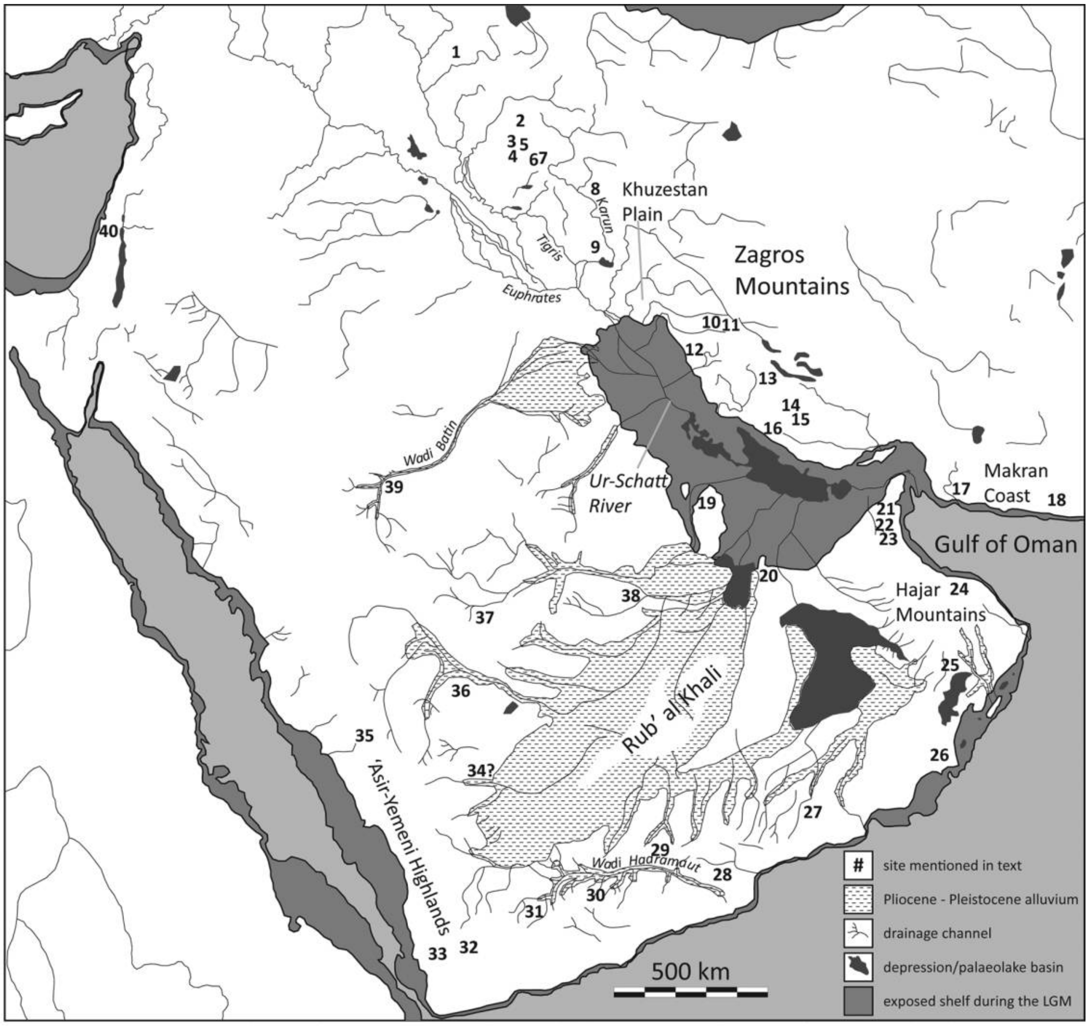


Figure 1. Physical map of the Arabian Peninsula depicting littoral zones exposed by reduced sea levels and proposed environmental refugia (digital elevation model base map courtesy of M. Otte).

during the Terminal Pleistocene and Early Holocene. To what extent was the process of Neolithization, even Mesolithization, driven by human ecology within the fertile yet isolated Gulf Oasis? This line of reasoning invokes V. Gordon Childe and requires a reappraisal of his oasis hypothesis (Childe 1928, 1936, 1952) in light of new archaeological evidence around the Gulf.

In order to investigate the likelihood of an indigenous community within the Gulf Oasis, paleoenvironmental and archaeological evidence are synthesized, working to build a picture of prehistoric occupation over the course of the Late Pleistocene and Early Holocene. The first section of this paper draws on hydrology, deep sea cores, geochemistry, and landscape geomorphology to describe the different environments



1 Shanidar Cave, Iraq
Solecki & Solecki 1994

2 Bisitun, Iran
Coon 1951; Dibble 1984

3 Warwasi, Iran
Dibble & Holdaway 1994

4 Kobeh, Iran
Lindly 2005

5 Ghar-e-Khar, Iran
Olszewski & Dibble 1994

6 Yafteh Cave, Iran
Otte et al. 2007

7 Gar Arjeneh, Iran
Olszewski & Dibble 1994

8 Kunji, Iran
Baumler & Speth 1994

9 Izeh Plain, Iran
Niknami et al. 2009

10 Sarab Syah, Iran
Conard et al. 2005, 2006, 2007

11 Qaleh Bozi, Iran
Biglari et al. 2009

12 Ghar-e-Boof, Iran
Conard et al. 2007

13 Eshkaft-i-Gavi, Iran
Rosenberg 1985; Scott & Marean 2009

14 Bab Anar, Iran
Dashtizadeh & Hossaini 2008

15 Jahrom, Iran
Piperno 1972

16 Jam-o-Riz Plain, Iran
Dashtizadeh 2009

17 Kuhestak, Iran
Vita-Finzi & Copeland 1980

18 Konarak, Iran
Vita-Finzi & Copeland 1980

19 Ras 'Ushayriq, Qatar
Al-Naimi 2009

20 Jebel Barakah, UAE
McBrearty 1993, 1999;
Wahida et al. 2009

21 Fili, UAE
Scott-Jackson et al. 2008, 2009

22 Jebel Faya Rockshelter, UAE
Uerpmann et al. 2009; Marks 2009

23 Nad al-Thaman, UAE
Uerpmann et al. 2009

24 Wadi Wutayya, Oman
Uerpmann et al. 2009

25 Haushi-Huqf, Oman
Biagi 1994; Rose 2006; Jagher 2009

26 Ad Duqm, Oman
Jagher 2009

27 Nejd Plateau, Oman
Hawkins & Payne 1963; Pullar 1974;
Zarins 2001; Whalen et al. 2002;
Rose 2004, 2006; Rose & Usik 2009

28 Mahra, Yemen
Amirkhanov 1994, 2006; Rose 2002

29 Wadi Wa'shah, Yemen
Crassard 2009

30 Hadramaut, Yemen
Caton-Thompson & Gardner 1939;
Van Beek et al. 1963;
Amirkhanov 1994, 2006; Crassard 2009

31 Shawba, Yemen
Inizan & Ortlieb 1987

32 'Asir-Yemeni Highlands, Yemen
Garbini 1970; de Bayle des Hermens 1976;
de Maigret 1984, 1985; Bulgarelli 1988;
Fedele 2009

33 Shi'bat Dihya 1 & Tihama Plain, Yemen
de Maigret 1986; Whalen & Pease 1991;
Whalen & Schatte 1997;
Delagnes et al. 2008

34 Faw Fell assemblage, Saudi Arabia
Edens 2001

35 Western Province, Saudi Arabia
Zarins et al. 1980, 1981; Whalen et al. 1988

36 Wadis Dawasir & Tathlith, Saudi Arabia
Zarins et al. 1981; Zarins & Zahrani 1985;
Zarins & al-Badr 1986

37 Saffaqah & Riyadh, Saudi Arabia
Zarins et al. 1982; Whalen et al. 1984;
Alsharekh 1995; Petraglia & Alsharekh 2003

38 Yabrin Oasis & Wadi Sahba, Saudi Arabia
Adams et al. 1977

39 Northern Province, Saudi Arabia
Parr et al. 1978

40 Skhul & Qafzeh Caves, Israel
Schwarcz et al. 1988; Mercier et al. 1993

Figure 2. Map of southwest Asia depicting exposed landscapes during the Last Glacial Maximum as well as ancient and modern drainage systems. Numbers indicate Pleistocene and Early Holocene sites mentioned in the text.

that were present in the region and erects a rough chronological framework with which to model stages of climate change and marine incursion. The paper then turns to the Late Pleistocene and Early-Middle Holocene archaeological record around the Arabo-Persian Gulf. In the last few years, the number of known prehistoric sites around the Gulf coast and hinterlands has soared (fig. 2). This section reviews these new data, taking into account relative and absolute ages, lithic technology, and site distribution patterns. This evidence is used to construct a model of human occupation around the basin over the course of the last 100,000 years. The final section discusses the implications of the Gulf Oasis on current scenarios of modern human expansion out of Africa as well as the Neolithic demographic transition in southwest Asia.

Paleoclimate in the Arabo-Persian Gulf

There are few places on earth that have undergone such profound shifts in landscape as the Arabian Peninsula. Over the course of the Quaternary, the subcontinent has been affected almost exclusively by two climatic regimes: westerlies and the Indian Ocean monsoon system. Westerlies are storms that form over the Mediterranean and advance down the Arabo-Persian Gulf, scattering light to moderate rainfall (40–120 mm/yr) around the Gulf territories throughout the winter months. The Indian Ocean monsoon is responsible for summer *khareef* storms that bring cool temperatures, high humidity, and frequent rains to the Dhofar Mountains and coastal plain along the southern coastline of Arabia between late June and early September.

The Indian Ocean monsoon is particularly sensitive to fluctuations in global insolation patterns; during glacial periods, the intertropical convergence zone (ITCZ) drifts to the south, while a return to warmer conditions causes the ITCZ to shift further north and deposit seasonal rains far into the Rub' Al Khali desert. Throughout the Pleistocene, these meteorological dynamics have caused dramatic oscillations across the interior, transforming barren sand seas into fertile grasslands and back again (e.g., Fleitmann et al. 2007; McClure 1976; Parker and Rose 2008). Variable distribution of water and food over time likely had significant demographic implications, creating a cyclical ebb and flow of population expansion and contraction from the three core refugia depicted in figure 1 into marginal zones along the periphery.

Given the extent of the exposed land within the Gulf basin, the abundance of food, water, lithic raw material, and its conscripted geographic position, this sizable inland depression is thought to have formed one of the most important oases in the ancient world. Situated along the eastern edge of the peninsula, the Arabo-Persian Gulf is among the shallowest seas in the world, with average depths of just 40 m. When global sea levels dropped below this mark at the onset of MIS 4, more than 100,000 km^2 of land were continuously exposed for the ensuing 70,000 years. During that interval, the basin housed a rich mosaic of freshwater springs, river floodplains, mangrove swamps, and estuaries (Al-Hinai, Moore, and Bush 1987; Alsharhan and Kendall 2003; Butler 1969; Diester-Haass 1973; Evans 1966; Georgiev and Stoffers 1980; Gischler et al. 2005; Lambeck 1996; Saleh et al. 1999; Sarnthein 1972; Seibold and Vollbrecht 1969; Stoffers and Ross 1979; Sugden 1963; Uchupi, Swift, and Ross 1996, 1999; Williams 1999; Wilkinson and Drummond 2004). Adding to its appeal, there are high-quality chert deposits exposed in patches across the landscape. Bahrain, Qatar, and the islands just off the coast of Abu Dhabi Emirate are riddled with such outcrops (Beech, Elders, and Shepherd 2000; Cavelier 1970; Edgell 1992; Kapel 1967).

The Arabo-Persian Gulf basin is the terminus of several major river systems (fig. 2); the majority of all freshwater in southwest Asia ultimately drains into this large depression via surface runoff and underground rivers (Alsharhan et al. 2001; Shiraz and Münster 1992; Sultan et al. 2008). Currently much of the subterranean freshwater upwells from beneath the central Gulf through karstic limestone lining the basin, called *khawakb* in local Bahraini dialect. "Coastal oases" are likely to have formed around these *khawakb* when reduced sea levels exposed the surrounding landscape and triggered increased pressure on the hydrostatic head of the aquifers (Faure, Walter, and Grant 2002). The island of Bahrain, meaning in Arabic "the two seas," is thought to reference the dual saltwater sea surrounding the island and freshwater sea upwelling from the submerged floor of the Gulf. On witnessing the local exploitation of *khawakb* during his visit in 1603, Portuguese explorer Pedro Teixeira wrote,

> There is water in plenty, rather brackish than sweet. The best is that of Nanyáh, the name of certain very deep wells in the centre of the isle. The next is that got from the bottom of the sea, as follows. The chief town of the isle, Manamà, is on the sea shore, and near it, in the depth of three or three and a-half fathoms, are several great springs of fresh, clear, and wholesome water. There are some men who make their living by bringing it up from below in waterskins, which they do very cleverly and easily, where it bubbles up, and sell it cheap. Certain of the oldest Moors of the isle, with whom I spoke of this, told me that *these springs were once far inland; but the sea broke in and overflowed them, as we see at this day*. (Teixeira, Sinclair, and Ferguson 1902: 175, italics added)

Climatic conditions were not entirely favorable while the Gulf Oasis was exposed. Dune formation (Al-Hinai, Moore, and Bush 1987; Teller et al. 2000) and the reduction of alluvium deposited from Zagros drainage systems during the Last Glacial Maximum (LGM) signal a significant drop in surface runoff between approximately 20,000 and 12,000 years ago (Sarnthein 1972). A series of 13 piston cores sampled by the Atlantis II expedition to the Arabo-Persian Gulf in 1977 identified three distinct depositional phases (Stoffers and Ross 1979). The lowest unit, laid down between 30,000 and 12,000 cal BP, is made up of thick detrital silt indicative of an active river valley, formed by the aggradation of Ur-Schatt River alluvial sediments. The overlying layer, bracketed from 12,000 to 6000 cal BP, is carbonate-rich mud signaling increasingly brackish, marine conditions. This stratum is interpreted as a period of rising sea levels that induced marine conditions within the basin. The uppermost unit, laid down from 6,000 years ago to present, is composed of carbonate-rich marls characteristic of the current depositional environment. From this, it can be inferred that sea levels have remained relatively stable in the interim.

Cores taken from the Lower Khuzestan plain (fig. 2) depict three sedimentary facies from the Late Pleistocene to the Middle Holocene. The lowest unit is made up of silty alluvium attesting to the existence of an ancient river plain before 9000 cal BP. This floodplain horizon is capped by a peat layer that formed between approximately 9000–8500 cal BP, at which time the rising water table and advancing shoreline transformed the plain into a freshwater marsh and estuarine environment. By 5500 cal BP, marine transgression had completely inundated the plain, evidenced by the transition from tidal flat to coastal *sabkha* sedimentation (Heyvaert and Baeteman 2007).

Shoreline reconstructions of marine incursion into the Arabo-Persian Gulf show that the Indian Ocean ingressed more than 1,000 km between 12,000 and 6,000 years ago (e.g., Al-Farraj 2005; Bernier et al. 1995; Bruthans et al. 2006; Cooke 1987; Evans, Kirkham, and Carter 2002; Ivanovich, Vita-Finzi, and Hennig 1983; Lambeck 1996; Teller et al. 2000; Williams and Walkden 2002). Both Sarnthein (1972) and Dalongeville and Sanlaville (1987) observe four sea stands signaled by shoreline sedimentation at 125–105-m, 64–61-m, 54–40-m, and ~30-m depths. Models of lateral transgression predict a relatively slow, gradual rise in sea level punctuated by a rapid phase of incursion from 12,000 to 11,000 cal BP, followed by a second phase from 9000 to 8000 cal BP, at which times the coastline advanced upward of 1 km/yr in some places (Kassler 1973).

Figure 3 provides a summary of sea-level change and the paleoclimatic record in the Gulf basin from 74,000 BP to present. The eustatic sea-level data are derived from the Red Sea curve calculated by Siddall et al. (2003) as well as analyses of geomorphic features within the Gulf basin used to date the local timing of these fluctuations (Al-Asfour 1982; Alsharhan and Kendall 2003; Kassler 1973; Lambeck 1996).[2] The pluvial signal curve is taken from Parker and Rose (2008) and represents a sum probability based on a data set of environmental proxy signals recorded throughout the Arabian Peninsula. The magnitude of the sum probability curve is not a measure of the amount of precipitation; rather, it represents the statistical likelihood of wet conditions calculated from the radiometric ages of the different paleoenvironmental proxies.

There is an inverse relationship between Arabian pluvial phases and the amount of land exposed along the continental shelf. This suggests that at times when the interior of Arabia became desiccated and uninhabitable, sea levels dropped and created new coastal habitats around the margins of the peninsula. At the height of the LGM around 18 kya, reduced sea levels produced 200,000 km^2 of additional land in the Gulf basin—a territory roughly the size of Great Britain. It is expected that nomadic groups were forced to contract toward the coastal margins during periods of low sea level and aridity, particularly glacial phases associated with MIS 4 (74–60 kya) and MIS 2 (24–12 kya). Conversely, populations would have expanded from the exposed shelf into the hinterland during pluvial episodes from 55 to 24 kya and from 12 to 6 kya.

The Terminal Pleistocene–Early Holocene phase of postglacial flooding coincides with an increase in annual precipitation, which generated both "pulling" mechanisms from amelioration of the interior that drew populations into the hinterlands, as well as "pushing" mechanisms caused by marine inundation of the exposed lowlands. The Holocene incursion was the first time since MIS 5e (128–120 kya) that the Indian Ocean had ingressed so far into the basin. Consequently, the Gulf Oasis hypothesis predicts an abrupt spike in human settlement after 8000 BP, at which time displaced communities were forced to retreat upslope as sea levels submerged the floodplain. The presence of archaeological sites around the hinterlands of the basin support this claim, demonstrating a long tradition of human occupation in the region for more than 100,000 years, punctuated by a pronounced wave of settlement activity around 7,500 years ago. These archaeological data are presented in detail in the following section.

Prehistoric Archaeology around the Arabo-Persian Gulf

The State of Paleolithic Research

Prehistoric archaeology in eastern Arabia began with somewhat of a false start. The first documented "Paleolithic" stone tools were lithic surface scatters reported by the Danish archaeological mission to Qatar in the late 1960s.[3] Kapel (1967) classified supposedly Mousterian artifacts as "Qatar A-Group," followed in chronological succession by "B-Group," "C-Group," and "D-Group" assemblage types arranged on the basis of typological attributes rather than relative or ab-

2. Recent paleoenvironmental investigations carried out in the North Sea demonstrate the potential for several hundred years lag in dates of transgression due to differing models of sea-level change, bathymetry, isotasy, and margin of error in radiometric dates calculated from proxy signals (Ward, Larcombe, and Lillie 2006). Therefore, although the bathymetry in the Gulf basin points to a rapid period of inundation between 9000 and 8000 BP, this may have actually occurred up to a millennium later between 8000 and 7,000 BP. More detailed investigation of the rate of transgression in the Gulf is necessary to test these assumptions.

3. For the purposes of this paper, undated assemblages that authors have attributed to specific archaeological phases are placed in quotes in order to clarify their indeterminate nature.

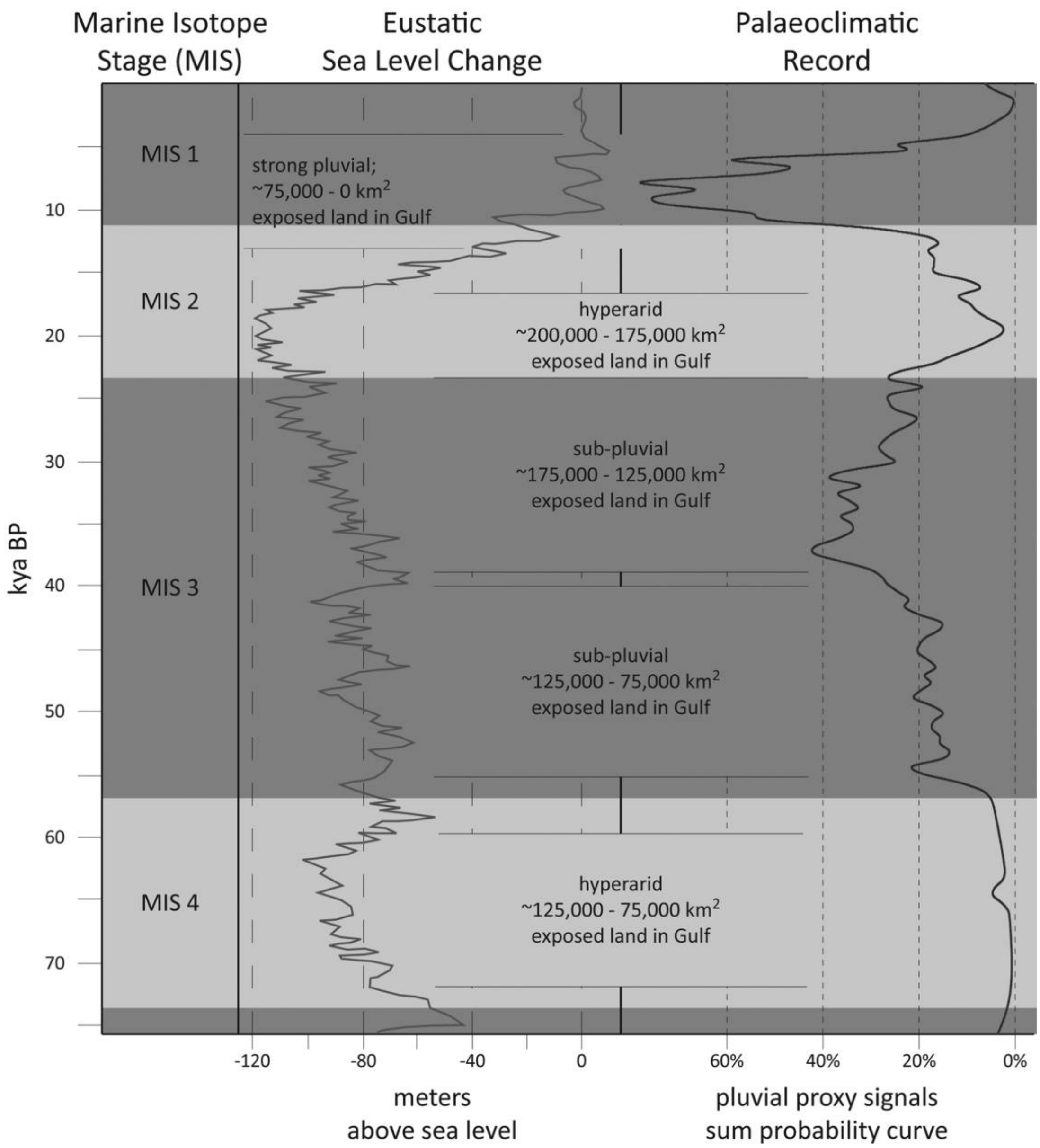


Figure 3. Environmental fluctuations in Arabia from marine isotope stage (MIS) 4 to MIS 1. Sea-level curve after Siddall et al. (2003, fig. 4, p. 857); exposed landmass in Gulf and paleoshoreline reconstructions from Lambeck (1996); paleoclimatic sum probability curve after Parker and Rose (2008, fig. 4, p. 31).

solute dating methods. A decade later, French archaeologists investigating the site of Khor B on the eastern coast of Qatar excavated a Middle Holocene sequence with lithic assemblages bearing similar characteristics to the "Mousterian" A-Group material (Inizan 1978, 1980). The discoveries at Khor B cast doubt on the Danish chronology, later described as "worthless" (Tosi 1986:466), and caused scholars to reorganize the entire corpus of Qatar lithic assemblages within a Holocene timeframe. Since then, researchers have presumed the absence of Paleolithic archaeology in eastern Arabia and have curtailed any targeted investigation of this time period until quite recently. While this paper was being prepared, Al-Naimi (2009) presented new findings of a lithic surface scatter from Ras 'Ushayriq on the northwestern coast of Qatar (*19* in fig. 2) with potential Middle Paleolithic (MP) and Upper Paleolithic (UP) elements, once again raising the specter of a Pleistocene population on the Qatar peninsula.

The first conclusive evidence of a Late Pleistocene human presence in eastern Arabia was unearthed in 2005 by a joint expedition between the Sharjah Emirate and Tübingen University. While excavating a test trench in the Jebel Faya 1 rockshelter (*22* in fig. 2), the team discovered a stratified Paleolithic sequence composed of three archaeological horizons; radiometric dates place these occupations between MIS 5 and MIS 3 (Marks 2009; Uerpmann, Potts, and Uerpmann 2009; Uerpmann et al. 2007).[4] New surface assemblages from other findspots around the shoreline of the basin have been identified that exhibit technologically and typologically similar lithic material tentatively anchored to the Jebel Faya optically stimulated luminescence dates (OSL; Scott-Jackson, Scott-Jackson, and Rose 2009; Scott-Jackson et al. 2008; Wahida et al. 2009). However, these sites (and all lithic surface scatters in Arabia for that matter) must be approached with extreme caution as there is a paucity of stratified Pleistocene deposits and, consequently, too few absolute dates.

In comparison to Arabia, considerably more is known of the Middle Paleolithic ("Zagros Mousterian") and Upper Paleolithic ("Baradostian" or "Zagros Aurignacian") periods in the Zagros Mountains of Iran (e.g., Lindly 2005; Olszewski and Dibble 1994). Here, direct evidence for early human exploitation of the Arabo-Persian Gulf was discovered at Yafteh Cave (*6* in fig. 2), where perforated marine shells carried some 350 km upriver from the ancient shoreline of the basin were discovered within the dated Upper Paleolithic horizon (Otte et al. 2007). Although there are only a small handful of findspots reported along the Iranian coastline of the Gulf (Conard et al. 2005, 2006, 2007; Dashtizadeh 2009; Ghasidian et al. 2006) the abundance of Middle and Upper Paleolithic findings in the northern and central Zagros regions suggests that the scarcity of sites in the south is related to insufficient investigation rather than absence of occupation.

There is a sizable gap in the distribution of Late Pleistocene archaeological sites along the Gulf's northern and northwestern shorelines. This deficiency is probably owed to a combination of postdepositional factors, first and foremost the massive sedimentation of the Tigris, Euphrates, and Karun river systems responsible for covering the Mesopotamian floodplain in tens of meters of alluvium, effectively masking the Late Pleistocene landscape surface. Since the region was the cradle of civilization, it is also likely that human activity over long periods of history also greatly contributed to wiping out traces of prehistoric inhabitants.

Given the presence of Middle and Upper Paleolithic archaeological sites around the eastern and western margins of the Gulf Oasis, albeit many of them undated, it is clear that the area surrounding the basin was exploited by many groups of hunter-gatherers at various times throughout the Late Pleistocene. In order to test the hypothesis presented in this paper, it is critical to determine whether human occupation has been continuous or intermittent during this interval.

The Middle and Upper Paleolithic of Eastern Arabia

Virtually all that is known of the Late Pleistocene period from the Arabian side of the Gulf comes from the site of the Jebel Faya 1 rockshelter in Sharjah Emirate, as it represents the sole findspot that has yielded radiometric dates (Marks 2009; Uerpmann, Potts, and Uerpmann 2009; Uerpmann et al. 2007). In four seasons of fieldwork, excavations uncovered more than 3 m of in situ archaeological material associated with at least three distinct archaeological layers spanning most of the Late Pleistocene. The lowest level, assemblage C, is characterized by small handaxes, thick bifacial foliates, hard hammer blades, and centripetal cores. Assemblage B yielded multiple platform cores with flat converging and flat 90° flaking surfaces, as well as a high frequency of blades produced from these cores. Tools include burins, endscrapers, and sidescrapers. In contrast to the underlying assemblage C, there is no evidence for the use of the Levallois technique nor any sign of platform faceting. Assemblage A yielded multiple platform cores, mostly flake (rather than blade) production, no Levallois cores or debitage, and no evidence of platform faceting. Similar to assemblage B, some Upper Paleolithic tool types are present, such as burins and endscrapers. Given their generally nondiagnostic characteristics, it is difficult to classify assemblages A and B within any known technological or typological category (Marks 2009). Although the radiometric dates have not yet been finalized, preliminary results indicate an age of at least MIS 5 for assemblage C, while assemblages A and B fall sometime between MIS 5 and MIS 2 (Uerpmann et al. 2007).

Taking into account the suite of technological and typological characteristics observed in assemblage C, corresponding to radiometric dates that place the assemblage within the timeframe of the Levantine Middle and Upper Paleolithic, Marks (2009:305) points out a conspicuous absence of Levantine features such as elongated blanks, Levallois points, and unidirectional-convergent reduction strategies, showing "tendencies totally unknown in the Levant in Middle Paleolithic contexts." Marks also notes distinct differences between Jebel Faya assemblage C and the potentially coeval Sibakhan sites (sensu Rose 2006) recorded in central and southern Oman (*25*, *27* in fig. 2), which are characterized by large flat bifacial forms and hard hammer blades but have no evidence for Levallois or discoidal cores (Biagi 1994; Jagher 2009; Rose 2006). Marks draws tentative correlations between assemblage C and early MSA assemblages from east/northeast Africa, citing parallel modes of *façonnage* reduction to manufacture similar handaxe and foliate tool forms. From this, he speculates that the assemblage C archaeological level of occupation at Jebel Faya may be attributed to human groups expanding out of Africa at the beginning of the Late Pleistocene (if not earlier); assemblage C then appears to develop into a region-

4. At least two additional lower archaeological layers have been discovered at Faya; however, small sample sizes do not permit any reliable description of the assemblages (Marks 2009).

ally distinct tradition over time. Assemblages A and B bear no affinities with surrounding Middle/Upper Paleolithic assemblages known from the Levant, Zagros, the Horn of Africa, or even other parts of Arabia outside the basin, supporting the notion of a continuous, autochthonous occupation within the Gulf Oasis.

At the moment, Jebel Faya 1 represents the only stratified Paleolithic site in eastern Arabia. There are, however, techno-typologically related surface scatters reported nearby at Fili around the flanks of the Hajar Mountains (*21* in fig. 2; Scott-Jackson, Scott-Jackson, and Rose 2009; Scott-Jackson et al. 2008), at Jebel Barakah on the coast in western Abu Dhabi Emirate (*20* in fig. 2; McBrearty 1993, 1999; Wahida et al. 2009), and at Ras ʻUshayriq on the northwestern coast of the Qatar Peninsula (*19* in fig. 2; Al-Naimi 2009). Although undated, lithic artifacts collected at Jebel Barakah exhibit "Middle Paleolithic" diagnostic features showing some overlap with Jebel Faya assemblage C. The predominant core reduction strategy is a centripetal Levallois technique, grading into biconical and high-backed radial cores. There are also a few pieces bearing evidence of bidirectional Levallois reduction and a low number of Nubian cores. In addition to an array of nondiagnostic tool types such as denticulates and notches, the Jebel Barakah toolkit includes a cordiform bifacial handaxe and a bifacially retouched sidescraper (fig. 4*g*; Wahida et al. 2009).

In the interior foothills of the Hajar mountain chain near Fili, some 20 km east of Jebel Faya (*21* in fig. 2; Scott-Jackson, Scott-Jackson, and Rose 2009; Scott-Jackson et al. 2008) collected a series of lithic surface scatters bearing characteristics similar to both Jebel Faya C and Jebel Barakah, namely, the *façonnage* production of bifacial tools in conjunction with discoidal cores and centripetal Levallois cores. These sites are composed of dense, extensive scatters of lithic artifacts found on a series of limestone ridges approximately 300 m in elevation. Among the tools collected, there is a high frequency of sidescrapers and bifacial implements such as bifacially worked sidescrapers with flat invasive retouch, backed bifacial knives, foliates, limandes, and a large elongated bifacial handaxe (fig. 4*a*–4*c*). The Fili assemblages also exhibit elements of Levallois technology, ranging between centripetal and unipolar-convergent reduction strategies, as well as an assortment of biconical and high-backed radial cores (fig. 5).

Although there is still much to be learned in regard to the Late Pleistocene archaeological sequence of eastern Arabia, fragmentary data permit a few preliminary observations. (1) There were populations present around the western hinterland of the Gulf basin sometime earlier than 100 kya. (2) The Middle Paleolithic at Jebel Faya assemblage C and related findspots is characterized by the production of small bifacial handaxes, bifacial foliates, discoids centripetal Levallois, and Nubian cores. (3) The lithic artifacts from Jebel Faya assemblages A and B do not resemble any other techno-complex in southwest Asia or east Africa; therefore, these assemblages may belong to an autochthonous lithic tradition.

The Middle and Upper Paleolithic of Southern Zagros

Archaeological and geochronological evidence of the Middle and Upper Paleolithic periods in the Zagros Mountains come primarily from lithic assemblages recovered at caves such as Warwasi (*3* in fig. 2; Dibble and Holdaway 1994), Bisitun (*2* in fig. 2; Coon 1951; Dibble 1984), Kunji (*8* in fig. 2; Baumler and Speth 1994), Kobeh (*4* in fig. 2; Lindly 2005), Shanidar (*1* in fig. 2; Solecki and Solecki 1994), and Yafteh (*6* in fig. 2; Otte et al. 2007). As these sites are all situated in the central and northern Zagros Mountains several hundred kilometers from the Gulf, they are probably too far away to be directly related to the oasis population envisioned in this paper. On the other hand, the discovery of a perforated Arabo-Persian Gulf marine shell within the earliest Aurignacian stratum at Yafteh Cave, 350 km upriver from the current mouth of the Gulf, suggests some degree of interaction and/or overlapping mobility patterns between central and southern Zagros populations.

As in Arabia, the chronology of the Middle Paleolithic in Iran is poorly understood; there are no absolute dates to establish the earliest appearance of Zagros Mousterian assemblages, only indications that it was replaced sometime around 36,000 BP by a variant of the Aurignacian techno-complex (Otte et al. 2007). The Zagros Mousterian is a Middle Paleolithic industry characterized by the frequent use of discoids and centripetal Levallois cores. The tools exhibit heavy, invasive, semiabrupt retouch, while the most common implements are sidescrapers and Mousterian points, followed by denticulates and notches. In contrast to the eastern Arabian assemblages, bifacial tools are almost completely absent. The signature heavy retouch on tools from this region has been interpreted by Lindly (2005) to indicate the seasonal occupation of upland zones. Since high-quality raw material sources are scarce in the mountains, prepared cores and blanks were carried into the highlands and subsequently reduced and resharpened as required over the course of an entire season, thereby accounting for the extensive and intensive retouch. Building off of this proposed transhumance scenario, it is reasonable to suggest a mobility strategy between the Gulf basin lowlands and Zagros highlands that allowed for seasonal exploitation of both zones at optimal times throughout the year.

The taxonomic identity of Zagros Mousterian populations is of particular interest to the Gulf Oasis hypothesis, given the postulated early modern human refugium within the basin. Although it is hazardous to associate any one lithic industry with a specific hominin group, it is possible to say with confidence that the Zagros Mousterian assemblage excavated at Shanidar Cave was manufactured by Neanderthals, indicated by specimens found within the same stratigraphic horizon (Solecki and Solecki 1994; Trinkaus 1983). A hominin radius, also identified as Neanderthal, was recovered from the Zagros Mousterian layer at Bisitun (Trinkaus and Biglari 2006). Thus, the limited demographic information indicates

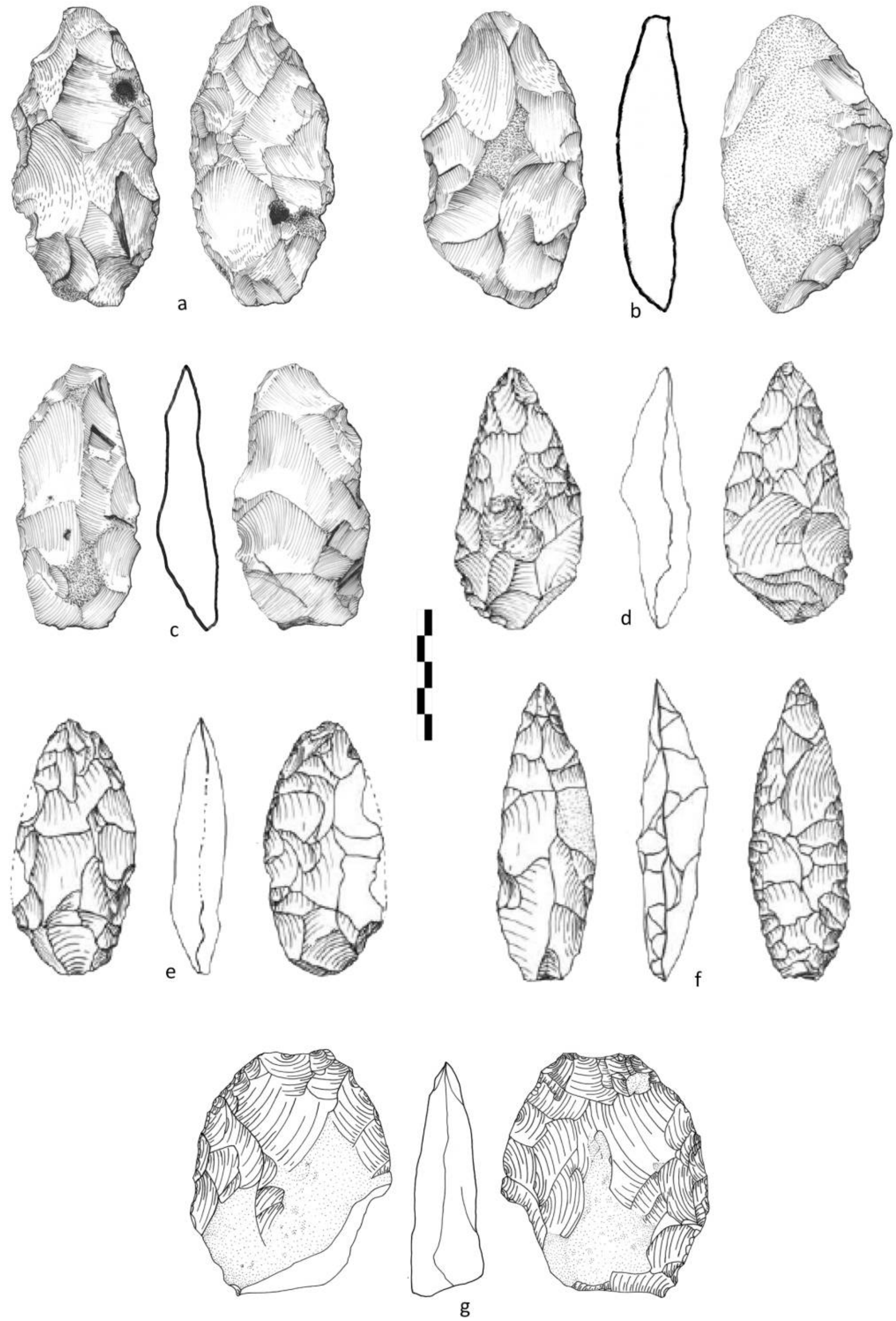


Figure 4. Bifacial foliates and other bifacial elements associated with Middle Paleolithic assemblages around the Gulf basin. *a–c*, Fili surface sites in Sharjah Emirate from Scott-Jackson, Scott-Jackson, and Rose (2009, figs. 7, 8); *d–f*, Qaleh Bozi cave complex in Isfahan Province, Iran, from Biglari et al. (2009, fig. 2.6, 2.10); *g*, Jebel Barakah surface site, Abu Dhabi Emirate, from Wahida et al. (2009, fig. 6). Scale bar = 5 cm, shown in 1-cm increments.

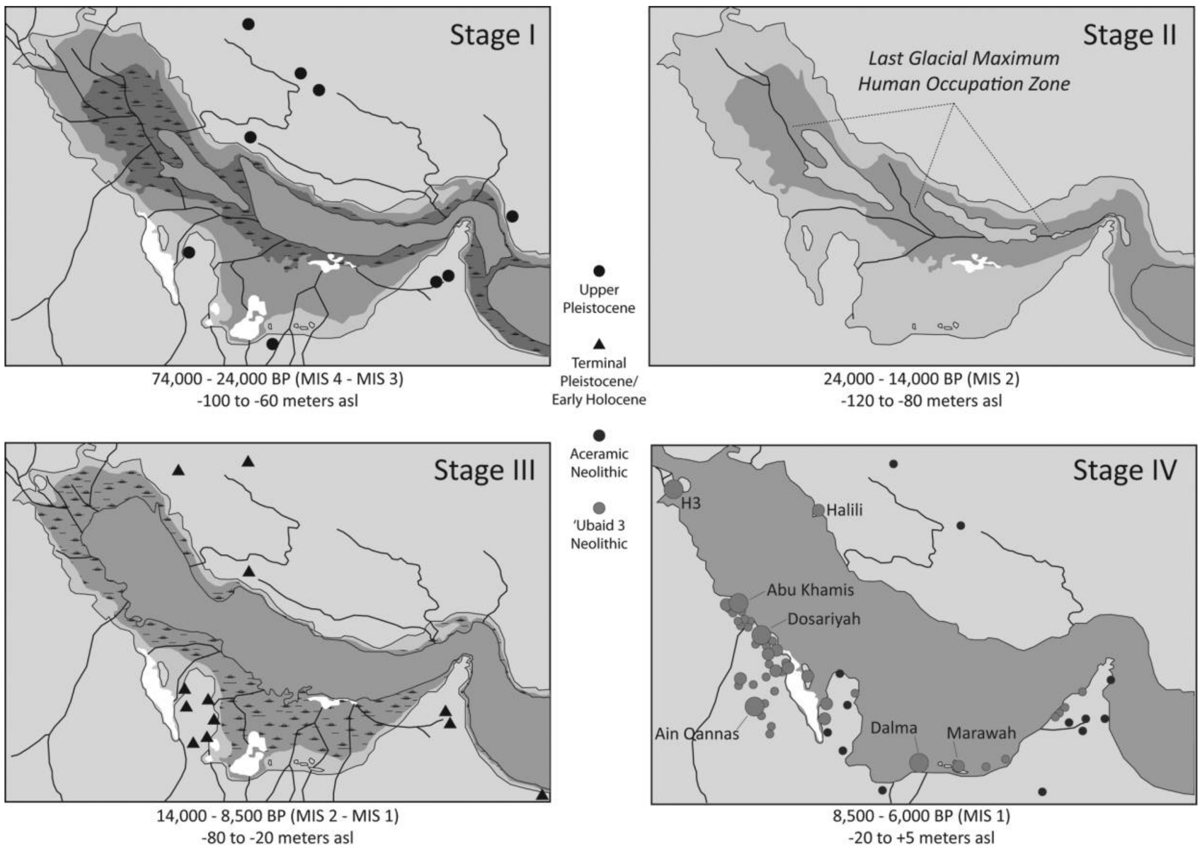


Figure 5. Paleoshoreline configuration, drainage systems, and archaeological sites around the Arabo-Persian Gulf basin during the Late Pleistocene and Early Holocene. The position of the shoreline during these intervals is based on Lambeck (1996, fig. 7), and the drainage channels are taken from Zarins (1998, fig. 1). Sources for archaeological site distributions: Carter (2006, forthcoming); Charpentier (2008); Conard et al. (2005); Kapel (1967); Rosenberg (1985); Uerpmann, Potts, and Uerpmann (2009).

that a Neanderthal population was present in the northern and central Zagros Mountains during the Late Pleistocene, thousands of years after the earliest recorded modern human expansion into the Levant (Mercier et al. 1993; Schwarcz et al. 1988).

New data from southern Iran suggest some degree of regional variation in terms of stone tool-making traditions. "Middle Paleolithic" findspots from the southern Zagros include the basal stratum at Eshkaft-i-Gavi (*13* in fig. 2; Rosenberg 1985; Scott and Marean 2009), the lowest archaeological levels at Qaleh Bozi (*11* in fig. 2), surface scatters collected near Jahrom (*15* in fig. 2; Piperno 1972), Bab Anar (*14* in fig. 2; Dashtizadeh and Hossaini 2008), Jam-o-Riz Plain (*16* in fig. 2; Dashtizadeh 2009), and several recently recorded findspots from the central provinces of Esfahan, Fars, and Kohgiluyeh-Boyerahmad (Conard et al. 2005, 2006, 2007; Ghasidian et al. 2006). Farther to the east, two assemblages were reported by an expedition to the Makran coast in the mid-1970s (Vita-Finzi and Copeland 1980). The geological survey team, composed of nonspecialists, collected lithic artifacts at Konarak (*18* in fig. 2) and Kuhestak (*17* in fig. 2), which they classified as "Middle Paleolithic" from the identification of Levallois cores and blanks. This material, however, comes from surface scatters and should be treated cautiously.

The site of Qaleh Bozi is a complex of two rockshelters and a cave overlooking the Zaiandeh Rud floodplain below (Biglari et al. 2009). The "Middle Paleolithic" assemblage found within these deposits is fundamentally different from the Mousterian of the northern Zagros. Excavators report the predominant use of simple, unidirectional blanks struck from split cobbles, followed by discoids, globular multiple platform cores, and *façonnage* reduction strategies. Striking platforms are for the most part unfaceted, and there is no evidence for the use of the Levallois method. Bifacial tools, completely absent from the northern Zagros Mousterian record, make up an important element of the Qaleh Bozi assemblage. *Façonnage* reduction was used to produce small bifacial foliates (fig. 4*d*–4*f*), bifacial knives, and backed bifacial scrapers. To explain this anomalous technology, alien to the Zagros Mousterian, Biglari et al. (2009:38) point out similarities with material from eastern Arabia: "If we do not envisage a local invention, the Qaleh Bozi industry may be intrusive to the Iranian Central Plateau and could be related to the Middle Paleolithic industries of Oman to the south." This suite of reduction strategies and associated bifacial tools does indeed resemble material Jebel Faya C, as well as Jebel Barakah and Fili surface sites situated on the opposite shore of the Gulf (fig. 4).

"Middle Paleolithic" surface scatters have recently been collected near the eastern coast of the Gulf on the Jam-o-Riz Plain, located 23 km from the present shoreline (*16* in fig. 2). One end of this long, narrow upland plain serves as a pass down into the Gulf basin, providing access for groups traveling between the coast and mountains. Twenty-two sites were documented during the survey, although only a brief account of the material has yet been published. Preliminary reports describe Levallois cores and flakes, tools made on blades, and endscrapers (Dashtizadeh 2009). Scrapers comprise a low percentage of the toolkits, in contrast to the nearby "Middle Paleolithic" assemblages collected at Bab Anar and Jahrom (*14*, *15* in fig. 2) that exhibit a high frequency and wide variety of scraper types (Dashtizadeh and Hossaini 2008).

These surface sites suggest the presence of a Late Pleistocene population in proximity to the eastern Gulf shoreline. It is noteworthy that bifacial implements are absent from the Jam-o-Riz assemblages, drawing a clear distinction between this and the *façonnage* assemblage excavated from the "Middle Paleolithic" horizon at Qaleh Bozi. While this observation does not help to identify those responsible for creating these artifacts, it does insinuate that more than one population was present in the region during this interval, distinguished by their fundamentally different use of prepared core technology versus *façonnage* bifacial production.

The subsequent UP archaeological phase in the Zagros region was initially dubbed the Baradostian (Solecki 1958). This UP industry was first recognized in layer C of Shanidar Cave, overlying the Zagros Mousterian horizon. The type assemblage was described as a combination of flake- and blade-based technologies used to produce burins, endscrapers, carinated pieces, sidescrapers, and points (both Mousterian and Font Yves/Arjeneh). While the core reduction technology and most of these tool types resemble the European Aurignacian, the presence of Mousterian points and sidescrapers distinguish the industry as a regional variant. To underscore these differences, the excavators of Shanidar gave it the name Baradostian after the nearby Baradost Mountains that form part of the northern Zagros chain. More recently, scholars emphasizing affinities to the larger Aurignacian techno-complex distributed throughout Europe and Western Asia have changed the name to Zagros Aurignacian (Olszewski and Dibble 1994).

One of the only stratified and radiometrically dated UP archaeological sequences from the southern Zagros was excavated at Eshkaft-i-Gavi (*13* in fig. 2), a large cave situated at the confluence of the Kur and Sivand rivers near ancient Persepolis. The sediments inside Eshkaft-i-Gavi yielded Middle and Upper Paleolithic and Epipaleolithic stone tool assemblages. A series of six radiocarbon dates on charcoal from the UP layers cluster between 18,000 and 30,000 cal BP, placing the Aurignacian occupation at this site within the latter half of MIS 3 and first half of MIS 2 (Rosenberg 1985). Eshkaft-i-Gavi also yielded fragmentary human fossil remains distributed throughout the Upper Paleolithic and Epipaleolithic strata. These bones represent the earliest direct evidence of *Homo sapiens* in the region and confirm the association between (some) Zagros Aurignacian assemblages and anatomically modern human specimens (Scott and Marean 2009).

Like the preceding Mousterian phase, there again appears to be regional variation between northern and southern Zagros assemblages during the UP, evidenced by recent work carried out in southwestern Iran by a joint Tübingen-Iranian team working there (Conard et al. 2005, 2006, 2007; Ghasidian et al. 2006). Archaeologists have documented a series of diminutive, single-platform bladelet assemblages different enough from the Zagros Aurignacian and Zarzian industries to warrant a separate taxonomic designation of "Late Paleolithic" (Ghasidian et al. 2006). Initially, the frequency of microlithic debitage and bladelet manufacture led excavators to classify the assemblage as Epipaleolithic; however, radiocarbon dates between 36,500 and 30,000 cal BP from the stratified cave of Ghar-e-Boof (*12* in fig. 2) suggest a much earlier date coeval with Upper Paleolithic assemblages found throughout Eurasia. Excavators note that the bottom of the "Late Paleolithic" occupation has not yet been reached at Ghar-e-Boof, hinting at potentially older dates for this southern Zagros industry (Conard et al. 2007).

From radiocarbon dates on charcoal at Yafteh Cave, it is possible to place the earliest appearance of the Zagros Aurignacian industry in the north around 35,500 cal BP (Otte et al. 2007). In contrast to Ghar-e-Boof, excavators working at Yafteh Cave observe typical Zagros Aurignacian core reduction strategies including centripetal flake cores and laminar blade and bladelet production. Small centripetal flake blanks were struck for the creation of specific tool forms, while blades and bladelets were obtained from unidirectional cores and the proximal ends of carinated burins. There is also the usual suite of Zagros Aurignacian tool categories present including an abundance of bladelet tools, Arjeneh points (alternately called Font Yves points; these are rectilinear in cross section and have marginal retouch creating a fusiform shape) and Dufour bladelets (semiabrupt fine ventral or alternating retouch limited to the lateral edges). The Yafteh Cave toolkit also includes pointed blades and bladelets, a high frequency of burins, endscrapers on blades, and occasional perforators. In addition to the lithic assemblages, the deposit yielded the aforementioned marine shells from the Arabo-Persian Gulf, a bone awl, perforated deer canines, and a hematite pendant.

The early dates, central geographic position, and classic Aurignacian features observed among Zagros assemblages have led Otte et al. (2007:94) to speculate that "the high regions of the Zagros, mainly in modern Iran, can be proposed as the most probable centre for the origin of the Aurignacian and modern humans in Europe." The authors describe the region as a "demographic reservoir" from which the early Upper Paleolithic expansion into Eurasia might have emanated. This proposition, in turn, begs the question as to the origins of the Upper Paleolithic in the Zagros region. If, according to some scholars (e.g., Olszewski and Dibble 2006; Otte and Kozlowski 2007; Otte et al. 2007), the initial wave of modern human expansion into Europe radiated from the Zagros and is marked by the spread of the Aurignacian culture, from whence came the Zagros Aurignacian?

There are a few sites in the region that have archaeological sequences straddling the Middle and Upper Paleolithic boundary, including Shanidar in the northern Zagros range; Warwasi, Ghar-e Khar (*5* in fig. 2), and Gar Arjeneh (*7* in fig. 2) in the central Zagros valleys; and Eshkaft-i-Gavi (*13* in fig. 2) in southern Zagros. While producing a wealth of information regarding lithic technologies before and after the MP-UP transition, none of these assemblages permit a decisive answer as to the nature of the transformation itself from the Zagros Mousterian to the Zagros Aurignacian. Of direct relevance to the thesis promoted in this paper, scholars observe certain techno-typological traits found across both Middle and Upper Paleolithic assemblage types that suggest some degree of continuity, including sidescrapers, Mousterian points, truncated-faceted pieces, and small radial cores (Baumler and Speth 1994; Olszewski and Dibble 1994; Solecki and Solecki 1994). At the Warwasi rockshelter, Dibble and Holdaway (1994) describe a virtually continuous archaeological sequence spanning the Middle and Upper Paleolithic.[5] They note that the small, flake-based centripetal core technology from the Zagros Aurignacian levels at Warwasi follows a general core reduction tradition rooted in the Zagros Mousterian at the site. In addition, they observe that the tendency toward heavy retouch on tools, one of the defining characteristics of the preceding Mousterian phase, is also frequent in the Aurignacian levels at Warwasi.

The survival of a significant modern human population within southwest Asian refugia may explain the localized origins of the Zagros Aurignacian and the elements of technological and typological continuity between the Mousterian and Aurignacian. However, the interpretation of the Zagros Middle–Upper Paleolithic transition as a local event is incongruous with fossil evidence linking Neanderthals with Zagros Mousterian assemblages at Shanidar and Bisitun and with modern humans associated with the Zagros Aurignacian assemblage at Eshkaft-i-Gavi. In this case, technology clearly transcends taxonomy.

Considering the distribution of Late Pleistocene archaeological sites throughout the arid margins of the Gulf basin in both Iran and Arabia, it is reasonable to presume hunter-gatherer communities also exploited the estuaries, lagoons, springs, fresh and saltwater marshes, anastomosing rivers, and alluvial floodplains found within the core of the oasis. Although direct confirmation of the envisioned Paleolithic population is now submerged, there was a substantial wave of settlement within a millennium following the Holocene incursion that provides compelling evidence for some critical demographic event around this time (fig. 5). To that end, the next subsection reviews archaeological findings from the Terminal Pleistocene and Holocene periods that have been discovered around the Gulf basin.

The Terminal Pleistocene–Early Holocene of Eastern Arabia and Southern Zagros

As the cold, hyperarid conditions of MIS 2 set in beginning around 24,000 BP, archaeological evidence for human habitation vanishes from the basin. At the Jebel Faya rockshelter, the uppermost Paleolithic stratum, from which assemblage A was excavated, is capped by a layer of sterile sand. The excavators have interpreted this stratigraphic sequence, as well as the complete absence of archaeological sites in Arabia during the LGM, as an indication of population discontinuity across the Pleistocene-Holocene boundary. They write that the Holocene peopling of Arabia was "a process which may initially have involved hunters and gatherers coming from the south, soon followed by aceramic herders from the northwest using some variant of [Levantine] PPNB-related lithic technology" (Pre-Pottery Neolithic B; Uerpmann, Potts, and Uerpmann 2009:213).

The archaeological evidence, however, does not fully support this proposition. There is no observable overlap in lithic technologies, settlement patterns, or subsistence strategies between contemporary archaeological sites in the Levant and eastern Arabia. The "Levantine hypothesis" (Drechsler 2007; Uerpmann, Potts, and Uerpmann 2009) is largely based on the correlation between tanged unifacial Byblos points found in PPNB assemblages from the Levant with tanged unifacial Fasad points characteristic of the Qatar B-Group/Fasad facies in Arabia (Charpentier 1996, 2008; Kapel 1967).[6] Recent excavations at the Al Hatab rockshelter in the Dhofar mountains of southern Oman (*27* in fig. 2) suggest that the Fasad facies

5. Excavators initially had such difficulty distinguishing the MP and UP horizons within this continuous archaeological sequence that the lowest Aurignacian stratum was classified as Mousterian with UP elements in early site reports (Dibble and Holdaway 1990).

6. More recently, Charpentier (1996) has renamed the Qatar B-Group assemblages "Fasad facies." To avoid confusion, this industry shall henceforth be referred to as "Fasad" in this paper.

is derived from a local South Arabian lithic tradition that predates, and is unrelated to, the PPNB Byblos points (Rose and Usik 2009).

Within the Levantine PPNB toolkit are found a variety of arrowheads including el-Khiam, Helwan, Abu Maadi, Nizzanim, Jericho, and Amuq types; these arrowheads are found in a wide range of shapes and sizes and were often formed by fine pressure-flaked retouch (Gopher 1994). The Fasad facies in Arabia, on the other hand, is limited to a single point type that does not show any indication of pressure flaking. Uerpmann, Potts, and Uerpmann (2009:213) themselves observe that "the Fasad and other blade arrowheads of Qatar B type are similar to but certainly not identical to PPNB types." In both industries, points are typically manufactured on blade blanks. However, Levantine PPNB blade blanks were struck from single-platform unidirectional-parallel or double-platform bipolar naviform (hull-shaped) cores, while Fasad facies cores exhibit simple unidirectional-convergent working surfaces that are distinct in the use of the Wa'shah method (sensu Crassard 2008) to obtain elongated pointed blanks.

The second line of evidence on which the Levantine hypothesis rests is the discovery of domesticated sheep, goat, and cattle remains at Arabian Neolithic archaeological sites beginning around 7,500 years ago.[7] The bovids are *Bos taurus* of Near Eastern origin, supported by ancient DNA samples from faunal remains at the site of Jebel Buhais 18 in Sharjah Emirate, which indicate a genetic origin of Arabian domesticated cattle somewhere within the Fertile Crescent (Uerpmann and Uerpmann 2008). However, as the Gulf Oasis formed the southeastern extension of the Fertile Crescent for tens of thousands of years before the Terminal Pleistocene–Early Holocene inundation—arguably a fertile tip of the crescent—the locus of domestication could be anywhere within this expanded zone. Aurochs, the wild progenitor of domesticated cattle, are native to both Arabian and Iranian sides of the Gulf basin. The only species of domesticated fauna within the Arabian Neolithic package that knows no wild precursor in Arabia is sheep; hence, this species must have been imported from outside of Arabia (Uerpmann, Potts, and Uerpmann 2009).

There are new genetic data suggesting that one animal species may have been domesticated within Arabia itself: *Felis catus*, the housecat. All modern feline populations derive, in part, from Near Eastern wildcats (*Felis silvestris lybica*). Phylogeographic analysis of Felidae mtDNA has identified the most ancient domesticated lineages in the deserts of Israel, Saudi Arabia, and the United Arab Emirates, dating to between 10,000 and 8000 BP (O'Brien et al. 2008). Surprisingly, unlike other domesticates that were deliberately selected for their primary and secondary food resources, Driscoll et al. (2007) have suggested that felines "chose" to domesticate themselves, opportunistic hunters attracted to rodent populations that flourished around Neolithic human settlements.[8] This observation, in turn, hints at the presence of sedentary or semisedentary communities in this region between 10,000 and 8000 BP.

New radiometric dates indicate that the Fasad lithic facies, considered the *fossile directeur* of the Levantine colonists, is bracketed between 13,000 and 8500 cal BP (Uerpmann, Potts, and Uerpmann 2009). Domesticated fauna, on the other hand, do not appear until later in the archaeological record after 7500 BP and are consistently found in association with a fundamentally different lithic techno-complex referred to as the "Arabian bifacial tradition" (ABT; Charpentier 2008; Edens 1988; Potts 1993; Uerpmann 1992). The ABT is a distinctly eastern and southern Arabian stone tool industry characterized by small, globular multiple-platform cores and pressure-flaked bifacial arrowheads. Fasad points and domesticated fauna, the two key elements of the posited Levantine expansion, have never been found together within the same archaeological context and are separated in time by more than a millennium.

The model presented in this paper explains that, rather than radiating from the Levant, the distinct characteristics found at eastern Arabian Neolithic sites developed from a Pleistocene population native to the Gulf Oasis. Hence, archaeologists working in eastern Arabia have been unable to locate sites from the Terminal Pleistocene–Early Holocene because populations had contracted toward the currently inundated lowlands of the basin. Uerpmann, Potts, and Uerpmann (2009:208) surmise that "older dates cannot be expected from coastal sites, because any sites pre-dating the sixth millennium BC would now be under water."

To illustrate this point, the correspondence between fluctuating shoreline around the Gulf and human settlement is depicted in figure 5. Four intervals of time have been chosen that are representative of relatively stable landscape phases. *Stage I* in figure 5 shows the Gulf basin from MIS 4 to MIS 3, between 74,000 and 24,000 BP. During this stage, sea levels were 60–100 m lower than they are now. Annual precipitation was greatly reduced during MIS 4, picking up in intensity after the onset of MIS 3 around 55,000 BP (fig. 3). Considering the favorable conditions of the Gulf hinterlands during the MIS 5 and MIS 3 climatic optima, it is not surprising to find a scattering of Middle and Upper Paleolithic sites in eastern Arabia and the southern Zagros—the periphery of the refugium—within this time frame.

Archaeological sites disappear from the hinterlands of the Gulf during *Stage II*, from roughly 24,000 to 14,000 BP, when the region had become all but uninhabitable save for the postulated oasis at the heart of the basin. The "coastal oasis hypothesis" (sensu Faure, Walter, and Grant 2002) is invoked to explain human settlement during this stage, when increased

7. The term Neolithic is used sensu stricto here to indicate archaeological sites that demonstrate multiple aspects of the Neolithic package, those being permanent architecture, animal husbandry, and plant cultivation.

8. Perhaps not so surprising for cat owners.

hydrostatic pressure on subterranean river systems is likely to have triggered increased freshwater upwelling along the floor of the Gulf basin. Despite the well-documented hyperarid phase that occurred at this time, there appears to have been some surface runoff flowing through the Ur-Schatt River valley, signaled by the magnitude of Terminal Pleistocene downcutting.

Stage III, between 14,000 and 8,500 years ago, witnessed the onset of postglacial flooding. Global sea levels rose sharply from 80 to 20 m below current levels, inundating over 100,000 km^2 of previously dry land within the basin. Corresponding with a rise in eustatic sea levels, there is evidence for a spike in Indian Ocean monsoon activity around 13,500 years ago, coeval to the Bølling-Allerød interstadial in Europe (Ivanochko et al. 2005; Overpeck et al. 1996; Sirocko et al. 1993). While evidence for human occupation can be found around the margins of the Gulf basin at the onset of the Holocene, archaeological traces remain scarce and comprise small, ephemeral camp sites. There are only three radiometrically dated findspots from the region around the Gulf basin at this time: Wadi Wutayya in northern Oman (*24* in fig. 2), and Nad al-Thamam (*23* in fig. 2) and Jebel Faya 1 (*22* in fig. 2) in Sharjah Emirate (Uerpmann, Potts, and Uerpmann 2009). Together, these sites have produced a series of absolute dates clustering between 9680 and 8396 BP (uncalibrated). Although the lithic material from Wadi Wutayya does not have any diagnostic elements, Nad al-Thamam and Jebel Faya 1 assemblages include typologically distinct Fasad points that permit the attribution of this industry to the Early Holocene. From these data, we can infer that the B-Group sites mapped in Qatar (Kapel 1967), bearing a similar blade technology and Fasad point production, also fall within the range of roughly 10,000–8,000 years ago.[9]

Just as in Arabia, evidence for human occupation all but disappears on the eastern side of the Gulf during MIS 2. There is a significant temporal gap between Zagros Aurignacian sites and subsequent Epipaleolithic (Zarzian) sites, which date to between 15,000 and 12,000 BP. Zarzian lithic assemblages are characterized by the production of short trapezoidal and triangular geometric microliths (Olzewski 1994). Faunal assemblages indicate the intensive exploitation of large herbivores, leading researchers to suggest that the Terminal Pleistocene human groups occupying this region were specialized hunter-gatherers preadapted to animal husbandry (Hesse 1989). Zarzian sites are restricted to the northern Zagros Mountains, while preliminary data from recent archaeological surveys point to a different lithic techno-complex in the southern Zagros around the Gulf.

Just north of the Gulf basin, the first potential Terminal Pleistocene–Early Holocene findspots were identified during a survey of the Izeh alluvial plain in northeastern Khuzestan province (*9* in fig. 2), about 150 km from the present shoreline (Niknami, Mozhgan, and Salahshour 2009). The team documented 54 Epipaleolithic assemblages that feature a technology based on pyramidal, unidirectional-parallel reduction of bladelet cores. The bladelets exhibit heavy retouch for manufacturing endscrapers, thumbnail scrapers, borers, burins, and backed blades and bladelets. Regionally distinct Epipaleolithic features such as geometric microliths (Zarzian) and Fasad points (Arabian) are not found among the Izeh assemblages.

Conard et al. (2005) document a wealth of "Epipaleolithic" stone tool scatters in the vicinity of Dasht-e-Rostam, southwestern Iran. Similar to the material from the Izeh Plain, these assemblages are characterized by a partially volumetric, unidirectional-parallel core reduction method for the manufacture of bladelet tools. In one particular valley near the Sarab Syah spring in Fars Province (*10* in fig. 2), in a drainage system emptying into and less than 100 km from the Gulf, the Tübingen-Iranian team report a valley with "Epipaleolithic" tools scattered among bedrock mortars, a grinding basin, and possible stone structures on an artificial terrace (Conard et al. 2006, 2007). Although not yet systematically studied or radiometrically dated, the "Epipaleolithic" sites associated with Sarab Syah spring have great potential for testing the Gulf Oasis model, supplying evidence for a coeval southern counterpart to the Zarzian and Natufian groups respectively found in the northern and western reaches of the Fertile Crescent. Evidence of mortars, structures, and grinding basins points to some degree of sedentism and plant processing in the Terminal Pleistocene and/or Early Holocene.

Survey of the Jam-o-Riz Plain, adjacent to the eastern shoreline of the Gulf, produced additional lithic scatters described as "Epipaleolithic" (Dashtizadeh 2009). Core reduction in these assemblages is based on blade/bladelet manufacture. The most frequent tool types are endscrapers and burins, while typically Zarzian elements like geometric microliths, backed bladelets, and borers are absent. Although the southern Zagros sites represent just a few data points and have not undergone detailed lithic analysis or dating, the emerging picture of Terminal Pleistocene human occupation in southern Iran hints at a population around the eastern Gulf basin and associated tributaries distinct from its northern Zarzian neighbors carrying out some form of intensive plant processing. The only roughly contemporary assemblage known from Arabia that spans the Terminal Pleistocene–Early Holocene is the Al Hatab rockshelter (*27* in fig. 2), which is equally distinct in both its simple unidirectional blade technology and toolkit dominated by the production of retouched points, bifacial foliates, and burins (Rose and Usik 2009).

Middle Holocene Settlement Activity in Eastern Arabia

There is a noticeable spike in settlement activity around the shoreline of the Gulf between 8,500 and 6,000 years ago, depicted in *Stage IV* of figure 5. In particular, the millennium lasting from 7500 to 6500 cal BP witnessed a dramatic increase

9. As early as 13,000 BP if the dates from the Al Hatab rockshelter are included as well.

in the number of archaeological sites around the basin from approximately 10 to more than 60 (Beech and Shepherd 2001; Beech et al. 2005; Biagi 2006; Carter 2006; Diedrich 2006; Haerinck 2007; Howard Carter 1972; Inizan 1978, 1980; Masry 1997; McClure and Al-Shaikh 1993; Uerpmann and Uerpmann 1996). Although part of that jump in settlement may be a shift from ephemeral hunting camps to more sedentary occupations with permanent architectural structures, thus, greater archaeological visibility, other indications in the material record suggest that the inhabitants of the region underwent a fundamental demographic transformation.

Middle Holocene sites around the Gulf are distinguished by the appearance of Mesopotamian-style plain and painted pottery called "'Ubaid ware." Stylistically, ceramics from these sites fall within the 'Ubaid 3 to 'Ubaid 5 archaeological phases (Oates 1983). A recent appraisal of 'Ubaid ceramics around the Gulf places almost all of these assemblages within the 'Ubaid 3 period;[10] only a few sites possess a subsequent 'Ubaid 4 element, and just two findspots in Qatar and Bahrain have a final 'Ubaid 5 component (Carter, forthcoming). Carter's reinterpretation of the material record is significant, suggesting that the introduction of 'Ubaid-related sites in eastern Arabia falls within a single millennium. Even more critical to the thesis of this paper, there is only one stratified 'Ubaid-related site in eastern Arabia, Ain Qannas, that has an underlying archaeological horizon (Masry 1997), implying that all other 'Ubaid-related sites were established on previously unsettled land. This is corroborated by the associated lithic assemblages, in which 'Ubaid ceramics are consistently found with ABT lithic artifacts but never in conjunction with the earlier Fasad facies.

Long-distance trade is another primary feature of 'Ubaid-related settlements. The presence of 'Ubaid pottery exported from southern Mesopotamia as far as the Strait of Hormuz demonstrates the existence of trade networks operating across more than 1,000 km. In exchange for Mesopotamian pottery, Carter (2006) proposes a variety of eastern Arabian exports including pearls, shell beads, chert, livestock, and fish. The author argues that the widespread distribution of 'Ubaid pottery at both larger settlements and more peripheral encampments, as well as ceramic vessels exported from several manufacturing locations in southern Mesopotamia, suggests that "this was more than an aggregate of opportunistic exchanges, but was a mature, stable and structured system that persisted for many generations" (Carter, forthcoming). The Gulf Oasis hypothesis supplies a parsimonious explanation for the introduction of an already developed trade network in the Middle Holocene, allowing for an incipient interaction sphere that had begun to form around Terminal Pleistocene–Early Holocene waterways within the basin.

Trade was conducted up and down the Gulf via reed-bundle boats. Direct evidence for boat-building was discovered at the 'Ubaid 3 period site of H3 in Kuwait, dated to 7500–7000 cal BP. Excavators report finding bitumen fragments with reed impressions and barnacles, a small clay replica of a reed-bundle boat, and a painted clay disc depicting a boat with masts (Carter 2006). Although there is indirect evidence for maritime exchange networks as early as 12,000 years ago in the Aegean (e.g., Broodbank 2006), the bitumen fragments at H3 represent the oldest physical remains from a seafaring vessel; moreover, the masts shown on the painted clay disc are the earliest indication for the use of the sail. Indirect evidence for seafaring was discovered at the site of Marawah 11 off the coast of Abu Dhabi. Domesticated faunal remains were discovered on the island that could only have been transported there via boat (Beech et al. 2005). This unique development of advanced nautical technology around the Gulf is yet further evidence as to the level of complexity 'Ubaid-related groups had already achieved before becoming archaeologically visible along the newly configured Middle Holocene shoreline during the 'Ubaid 3 phase.

Perhaps the most revolutionary characteristic of these new Middle Holocene settlements is the shift in food procurement. Domesticated sheep, goat, and cattle first appear in the archaeological record at this time, along with date stones, fish, and shellfish remains and plant processing equipment. Together, these data signal a fundamental transition from hunting and gathering to fishing, cultivating, and animal husbandry. While it is unclear whether these were wild or domesticated date palms, a survey of the earliest date stones in the archaeological record points to an area of initial cultivation around lower Mesopotamia "in some oases in the southern fringe of the Near Eastern arc" (Beech and Shepherd 2001:86). It is relevant that the words for date and date palm tree in Sumerian (the earliest written language in southern Mesopotamia) belong to a linguistic class thought to be carried over from an indigenous, pre-Sumerian language dubbed "Proto-Euphratic" (Landsberger 1974; Rubio 1999).[11]

Taking into account the suite of innovative features appearing around the shoreline of the Gulf some 7,500 years ago, there can be little doubt that the Neolithic demographic transition had swept across eastern Arabia by this time. The process of Neolithization, however, remains an enigma. To say that the material culture of Early Holocene hunter-gatherers versus that of Middle Holocene fisher-herder-cultivators is incongruous would be an understatement. This proposed version of the oasis hypothesis predicts that the missing pieces of the archaeological puzzle evidencing the process of Neolithization will be found in the depths beneath the Arabo-Persian Gulf.

10. Sometimes referred to in the literature as 'Ubaid 2/3 or early 'Ubaid 3.

11. Other "Proto-Euphratic" words appearing in Sumerian include reed weaver, cobbler, potter, launderer, plowman, fattener of oxen, carpenter, herald, foreman, cook, gardener, smith, shepherd, land registrar, mason, fisherman, craftsman, supervisor, furrow, plow, and beer.

Discussion

The Gulf Oasis and Modern Human Origins

There is now ample evidence indicating that prehistoric peoples occupied the margins of the Gulf Oasis at various times throughout prehistory, although radiometric dates still remain elusive. In recent years, several new Late Pleistocene archaeological sites have been discovered around the periphery of the basin, all of which are located on drainage systems emptying into the Gulf. As early humans occupied the semiarid fringes of this refugium, it is reasonable to presume that their range also included the mosaic of favorable microenvironments found within the core of the basin.

There are not yet physical remains to determine the taxa of species responsible for producing Paleolithic artifacts found around the Gulf. Given the human fossil record recovered immediately adjacent to the Arabian Peninsula, in the Levant and East Africa, it is reasonable to speculate that Late Pleistocene inhabitants of Arabia were among the first anatomically modern humans (AMH) to branch from the common ancestral population that first appeared in East Africa some 190,000 years ago (McDougall, Brown, and Fleagle 2005; White et al. 2003). Fossil remains from Skhul and Qafzeh caves in Israel (*40* in fig. 2) indicate that AMH had reached the Levant by at least 100,000 BP (Mercier et al. 1993; Schwarcz et al. 1988). It is equally plausible to consider that Neanderthal ranges included parts of Arabia and the southern Zagros at times, with the nearest specimens found just 900 km away at Shanidar and Bisitun caves in the northern Zagros and some 1,300 km away at Amud, Hayonim, Kebara, and Tabun caves in the Levant. A third possibility is that eastern Arabia was a place of admixture. Just as freshwater flowing from Mesopotamia, the Zagros, and across Arabia intermingles within the Gulf, so too perhaps the Late Pleistocene gene pool was composed of elements from all three surrounding regions. Certainly, from the perspective of lithic technological patterning, the variety and geographic distribution of traditions scattered across Arabia suggests multiple sources of demographic input at different times during the Middle and Upper Paleolithic periods. In their analysis of Iranian Y chromosome DNA, Reguiero et al. (2006:132) refer to the region as a "tricontinental nexus" of human migration.

To date, the only potential archaeological affinities between East Africa and southern Arabia suggesting a modern human range expansion across the southern route of dispersal have been found within assemblage C from Jebel Faya (Marks 2009). As this archaeological horizon has been tentatively dated to MIS 5 (Uerpmann et al. 2007), it falls within the time frame of the Skhul/Qafzeh expansion rather than a later movement out of Africa during MIS 4 and MIS 3. This timing coincides with a long-term episode of increased precipitation across the interior of Arabia as well as a high sea stand in the Gulf, hence, a period when early human groups were more likely to be found throughout the ameliorated hinterlands. By no means does this suggest that lithic material from eastern Arabia resembles that of the Levant; the two regions are fundamentally different in their use of *façonnage* versus Levallois core reduction, respectively.

There do not appear to be any technological or typology affinities between Paleolithic assemblages in Arabia and East Africa after MIS 5. Scholars working around the Tihama Plain in southwestern Yemen (Delagnes et al. 2008), the Hadramaut valley cutting across central Yemen (Crassard 2009), the Dhofar mountains of southern Oman (Rose and Usik 2009), and at the Jebel Faya rockshelter (Marks 2009; Uerpmann, Potts, and Uerpmann 2009; Uerpmann et al. 2007) on the periphery of the Gulf basin have all pointed out a lack of connection with East African late MSA or Late Stone Age (LSA) assemblages. The sole exception is the Hargeisan lithic industry found along the coastline and interior of the Horn of Africa, which Rose and Usik (2009) have speculated to be evidence of an early human back migration from Arabia into Africa. Marks (2009:317) describes the distinct and unique characteristics of Jebel Faya assemblages A and B as exhibiting "no obvious technological relations to anything in the Levant, Africa, or in the rest of Arabia, for that matter . . . they may represent an expansion of peoples of the Ur-Schatt River Valley into its southern hinterlands."

The Genetics Conundrum

Genetic analyses point to a different scenario of modern human emergence than is indicated by the archaeological evidence. Some researchers working with mtDNA data envision that the initial Skhul/Qafzeh movement out of Africa was a failed expansion. They argue the first successful expansion out of Africa was associated with a genetic bottleneck release across the southern route of dispersal during MIS 3 or MIS 4 (e.g., Ambrose 1998; Macaulay et al. 2005; Quintana-Murci et al. 1999).[12] To explain these genetically predicted late dates for human expansion out of Africa, in light of relatively early dates for the colonization of Sahul between 60,000 and 40,000 years ago (O'Connell and Allen 2004), researchers have suggested that the successful AMH colonists were coastally adapted groups that moved rapidly along the continental shelf rimming the Indian Ocean. This expansion is thought to have occurred during MIS 4, at which time reduced sea levels made habitable vast tracks of fertile land along the exposed coastline (Field and Lahr 2006; Field, Petraglia, and Lahr 2007; Mellars 2006; Stringer 2000).

The puzzle pieces in this scenario of a single wave of expansion out of Africa do not quite fit together; there is disagreement between archaeological, genetic, and fossil lines of evidence. The timing of the MP-UP (MSA-LSA) transition

12. See Endicott et al. (2009) for a summary of different modes of calibration used to establish mtDNA coalescence dates for the out-of-Africa expansion within MIS 3.

in the material record of east Africa and southwest Asia is roughly 45,000–30,000 BP and shows vastly different lithic trajectories between the two regions (Marks 1990), the mtDNA coalescence dates of the first human groups to branch from the common ancestral population is between 85,000 and 45,000 BP, and there are fossil remains of an AMH expansion out of Africa into the Levant as early as 110,000–90,000 BP. In all three cases, the predicted time spans for each demographic "event" are so different they hardly overlap. Clearly, these data sets are measuring fundamentally different things.

One problem may lie in geographic inferences associated with the human phylogenetic tree, which can, in part, be traced back to a landmark study in the late 1990s that identified mtDNA haplogroup M1 among modern populations in the Horn of Africa (Quintana-Murci et al. 1999). Geneticists recorded a high frequency of a particularly ancient human lineage—haplogroup M1—thought to be the earliest modern human branch to have split from the ancestral haplogroup L3 population. As every person living outside of Africa is derived from a branch stemming from the L3 trunk, this marker is considered representative of the common ancestral population. Thus, the discovery of haplogroup M1 in the Horn of Africa, just across the Red Sea and within sight of Arabia, suggested to scholars that the "Arabian Corridor" (i.e., Yemen, Oman, and the UAE) served as a conduit for the first populations moving out of Africa and into Asia, thereby suggesting the existence of a posited southern dispersal route during MIS 4 or MIS 3 (Field, Petraglia, and Lahr 2007; Lahr and Foley 1994, 1998; Mellars 2006; Stringer 2000).

More recent studies of subclade M1 in North Africa and the Levant have led to a different explanation for the geographic distribution of this critical genetic marker. Some researchers now propose that M1 arose in southwest Asia and moved back into Africa sometime between 45,000 and 40,000 years ago (Olivieri et al. 2006). González et al. (2007) also report the most ancient M1 lineages in North Africa and the Near East, not East Africa, suggesting an Asiatic origin for this lineage. Other analyses within the last decade examining Y chromosome DNA markers have produced additional evidence of Late Pleistocene back migrations into Africa (Altheide and Hammer 1997; Cruciani et al. 2002; Hammer et al. 1998).[13] In light of these studies, it is necessary to look outside of Africa to find the region where AMH diverged from the common ancestral trunk, that is, the locus of expansion.

An additional problem with ascribing the haplogroup M expansion to the initial modern human groups leaving Africa is the timing of the M1 coalescence in east Africa versus the timing of haplogroup M coalescence elsewhere. The earliest coalescence dates indicating an mtDNA bottleneck release from the L3 ancestors are represented by the M2 subclade in India dated to 70,600 ± 21,000 BP (Metspalu et al. 2004) or 60,200 ± 8,600 BP (Thangaraj et al. 2006), while the M1 subclade in Ethiopia coalesces around 48,000 ± 15,000 BP (Quintana-Murci et al. 1999). Given these overlapping margins of error, there is no reason to presume that the founder M population originated in Eeast Africa rather than south Asia or some other place therein. In the case of subclade M2, Thangaraj et al. (2006) conclude that haplogroup M has in situ origins within South Asia.

Thus, it is significant that haplogroup M occurs in low frequencies throughout Arabia (Rídl, Edens, and Černý 2009). Among the Yemeni population in southwestern Arabia, almost every known M marker is derived from an Indian lineage unrelated to M1, leading researchers to conclude that "the available mtDNA data today [in Arabia] show no traces of the initial migration(s) out of Africa" (Rídl, Edens, and Černý 2009:76). Taking into account the mtDNA phylogenetic structure of populations in and around the Arabian Peninsula, Cabrera et al. (2009:84) write that "mitochondrial lineages carried by these colonizers were not yet ripe M and N lineages but their L3 ancestors." In their proposed scenario, the post-MIS 4 expansion originated in Asia, not Africa, and therefore better explains the rapid human colonization along the rim of the Indian Ocean and ultimately into Australia between 60 and 40 kya.

That is not to say there are no mtDNA lineages in Arabia surviving from the Late Pleistocene. Genetic samples taken from individuals in Qatar, UAE, Oman, Socotra Island, and Yemen (Abu-Amero et al. 2007, 2008; Černý et al. 2008; Kivisild et al. 2004; Rowold et al. 2007) have yielded several highly developed mtDNA branches, indicating that some haplogroups "may coincide with or originate prior to the LGM" and "human populations, therefore, could survive during terminal Pleistocene hyperaridity" (Rídl, Edens, and Černý 2009: 76).

Two particular mtDNA haplogroups provide evidence for deep genetic roots in southern Arabia: R0a and J1.[14] R0a is derived from haplogroup R, one of the three major founding lineages of all modern human populations outside of Africa. The highest frequencies of R0a and its derivatives are found in Yemen (25%; Černý et al. 2008), Socotra Island (38%; Černý et al. 2009), Saudi Arabia (22%; Abu-Amero et al. 2008), and Oman (16%; Abu-Amero et al. 2007). Haplogroup R0a has an overall Middle Eastern coalescent age around 19,000 years ago and exhibits a high degree of diversity in southern Arabia, indicating that it has persisted in the region for this entire span of time. Given the hypothesis proposed in this paper, it is noteworthy that the most ancient R0a markers in Arabia are found in the UAE, with a predicted coalescence date of 37,800 ± 12,100 (Rowold et al. 2007).

Haplogroup J1 is also well represented in Arabia, with high frequencies in Saudi Arabia (37.5%), Qatar (17.8%), and Yemen (30%). Like R0a, this lineage is characterized by con-

13. The "in through the out door scenario" sensu Rose and Usik (2009).

14. Renamed by Torroni et al. (2006) from its former classification of (pre-HV)1.

siderable diversity in all its main subbranches found throughout the subcontinent (J1, J1b, and J1c/J2). Of these subbranches, J1b is the most common and diverse in Arabia, with a coalescence age estimation of 19,480 ± 4119 BP (Abu-Amero et al. 2008). While neither R0a nor J1b reaches back far enough in time to relate directly to the initial modern human expansion out of Africa, they both suggest that some Late Pleistocene groups survived the LGM and persist today within the modern Arabian gene pool.[15]

The archaeological and genetic evidence is not irreconcilable. The point of disagreement is simply where one places the initial coalescence from the basal trunk. If we consider that the population bottleneck release(s) branching from the common ancestral group emanated from southwest Asia, not Africa, the threads of archaeological, genetic, and fossil evidence agree. The model described in this paper proposes that the AMH population movement out of Africa during MIS 5 was not a failed wave of expansion; rather, these carriers of the mtDNA L3 marker were bivouacked (so to speak) in southwest and/or central Asian refugia, such as the Gulf Oasis, until the ameliorated conditions that set in during MIS 3 permitted subsequent range expansions. As such, it is more likely to expect several waves of expansion radiating from multiple population centers at the onset of MIS 3 rather than the single expansion scenario out of Africa.

This is in agreement with the archaeology-based model put forth by Otte et al. (2007), who argue that the locus of early modern human expansion into Europe originated between Afghanistan and the Caucasus. In his review of archaeological data from the Middle-Upper Paleolithic transitions in Europe, Asia, and Africa, Marks (2005:81) arrives at a similar conclusion: "The immediate origins of the explosion of 'modern behavior' seen in Europe, but not in Africa, might be found at the contact between Eastern Europe and Western Asia."

Furthermore, the model of multiple expansions at the onset of MIS 3, due to the survival of the original MIS 5 AMH population in environmental refugia outside of Africa, is supported by analysis of modern human cranial diversity. Interregional comparison of Late Pleistocene human remains in Australia indicates that "early modern humans from the Levant either contributed directly to the ancestry of an early lineage of Autralasians, or they share a recent common ancestor with them" (Schillaci 2008:814). Examination of enamel growth increments (perikymata) on the Qafzeh specimens demonstrate that 12 of the 14 fall within the lower half of modern human variability, seven within the bottom 5% (Guatelli-Steinberg and Reid 2010). Although this study reveals a pattern not generally characteristic of modern populations, it does show a small degree of overlap between the Qafzeh humans and modern groups.[16] Both of these analyses point to the possibility that Skhul/Qafzeh related populations persist outside of the Levant to this day.

Social Evolution in the Gulf Oasis

The model presented in this paper proposes that the basin served as a demographic refugium, facilitating the autochthonous development of a distinctly Arabian culture group. This is supported by the unique characteristics of lithic industries from both eastern Arabia and southern Zagros. Assemblages A and B at the Jebel Faya 1 rockshelter have no known correlates from any surrounding region. Many of the recently discovered "Middle," "Upper" and "Epipaleolithic" assemblages in southern Iran are clearly distinguished from lithic industries in central and northern Zagros. Undoubtedly, the landscape desiccation and low sea levels of MIS 4 (74,000–60,000 BP) and MIS 2 (24,000–12,000 BP) would have affected hunter-gatherer ranges and mobility patterns. At that time, the interior savannas of Arabia became desiccated while tens of thousands of square kilometers of fertile land in the Gulf basin were exposed. It is possible these shifting environmental dynamics forced hunter-gatherers to increasingly rely on coastal resources rather than big- and medium-game hunting in the interior. The transition to aquatic subsistence and "beachcombing" is often invoked to explain the rapid modern human expansion across the Indian Ocean rim (e.g., Field and Lahr 2006; Field, Petraglia, and Lahr 2007; Mellars 2006; Stringer 2000). In this case, the Gulf Oasis model provides an environmentally driven mechanism that removed savannah hunting as a viable subsistence strategy during MIS 4, forcing the adoption of aquatic subsistence as biomass and freshwater resources became concentrated on the exposed continental shelf.

Fluctuating environmental conditions are likely to have caused populations tethered to the Gulf refugium to expand into adjacent areas during periods of amelioration and, subsequently, constrict back into the core zone during climatic downturns. Inevitably, this continuous flirtation with landscape carrying capacity must have impacted social evolution, as groups within the basin living under perpetually oscillating climatic conditions were persistently and consistently thrust

15. In this discussion of genetic data, it is important to consider that DNA extracted from modern Arabian populations has inherent limitations. Phylogeographic inferences based on the study of haplogroup distributions are subject to the complexities of human demographics over long periods of time. Just as every archaeological site undergoes post-depositional disturbance, so too do human populations move and change in composition over time. In places of relative climatic and socio-cultural stability this problem is less pronounced, whereas regions like the Arabian Peninsula, which have undergone such extreme oscillations in paleoenvironments and politics, the modern population is not an accurate representation of Late Pleistocene or Early Holocene residents of the subcontinent. The combination of high sea levels and hyperaridity during the fourth millennium BC wiped out all refugia and effectively eliminated most occupants of Arabia for nearly 1,000 years, an event Uerpmann (2003) dubbed the "Dark Millennium."

16. It is necessary to point out, however, that a sample population of 14 individuals precludes any definitive conclusions when dealing with a span of time numbering tens of thousands of years.

into a recurring series of negative feedback loops (cf. Flannery 1968).

One example of such a dynamic process in the Gulf basin is described by Kennett and Kennett (2006), who argue that the formation of aquatic habitats along the northern shorelines of the Gulf in the Middle Holocene played a critical role in the process of state formation in southern Mesopotamia. They present a model in which marine transgression into the Gulf basin and increased precipitation during the climatic optimum created rich coastal zones that promoted the development of ‘Ubaid communities. The onset of aridity beginning around 6000 BP, along with a large population density, forced inhabitants to make use of the high groundwater table to experiment with irrigation farming. In turn, the innovation of large-scale agriculture hearkens back to the “hydraulic civilizations” of Wittfogel (1956), who proposed that irrigation had a cascading effect on social evolution and led to annual scheduling (calendars), labor coordination (differentiated leadership), and increased productivity (amassed wealth).

Emerging clues from the “Epipaleolithic” of Iran (e.g., Conard et al. 2005, 2006, 2007) and southern Oman (e.g., Rose and Usik 2009) suggest that human groups were present in these refugia immediately after the LGM. In the case of Sarab Syah spring, Epipaleolithic artifacts were discovered in conjunction with plant processing equipment, hinting at intensive plant exploitation in the southern Zagros during the Terminal Pleistocene. The lithic assemblage from the Al Hatab rockshelter, with OSL dates between 13,000 and 11,000 BP, suggests that subsequent Early Holocene hunter-gatherer range expansions emanated from within Arabia itself. However, until prehistoric research commences within the depths of the Gulf, most archaeological evidence from the Terminal Pleistocene and Early Holocene will remain hidden.

There was a virtual explosion of settlement around the shoreline of the Gulf in the Middle Holocene, coinciding with the final phase of marine incursion into the basin. More than just the sheer number of sites that were established within a single millennium ($n = 65$), the characteristics of these sites have profound implications for social evolution in the Gulf Oasis. By the time that indigenous groups became archaeologically visible during the ‘Ubaid 3 phase around 7500 cal BP, these communities had already undergone a complete Neolithic demographic transition and were, in fact, on the cusp of the Urban Revolution. This is exemplified in the suite of features found at ‘Ubaid-related sites, including permanent stone structures, pottery, date palm cultivation, animal husbandry, fishing, extensive trade networks, and advanced boatbuilding.

Three millennia after the proposed (re)settlement of indigenous ‘Ubaid 3 groups along the northern shoreline of the Gulf, the region became known as Sumeria and was populated by the world’s earliest literate civilization. Albeit epiphenomenal, it is interesting to note that the oldest known version of the ubiquitous Near Eastern flood myth, the “Eridu genesis” (Jacobsen 1981), was written by the inhabitants of this region. The link between flood mythology and marine incursion into the Arabo-Persian Gulf basin has already been thoroughly explored by a number of authors (see Cooke 1987; Hamblin 1987; Kennett and Kennett 2006; Lambeck 1996; Sanford 2006; Teller et al. 2000) and does not require any further elucidation.

This climatologically deterministic model of social evolution in a fertile yet conscripted oasis is the reiteration of a very old idea. The oasis hypothesis, first envisioned by Pumpelly (1908) and later developed by Childe (1928, 1936, 1952), was speculated to have occurred within the ancient oases of southwest Asia, around which dense human populations huddled for survival during the LGM, “united in an effort to circumvent the terrible power of drought” (Childe 1936:77). The Gulf may very well house Childe’s lost oasis, perhaps the most fertile part of the crescent until it was plunged beneath the waters of the Indian Ocean some 8,000 years ago.

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Comments

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In light of paleoenvironmental and archaeological evidence, Rose has proposed that the Persian Gulf basin could be a continuous home of autochthonous modern human populations that survived, outside of Africa, from around 120 ka onward; that it could be a refuge, during the hyperarid MIS4 stadial, for human populations diffusing from east Africa to south Asia and beyond; and that it certainly was a focus of Neolithic expansion. In this last respect, the impressive climatic and sea-level fluctuations in glacial and interglacial periods in this area prompted him to resurrect the old and complementary oasis and population-pressure hypotheses that, a century ago, suggested that the Neolithic revolution was forced by the necessity to exploit every potential resource in the limited refuge that wider-range populations joined because of climatic constraints.

At first glance, this scenario contradicts the most accepted genetic model explaining the modern human expansion out of Africa, which, based on mitochondrial DNA phylogeography, proposes an exit through the Bab-el-Mandeb strait during MIS 4 and a rapid coastal expansion to reach Australia around 45 kya (Endicott, Metspalu, and Kivisild 2007; Macaulay et al. 2005; Richards et al. 2006). However, this model does not have unanimous support in the population genetics field. Others have suggested that in the Eem interglacial period, around 80 kya, when a wet hospitable Sahara existed, a modern human expansion represented mostly by the haplogroup L3 radiation occurred inside Africa (Cabrera et al. 2009; Maca-Meyer et al. 2001). During a favorable 20-kyr window, populations diffused through the Sinai Peninsula to habitats similar to that of the African savannah, expanding northward bordering the Taurus-Zagros arc to reach the central Asian grasslands and southward to reach Arabia and the Persian Gulf basin. These adapted big- and moderate-game hunters carried sister L3 lineages like those that spread inside Africa. In this advantageous humid period, the global population would have expanded in both size and geographic range. However, it has to be admitted that until very recently, the only archaeological evidence supporting this early exit was the Levantine modern human fossil remains at Skhul/Qafzeh. As the author mentions, there are now hints pointing to a presence of modern humans in southeastern Arabia at the same time (Marks 2009). Climatic conditions gradually worsened during the first stadial of the Würm Glacial around 60–40 kya. It can be deduced, from the behavior of present-day Australian aborigines, that when times were bad, the extended family or the tribe would disintegrate into smaller demes and disperse in search of any available resource. In this unfavorable period, the majority of demes became extinct, and only those that found and adapted to new conditions survived. The footprint of this harsh period in the mtDNA phylogeny is the survival of only two L3 lineages outside Africa, M and N. Its phylogeography suggests that N was the only survivor of the northern route and M the only survivor of the southern route (Maca-Meyer et al. 2001) and that both suffered a long stagnation period as attested to by the lack of derived lineages that share only some of the five or four mutations respectively accumulated in their basal trunks until their next ramifications. Those who propose only a southern route argue that both lineages are simultaneously present everywhere in Eurasia, but others disagree. The M lineage is absent in western Asia, and those present in central Asia are phylogenetically derived from eastern Asia lineages. In the Indian subcontinent, the presence of basic N lineages is very rare and has a clear western Asia origin. For instance, in an article about haplogroup N in India where the two-routes hypothesis was criticized (Palanichamy et al. 2004), only a putative autochthonous N lineage named N5 was detected. However, it is now known that it is also present in Iran (Ashrafian-Bonab, Lawson Handley, and Balloux 2007). As basic N lineages are the most frequent mtDNA lineages in Australia (Ingman and Gyllensten 2003), an Indian provenance for them is unlikely. Nevertheless, basal N lineages have been detected in aboriginal Malays and in Indonesia (Hill et al. 2006), signaling an alternative route to Australia that avoided India. It has to be mentioned that there is another lineage named R, which had a widespread Eurasian radiation, but it is derived from the basic N trunk by two mutations and different R haplogroups have different phylogeographic patterns overlapping, some of them with N and others with M branches.

The recent discovery of a well-documented Paleolithic site in Siberia, above the Arctic Circle and dated around 30 ka (Pitulko et al. 2004), similar to the age calculated for the oldest human occupation in Sri Lanka (Kennedy and Elgart 1998), at the southern tip of India, also supports the coeval existence of both northern and southern routes.

Another argument used in favor of only one rapid southern exit is that a coastal adaptation would facilitate a lineal displacement in a rather uniform environment. However, Paleolithic industries point mainly to game hunting and butchering usage. Of course, it is well known that hominids occasionally exploited coastal shellfish resources in difficult periods. The case of Neanderthals in Gibraltar is a paradigmatic one, but it marked the misery preceding extinction of the once-splendid big-game-adapted race. Considerable evidence suggests that the consistent exploitation of marine resources was a relatively late modern human achievement (Yesner 1984). Furthermore, geographic simulations of population movements along the hypothesized southern route have demonstrated that the Ganges-Brahmaputra Delta had to be a significant physical barrier to this route (Field and Lahr 2006). Although the phylogeography of mtDNA haplogroup M strongly supports the existence of this southern expansion (Maca-Meyer et al. 2001), other genetic studies also based on uniparental markers (Cordaux et al. 2003, 2004) have detected a sharp differentiation between indigenous populations at the western and eastern corners of this physical barrier.

Returning to the Persian Gulf, we are in agreement with the possibility that modern humans were there at around 100 ka. However, we (Abu-Amero et al. 2007, 2008) and others (Černý et al. 2008; Rowold et al. 2007) failed in the search for autochthonous L3 or primitive N and M lineages in Arabia. It could be that sampling was not extensive enough, but most probably these lineages, if really present at that time, were eliminated from the population by successive and strong bottlenecks that indubitably were suffered in arid periods. The same argument holds in explaining the lack of primitive lineages in present-day populations of the Saharan belt, central Asia, and Siberia, where uniform harsh conditions reigned for long inhabitable periods. A different scenario can be envisaged for those territories that, similar to India, Indonesia, or Australia, present a high richness of different biotopes to which populations could rather easily adapt. A more recent and vivid case of this can be imagined thinking that some descendants of the people that reached America through the Bering Strait ended in Amazonic tropical forests. In relation to later human expansions from Arabia, indeed, there are published and unpublished results pointing to three very informative mtDNA lineages. Phylogeny and phylogeography of haplogroup N1a shows the oldest Paleolithic expansion at around 41 ka, most probably initiated in Arabia and extending northward. The next Paleolithic wave, about 24 ka, is detected by the coalescence age of R0a and J1b, the two most frequent haplogroups in Arabia. There are also clues of later expansions from this subcontinent. The R0a1a and 16136-J1b subbranches are signals of Neolithic movements at 10 ka, and the R0a2c subbranch points to Bronze age activity at about 3,000 years ago. These results are highly coincident with the archaeological record of Arabia. As mentioned in this paper, there is disagreement only on the initial age of modern human settlement in Arabia. Geneticists today lack of a deep mtDNA genealogy in Arabia to confirm the archaeological model proposed by Rose, so we must wait for new genetic data to test its interdisciplinary value.

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The notion that coastal regions are more attractive than adjacent hinterlands because of moderate climates, abundant groundwater, ecological diversity and fertility on land, and marine resources; that such regions have been critically important as pacemakers of socioeconomic and demographic change throughout prehistory; and that their role has been largely ignored or misjudged because of sea-level change, has been widely canvassed by archaeologists during the past decade both in general terms and in relation to the Arabian Peninsula (Bailey 2009; Bailey and Flemming 2008; Bailey and Milner 2002; Bailey et al. 2008; Erlandson 2001, 2007; Erlandson and Fitzpatick 2006; Westley and Dix 2006; Westley et al. 2010). This paper usefully summarizes and adds to evidence presented in more detail in the volume recently edited by Petraglia and Rose (2009), demonstrating how much our knowledge of the Arabian Paleolithic has changed in recent years. The hypothesis presented here that periodic exposure of the now-submerged continental shelves of the region might have transformed the ecological potentials for Pleistocene settlement, provided refugia during periods of climatic aridity, and served as a source of population expansion in the early Holocene, is an attractive one.

My comments mainly concern the next stage of research needed to advance these ideas. The key problem is that we know little beyond broad generalization about what these submerged coastal regions were like or how they were affected by sea-level change, and almost nothing at all about any submerged archaeology. It is too early to say whether the development of springs hypothesized by Faure, Walter, and Grant (2002) could have transformed a landscape the size of the Persian Gulf into a well-watered mosaic of wetlands. These are at best hypotheses in need of testing against extensive reconstructions of the preinundation landscape—topography, geology, soils, vegetation, hydrology, and archaeology—using acoustic survey, underwater cameras and vehicles, and targeted coring and diving work. New work is now being devoted to this problem, most of it currently in Europe (Benjamin et al., forthcoming; Flemming 2004, Gaffney, Fitch, and Smith 2009) and some of it by our own team in the southern Red Sea (Bailey et al. 2007). Underwater work is not a trivial exercise, and active discussions are underway on how to organize the necessary research and obtain funding (SPLASHCOS 2010). This will almost certainly require large, multinational, multidisciplinary teams, collaboration with industrial partners, fundamental new research on the preservation and taphonomy of landscapes and archaeology subjected to marine inundation, and substantial funding. An exploratory survey involving ship time can easily cost $2–3 million, and a larger-scale exercise involving a number of related projects can be an order of magnitude higher. These are not impossible targets but will require international teamwork and sustained commitment on a scale unusual even by archaeological standards. Until such work is undertaken, much will remain speculative or oversimplified.

I am skeptical about the relevance of mythology and equally so about reliance on genetic proxy data, given the huge margins of error in coalescence dates and the many other assumptions involved. The role of the Arabian Peninsula has been further obscured by genetic deduction of a rapid coastal exit of modern humans from Africa at about 70 ka, supposedly fueled by new adaptations involving marine resources and seafaring. This idea appears to be supported mainly by calibration with first entry into Australia and New Guinea at about 60 ka. Since this involved modern humans, long sea-crossings, and exploitation of marine resources, the assumption is that first exit from Africa involved similar adaptations at some slightly earlier time. However, there is no reason to suppose that Australia provides an appropriate analogy for other parts of the world (Anderson, Barrett, and Boyle 2010); that expansion into southern Asia and Australasia was a single unified process; or that it was rapid, closely connected in time with exit from Africa, confined to coastlines, or necessarily involved seafaring or marine resources. At the Abdur site (Walter et al. 2000), the oyster shells that supposedly represent food remains and that were made much of in supporting the coastal hypothesis are actually a natural death assemblage (Bruggemann et al. 2004), and the southern Red Sea channel was narrow enough for long periods of the Pleistocene sea-level cycle to be easily crossed or circumvented without seafaring skills. The study of hominin dispersals deserves more serious engagement with the complexities of archaeological data and interpretation than this, more serious engagement between all the many disciplines that have something to contribute to the problem, and above all, sustained research in continental shelf archaeology. Genetic inference has a role to play but, as Rose demonstrates here, the archaeological data are key to forming and testing new hypotheses. Moreover, many other shallow shelf regions would have had similar potentials at lowered sea level, so this is an issue of worldwide interest and not unique to the Persian Gulf.

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This ambitious paper touches on a crucial issue in human prehistory—the dispersal of anatomically modern humans (AMHs) out of Africa—as well as the advent of Neolithic societies to Arabia. It challenges the model of a single rapid dispersal along a southern coastal route between ca. 60 and 40 ka BP, highlighting archaeological and genetic evidence for the existence of a significant AMH population within or bordering Arabia from ca. 128 ka BP, which survived hyperarid episodes formerly considered to have created a *tabula rasa* by the start of the Holocene. This review will focus on the second of the two issues, namely the contribution of the proposed reservoir population to the peopling and development of those regions neighbouring the Gulf basin. The existence of this population has rarely been considered, except for a putative role in the generation of the famous Mesopotamian flood myth.

Rose's identification of Arabia's Qatar B/Fasad point lithic assemblage as the product of an Epipaleolithic population based in the Persian Gulf Oasis is likely to be contested. In Rose's model, these would be the satellite sites of a population based in the Gulf basin. In contrast, according to the more widely published model, the appearance of the Qatar B/Fasad horizon indicates the dispersal of PPNB groups into a depopulated peninsula, marking the start of the Neolithic (Drechsler 2007; Uerpmann, Potts, and Uerpmann 2009).

It is unfortunate that so little is known of the Qatar B/Fasad horizon. Rose's observation that no domesticates are associated with these sites is valid, but it is undermined by the general paucity of evidence. He concludes that the PPNB lithic technology and that of Qatar B/Fasad are radically different, contending that the method of production and flaking techniques differ to the extent that they must have derived from entirely different ancestral populations. Charpentier (2008:95–96) concurs that the Fasad point horizon should be associated with early Holocene hunters rather than Neolithic groups, but not all experts agree, and it is to be hoped that further debate will resolve this conundrum.

Regarding the ultimate destination of the displaced people of the Persian Gulf Oasis, Rose hints at a key role in populating "the nexus of the ancient world, ground zero of the Agricultural and Urban revolutions." The people of the Gulf basin would have been well adapted to marshy riverine and estuarine conditions, such as were later found in southern Mesopotamia during the formative 'Ubaid and Uruk periods and certainly would have followed such environments as they retreated.

On the other hand, Rose also interprets the explosion of Arabian Neolithic sites from ca. 7500 BP as the result of demographic movement from the Gulf basin. Unless one completely dismisses the notion that lithic technology is passed down the generations, there are problems with assigning both the populations of southern Mesopotamia and eastern Arabia to the same demographic origin in the Gulf basin. The leptolithic (blade-based) industry of early southern Mesopotamia has little in common with the Arabian bifacial tradition(s) that prevailed in the Arabian Peninsula between 8 and 6 ka BP. It may, however, be fruitful to compare the leptolithic Qatar B/Fasad industry with that of the earliest documented horizons of southern Mesopotamia.

The appearance of the ABT, and disjuncture with the previous Qatar B/Fasad horizon, is one of the key issues that must be tackled to resolve the problem of population (dis)continuity in Arabia. One might alternatively seek the genesis of the Arabian Neolithic/ABT in Yemen, where the region's earliest domesticates have been identified at Manayzah, dated to the early eighth millennium BP, in association with bifacial lithic industries, themselves older than known bifacial industries in eastern Arabia (Martin, McCorriston, and Crassard 2009). For this reason, the possibility of a Yemeni population reservoir should be considered, or perhaps a different migration from the Levant, later than PPNB, down western Arabia. The latter model need not preclude population admixture with older Arabian populations, hence the genetic signals noted by Rose. One may therefore tentatively propose, as a modification of Rose's model, a significant population input from the Persian Gulf Oasis into southern Mesopotamia and eastern Arabia in the early-mid Holocene, with a later separate phase of Neolithic colonization of Arabia from the west. In neither area should it be assumed that Neolithicization occurred as the result of the demic expansion of PPNB groups. Rather, the southern Mesopotamian chalcothic (early 'Ubaid) and the Arabian Neolithic (ABT) could have emerged separately from interactions between different local reservoir populations with post-PPNB neighbors.

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Jeffrey Rose's article is an appealing example of how to merge not only paleoclimatological and archaeological but also archaeogenetic data to better infer and perhaps form a more reliable image of Arabian prehistory. Such a synoptic endeavor is not an easy task, as the data can mirror various phenomena. Paleoclimatology is about changes in natural environments associated with global climatic oscillations, but it usually indicates nothing about whether humans were really present in such environments. Archaeology can unambiguously provide direct proof of a human presence, but problems arise when nothing has been discovered: is it proof of an absence, or the absence of a proof? This is an especially important issue when considering the now-submerged Persian Gulf refugium. Archaeogenetics is the youngest discipline in prehistoric research and reveals demographic expansions of past populations by the study of genetic variability in contemporary populations (Renfrew and Boyle 2000). Vincent Sarich's (1973) sentence, "I know my molecules had ancestors, the paleontologist can only hope that his fossils had descendants," is generally cited to demonstrate that the direct genetic link between the present human population and the past one may not always exist in the opposite direction. However, as a relatively new discipline, archaeogenetics still suffers growing pains, which might explain why the author begins his discussion of the genetics conundrum with "Genetic analyses point to a different scenario of modern human emergence than is indicated by the archaeological evidence."

Age estimates of past demographic expansions are one of the archaeogenetic issues. For example, the mutation rate of the mtDNA molecule or its portions, according to which age estimates are calculated, as well as the choice of a proper statistical method, are questions still widely discussed (Soares et al. 2009). For example, when analyzing the Late Pleistocene and Holocene evolution of modern humans, some recent studies have recommended using a different calibration point than the commonly used human-chimpanzee divergence of 6 million years ago (Endicott et al. 2009). Moreover, Bayesian statistics have also been proposed as a better tool than the commonly used ρ statistic. Although these points would deserve further attention, I think that the main reason for the mutual incompatibility of archaeological and archaeogenetic data reported by Rose for Arabia lies in the relatively high proportion of date estimates based on small fragments only. There are still very few whole mtDNA genome studies of the haplogroups specific to the Arabian Peninsula, even if this is beginning to change.

The scenario of one successful out-of-Africa expansion through the so-called southern route questioned by Rose is still quite plausible, at least in archaeogenetic terms. The human mtDNA phylogeny data clearly show that only two daughter branches of the African L3 (called M and N) peopled Eurasia some 60–80 kya (Behar et al. 2008). The main argument for modern human dispersal by the southern rather than the northern route is the contemporary geographical distribution of these basal branches. While the populations of southern and furthermore also southeastern Asia and Australia harbor both M and N branches, the western Eurasian gene pool is composed (except for one younger M1 clade) only of derivatives of the N branch (Forster et al. 2001; Macaulay et al. 2005). The most parsimonious explanation of this observation is that the initial population split of the Eurasian mtDNA gene pool had taken place somewhere in the Indus Valley, where a sharp boundary has been detected (Metspalu et al. 2004). While the ancestral population going northwest had lost M representatives through genetic drift, probably a larger population retaining both M and N branches continued its "beachcombing" southern route (Oppenheimer 2003). The contemporary absence of genetic traces of the southern route in Arabia can be explained by its harsh climatic conditions during the Late Glacial Maximum, when the population died out and was later replaced by a west Eurasian gene pool from the north.

I highly value how the author of the article works with paleoclimatological data to infer possible refugial zones from population dynamics. In fact, an example of an Holocene expansion can be demonstrated by our phylogenetic study of the haplogroup R0a (Černý et al. 2009). This haplogroup abounds in the Arabian Peninsula and neighboring regions of east Africa, but its younger clades (e.g., R0a1a1, R0a2f1) are found not only on Socotra but likewise in Al-Mahra, where, as demonstrated by our new whole-mtDNA genome study (unpublished), they must have been diversifying during the Holocene. Interestingly, the geographic localization of this demographic upheaval coincides quite well with one of the three past population refugia localized recently within the Arabian Peninsula (Rose and Petraglia 2009). Hopefully, in the way the existence of the southeast Arabian littoral zone refugium has been shown by R0a, other haplogroups, in accordance with archaeological data, can confirm remaining refugia, such as those in the Red Sea basin or the Persian Gulf.

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As has been noted many times before (see Rose and Petraglia 2009), Arabia—despite its important geographic position—has been relatively neglected by archaeologists and molecular anthropologists until recently. Thus, our current knowledge is rather tentative; many archaeological sites remain undated (Petraglia and Alsharekh 2003), and systematic research of genetic diversity of Arabian populations is at the beginning stage (Abu-Amero et al. 2008; Rídl, Edens, and Černý 2009). Jeffrey Rose, who has spent the last years digging the Arabian sand during his ongoing archaeological excavations, is becoming one of the major contributors to "the emerging picture of prehistoric Arabia" (see references in this paper).

In this paper, Rose integrates multidisciplinary data from paleoclimatology, archaeology, and genetics in order to explore the hypothesis of the "Arabo-Persian Gulf Oasis"—a demographic refugium allowing continual settlement of human populations even during harsh arid periods that might have played role in initial human occupation(s) of Eurasia and in later development of human societies in southwest Asia. One interesting point is how both archaeology and genetics face similar problems, especially in the case of Arabia. It is possible that some important archaeological sites are hidden today under the waters of the Indian Ocean or might have become lost because of postdepository factors and/or recent human activities. Similarly, older genetic traces testifying to the presence of human populations during the Middle and Upper Paleolithic times might have been erased from the today gene pool by population bottlenecks and/or more recent demographic oscillations and gene flows.

From the geneticist's point of view, I agree that the most ancient node of human mtDNA phylogeny outside of Africa seems to lie in southwest Asia—as indicated by the most diverse lineages of haplogroup M recovered in India (Metspalu et al. 2004; Thangaraj et al. 2006). It is, therefore, reasonable to search for ancient haplotypes (either members of haplogroup M or its molecular ancestor) among today populations in Arabia; no matter whether the initial migration(s) from Africa went south or north. However, almost all genetic diversity in Arabia seems to postdate the hyperarid period of MIS 2, and to date there are no "ancestral" lineages recovered among Arabian populations (Abu-Amero et al. 2008; Rídl, Edens, and Černý 2009). Given the complex environmental and demographic history of the region (also reviewed in this paper), it is highly possible that they have become completely lost. The only evidence that human populations could survive during MIS 2 comes from haplogroups J1b and R0a, as their coalescence time is about 20 kya (Abu-Amero et al. 2007, 2008; Rowold et al. 2007). The crucial point here is the dating. Recently, there is an ongoing debate about the calibration of the molecular clock that is used to calculate mtDNA coalescence times. To cut the long story short, the computations based on "phylogenetic" calibration and constant substitution rate are being considered as overestimated by some researchers (see Endicott et al. 2009 and references therein). This may also hold true for J1b and R0a lineages.

New insights into the evolution and dispersal of modern humans come from a draft sequence of the Neanderthal nuclear genome published this year (Green et al. 2010). Some parts of the Neanderthal genome are shared with present-day Europeans and Asians but not with Africans. There are two possible explanations of this phenomenon. The first explanation is that there was an ancient polymorphism among archaic populations in Africa. In that case, Neanderthals and all humans outside of Africa would stem from the same population whose other descendants have become lost (or minor) in Africa.

The second and probably more parsimonious scenario involves interbreeding between Neanderthals and modern humans. This would mean that there was a single population of modern humans whose ancestors met (and mated) Neanderthals somewhere in southwest Asia and whose descendants subsequently colonized the rest of the world outside of Africa. Which begs the question, when and where did it happen? Was it in the Levant where modern humans first encountered Neanderthals about 100 kya? Then the human remains found in Israeli caves Skhul and Qafzeh would represent successful, rather then failed, waves out of Africa during MIS 5. Or does the answer lie in a demographic refugium such as the hypothesized Gulf Oasis? It is possible to imagine that groups of both—modern humans and Neanderthals—were pushed to exploit the same resources during the MIS 4 desiccation. Interestingly, the above-mentioned scenarios of interbreeding between modern humans and Neanderthals fit well with the "Arabo-Persian Gulf Oasis" model.

Jeffrey Rose has presented a viable hypothesis that can be further tested with new data. Indeed, the most decisive evidence would lie beneath the waters of the present-day Persian Gulf.

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In this article Jeffrey Rose has combined data derived from Paleolithic archaeology, paleoclimate studies, and genetics to propose some new innovative ideas concerning the significance of the Persian Gulf Oasis in human migration out of Africa and its possible application on the emergence of Aurignacian industries within the Zagros Mountains. The importance of Persian Gulf coastal regions has been well known since the beginning of the 1970s when some sporadic surveys were conducted in the surrounding areas focusing solely on finding early hominids migration footprints (Hume 1976; Vita-Finzi and Copeland 1980). Due to the severe climate conditions and lack of enthusiasm among the local archaeologists in the neighboring countries, not that many Paleolithic field missions have been conducted in the region. As a consequence, there still remain large gaps concerning the Late Pleistocene occupations in the studied area. Although the article has perfectly surveyed all published data in this regard, there are some ambiguities concerning some of the claims by the author.

The terms "Arabo-Persian Gulf" or "Gulf" cannot be scientifically applied to the studied region, which has been called "Persian Gulf" for the last two millennia. This name is also the only accepted term in United Nations documents. Although due to some political reasons some of the neighboring countries to this region have been trying to apply some other terminologies to the mentioned geographical zone, it is vital that in archaeological texts the researchers stand neutral in political debates and use the geographical names based on the UN official documents.

In a few instances in the article, it was mentioned that the Paleolithic artifacts recovered from the Arabian Peninsula are different from contemporaneous artifacts in East Africa and instead show some resemblance to those from the Levant and Zagros. The combination of Zagros and Levantine Paleolithic assemblages is a problematic issue since it is widely accepted that these two regions represent two very distinct forms of artifact assemblages, particularly when it comes to the Middle Paleolithic (Minzoni-Deroche 1994). In addition to that, the author indicates that centripetal Levallois cores are among the major features of the Zagros Mousterian. This claim is not entirely true, especially when it comes to the Middle Paleolithic sites excavated in this region. Although sites such as Bisitun, Kunji, Mar Tarik, and Warwasi (all contain Middle Paleolithic layers) posses artifacts made by the Levallois technique, the majority of their assemblages were made on small raw material sources, and as a consequence of that, their blank size is relatively small and tools mostly represent medium and heavy retouches. Low frequency of Levallois technique has been considered as one of the major differences between Middle Paleolithic assemblages of Zagros highlands and the Levant.

Locating geographical origins for Aurignacian industry has been one of the major concerns of the Paleolithic researchers, and as it was plainly discussed in this article, there have been claims for nominating Zagros Mountains in this matter. However, neither Otte (Otte et al. 2007) nor Olszweski and Dibble (1994, 2006) present convincing cases to support such a claim. Apparently one of the most fundamental requirements in this regard would be sites containing uninterrupted archaeological sequences from Middle to Upper Paleolithic in the Zagros Mountains. Yafteh, which was originally excavated by Hole and Flannery (1967) and just recently was reexamined by Otte (Otte et al. 2007) does not have Middle Paleolithic layers. On the other hand, the Warwasi rockshelter seems a suitable candidate, having archaeological layers assigning to Middle and Upper Paleolithic and Epipaleolithic; however, some methodological problems at the time of excavation (using 20-cm layers) might raise the issue that there might have been some admixtures among the layers. Therefore, it seems a bit premature to consider the Zagros Mountains as the geographical place for the origin of Aurignacian industry.

Throughout the article the differences between Paleolithic assemblages from the Zagros highlands and those coming from the southern Zagros and northern parts of Persian Gulf were discussed. Based on the published data it seems that such differences exist, especially between the lowland sites such as Eshkafte Gavi, Sarab Syah, Jam-o-Riz, and Qaleh Bozi and those in the highlands (Bisitun, Kunji, Warwasi); however, some technical issues concerning the natural formation of the sites and surveying strategies must be taken to account in order to make the assemblages comparable. One obvious reason behind such differences in Paleolithic assemblages could be because of different settlement patterns by different groups of people, depending on the duration of occupations and site function, which both had been under direct influence of bioenvironmental factors. On the other hand, some of the Paleolithic data (Jam-o-Riz and Sarab Syah) came from surface collections, which cannot be compared with those from excavations.

Rose proposes that eastern Arabia could be considered as a place for admixture of anatomically early modern humans and Neanderthals; however, he does not provide any convincing material to support such claim. In absence of any hominid remains in eastern Arabia, detail techno-typological comparisons between the late Pleistocene assemblages of Skhul and Qafzeh and those from eastern Arabia could help to develop a strong case for such claim.

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Overall, this is a fine synthesis of the latest evidence for the projected hypothetical occupation of East Arabia and the Perso-Arab Gulf. I would like to add a few comments concerning the region that should illustrate the close relationship between Arabia, southern Iraq, the Gulf, and the Levant—a fact not usually emphasized in the past. Concerning paleoclimate and the Arabian Peninsula, the boundary between the westerlies and the Indian Ocean monsoon is commonly called the intertropical convergence zone (El-Moslimany 1990; Fontugne and Duplessy 1986; Prell 1984). The boundary line fluctuates considerably, and in the hyperarid last glacial (18,000 BP), Zötl places it at the extreme southwest portion of the peninsula. In 8000 BP it reached just beyond the Nafud Desert (Zötl 1984:313, fig. 122). A similar pattern is illustrated by Butzer (1995:129, maps 2, 3). In both reconstructions, we can see the effects reaching past the Nafud, not just the Rub al Khali, thus linking the paleoclimate of Saudi Arabia with Iraq, Kuwait, Jordan, and Syria. This can be demonstrated by the presence of paleolakes and streams in this larger region. A series of interdunal lakes in the Nafud date to the late Quaternary and Early Holocene wet phases (MIS 2–4; Garrard and Harvey 1981; Schulz and Whitney 1986, 1987; Whitney 1983). Such lakes have been studied as far north as the Palmyra basin (Fujii et al. 1987; Sakaguchi 1987). In addition, relic runoff streams from southern Syria, western Iraq, and the Jordan flowing into the Mesopotamian basin (Zarins 1989: 32–33, fig. 2; 1990:32, fig. 1) can be seen as part of the larger pattern of Arabian Peninsula precipitation as well. The underground system resulting from this runoff providing aquifer water is well known (Al-Sayari and Zötl 1978:93–163, 182–193; Naimi 1965; Sowayan and Allayla 1989) and represents presumably interglacial rainfall periods since at least the Early Pleistocene. (The more recently traced Jowf-Hadhramaut-Wadi Masila drainage represents a similar system entering into the Indian Ocean; Cleuziou, Inizan, and Marcolongo 1992). The connection between alternating fluvial deposits and exposed river systems in the Gulf plain originating in the northern Gulf and Mesopotamia was first investigated in the middle nineteenth century and are summarized by Al-Zamel (1983), Larsen (1975), Lees and Falcon (1952), and Zarins (1992).

Middle Holocene Gulf archaeology and the origins of the enigmatic Sumerians must center on the excavations undertaken at Eridu, the town in which the Sumerians originated and created civilization. Eridu is situated on a typical large northeast Arabian lake of the type cited above and on the western edge of the Wadi Batin delta entering the South Mesopotamian trough. This lake was undoubtedly the Sumerian "waters of the deep," or *abzu* (Green 1975). Excavations in the middle twentieth century provided a very long 'Ubaid sequence of domestic and religious architecture beginning by ca. 5500/5000 BC (Safar, Mustafa, and Lloyd 1981). It was largely abandoned as a city by the Middle-Late Uruk periods, presumably due to the disappearance of the lake (Zarins 1992: 65), and by the Early Dynastic (ED) period became a pilgrimage center. The connections of the city (and other 'Ubaid Mesopotamian centers) with the Gulf cannot be overstated (for the projected shoreline in 6000 BC, see Nutzel 1975; Zarins 1992:64, fig. 5). In addition, we can revive the early study of Landsberger, who suggested that perhaps his Sumerian substrate language Proto-Euphratean could be identified with the 'Ubaid period (Landsberger 1943–1944; Rubio 1999). Finally, we can add a comment on the terms "Dilmun" and "Bahrain." As noted a number of years ago, D. Potts stated (1985) that the term "Bahrain" among Arab historians referred to the adjoining mainland of eastern Arabia until well past the medieval period with the island called Awal. Similarly, the term "Dilmun," first used in the Uruk IVa period texts (Nissen 1985), again most likely referred to the same mainland with its much more extensive 'Ubaid-ED remains (Piesinger 1983). "Dilmun" came to refer to the island only sometime during or after the Sargonic/Ur III period.

Reply

I thank the commentators for their critical reviews and valuable insights helping to articulate the Gulf Oasis hypothesis. I begin my response addressing the aspect of this paper that is least informative, albeit most tantalizing—that of mythology. In regard to the place of the Near Eastern deluge myth in this discussion, I agree with Bailey insofar that it should be relegated to anecdotal. However, I do not think we should dismiss its relevance outright. While it is not valid to start with the premise that the ubiquitous flood story might be rooted in an actual event, it is scientifically permissible to switch the question around and ask whether marine incursion into the Gulf basin impacted the development of local folklores, particularly given that the population living along the northern coast became fully literate within three millennia of the final inundation. During the last phase of postglacial flooding, the shoreline was ingressing at a pace of multiple kilometers per generation; therefore, it is reasonable to suppose this would have left an impression on incipient sedentary communities (trying to) settle along the rapidly advancing shoreline. Epigraphic evidence suggests this was indeed the case, with the oldest flood accounts impressed on Ur III clay tablets from Lower Mesopotamia, followed by a virtually unbroken chain of transmission through Akkadian, Babylonian, Hebrew, and Qur'anic iterations. In the words of Douglas Adams, "If it looks like a duck, and quacks like a duck, we have at least to consider the possibility that we have a small aquatic bird of the family Anatidae on our hands" (Adams 1987).

I wholeheartedly agree with Bailey's summation of the modern human coastal expansion hypothesis, that "the study of hominin dispersals deserves more serious engagement with the complexities of archaeological data and interpretation than this." Although rapid coastal migration is an attractive model, there is no archaeological evidence along the Arabian or south Asian littoral to support such a scenario. Given the data currently available, it is more plausible to consider an interior expansion onto the ameliorated savannas of Arabia during MIS 5 (Rose 2007; Rose and Usik 2009; J. I. Rose, V. I. Usik, A. E. Marks, Y. H. Hilbert, K. M. Price, J.-M. Geiling, A. Beshkani, et al., unpublished manuscript).

Carter homes in on a significant disparity between Middle Holocene lithic industries in eastern Arabia versus southern Mesopotamia. The former region is characterized by the Fasad Industry, followed abruptly by the distinct Arabian bifacial tradition (ABT), which I suggest in the paper is associated with the influx of displaced groups from the Gulf refugium. In southern Mesopotamia, however, we find a laminar rather than *façonnage* technology, contrary to what the Gulf Oasis hypothesis predicts. In light of this discrepancy, Carter speculates that the ABT might be attributed to a separate demographic expansion of cattle herders from a population reservoir in Yemen. While we do not have the chronological resolution to adequately assess this possibility, new archaeological evidence does suggest that there were indigenous groups in southern and southwestern Arabia during the Terminal Pleisocene and Early Holocene (Fedele 2009; McCorriston and Martin 2009; Rose and Usik 2009). This proposition is further bolstered by the recent discovery of deeply rooted mtDNA haplogroup R0a lineages in Yemen and Soqotra, indicating a population expansion from the south in the Early Holocene (Černý et al. 2009). Regardless of the source of the ABT, Carter's point about multiple expansions into Arabia is one of great importance and should be carefully considered in future investigations.

A few of the responses discuss shortcomings in the field of archaeogenetics. These are vital warnings to heed, particular given the almost giddy acceptance by archaeologists of phylogeographic inference and genetic confluence dating to model Late Pleistocene demographic movements. These calculations are riddled with assumptions and ambiguity depending on which statistical method one chooses and which DNA marker one considers; yet in recent years, scholars have accommodated their arguments to fit these models. This trend should be reversed as new archaeological data are discovered, with direct physical evidence used to calibrate the molecular clock.

Abu-Amero et al. call to attention another problem with archaeogenetic research in Arabia. They observe the absence of autochthonous L3 or primitive N and M lineages anywhere throughout the peninsula, arguing "most probably, these lineages, if really present at that time, were eliminated from the population by the successive and strong bottlenecks that indubitably suffered in arid periods." In particular, we should consider climatic conditions between roughly 6000 and 5000 BP, referred to as "the Dark Millennium" (Uerpmann 2003), at which time there is a virtual disappearance of archaeological sites from the Arabian Peninsula. This phase coincides with an abrupt weakening of the Indian Ocean monsoon that punctuated the end of the Holocene climatic optimum, juxtaposed against sea levels that where higher than they had been in over 100,000 years; thereby cutting off all coastal refugia as the interior became increasingly desiccated. While certainly not the only *tabula rasa* episode to cause a strong genetic bottleneck in Arabia, the widespread demographic decline experienced during this millennium would have undoubtedly obscured much of the peninsula's Pleistocene heritage.

In his comments, Rídl discusses the recently published draft sequence of the Neanderthal nuclear genome (Green et al. 2010), which suggests that Neanderthals interbred with modern humans somewhere in southwest Asia. This is an intriguing proposition in light of recent discoveries in southern Oman that provide unambiguous evidence for a modern human dispersal from Africa into Arabia during late MIS 5 (J. I. Rose, V. I. Usik, A. E. Marks, Y. H. Hilbert, K. M. Price, J.-M. Geiling, A. Beshkani, et al., unpublished manuscript). At the same time, we find an utterly different, coeval lithic industry in Jebel Faya assemblage C situated in the hinterlands of the Gulf basin. These distinct technologies may represent different demographic reservoirs associated with populations in southern (*Homo sapiens*?) versus eastern (Neanderthal?) Arabia. However, as Nasab cautions in his comments, there is no fossil evidence from Arabia to support any such claim. Until that time, the place of admixture must remain purely within the realm of speculation.

Ultimately, the purpose of this paper is to argue that the Gulf Oasis hypothesis is parsimonious and warrants testing, not a model to be accepted or rejected outright. My intention is to provide an updated prism with which to view human emergence in southwest Asia, as well as to "add a new cast of characters" to the discussion of the Neolithic demographic transition. Since the work of Field (1932) and Caton-Thompson and Gardner (1939), scholars have long suspected that the Arabian Peninsula holds clues vital to understanding the incipient development of our species. Within the past decade, we have finally begun to unearth such clues, and indeed, important pieces of the puzzle have come to light. These new data do not uphold conventional models of human emergence, however, and demand a reevaluation of some fundamental ideas.

—Jeffrey I. Rose

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