Genetic and archaeological perspectives on the initial modern human colonization of southern Asia

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It has been argued recently that the initial dispersal of anatomically modern humans from Africa to southern Asia occurred before the volcanic "supereruption" of the Mount Toba volcano (Sumatra) at ∼74,000 y before present (B.P.)—possibly as early as 120,000 y B.P. We show here that this "pre-Toba" dispersal model is in serious conflict with both the most recent genetic evidence from both Africa and Asia and the archaeological evidence from South Asian sites. We present an alternative model based on a combination of genetic analyses and recent archaeological evidence from South Asia and Africa. These data support a coastally oriented dispersal of modern humans from eastern Africa to southern Asia ∼60–50 thousand years ago (ka). This was associated with distinctively African microlithic and "backed-segment" technologies analogous to the African "Howiesons Poort" and related technologies, together with a range of distinctively "modern" cultural and symbolic features (highly shaped bone tools, personal ornaments, abstract artistic motifs, microblade technology, etc.), similar to those that accompanied the replacement of "archaic" Neanderthal by anatomically modern human populations in other regions of western Eurasia at a broadly similar date.

India | Paleolithic | archaeogenetics | mtDNA

Questions surrounding the character and chronology of the dispersal of anatomically modern human populations from their African origins ∼150–200 thousand years ago (ka) are currently a focus of great interest and debate. Issues surrounding the initial modern human colonization of the geographically pivotal region of southern Asia have generated intense controversy in the recent genetic and archaeological literature (1–13).

There are currently two sharply conflicting models for the earliest modern human colonization of South Asia, with radically different implications for the interpretation of the associated genetic and archaeological evidence (Fig. 1). The first is that modern humans arrived ∼50–60 ka, as part of a generalized Eurasian dispersal of anatomically modern humans, which spread (initially as a very small group) from a region of eastern Africa across the mouth of the Red Sea and expanded rapidly around the coastlines of southern and Southeast Asia, to reach Australia by ∼45–50 ka (7–10, 14–18) (Fig. 2). The second, more recently proposed view, is that there was a much earlier dispersal of modern humans from Africa sometime before 74 ka (and conceivably as early as 120–130 ka), reaching southern Asia before the time of the volcanic "supereruption" of Mount Toba in Sumatra (the largest volcanic eruption of the past 2 million y) at ∼74 ka (1–6).

The arguments advanced in support of the second ("pre-Toba") colonization model at present hinge on archaeological evidence recovered from recent excavations in the Jwalapuram region of southeastern India (Fig. 2), where a series of stone tool assemblages have been recovered from locations both underlying and overlying thick deposits of Toba ash-fall deposits, with a series of associated optically stimulated luminescence (OSL) dates ranging from ∼77 to ∼38 ka (1–6) (*Archaeology*). Technologically, all of these assemblages are of characteristically Middle Paleolithic form [attributed by the excavators to a generalized "Indian Middle Paleolithic tradition" (1)], broadly similar to those documented across a wide region of both Europe and western Asia over a similar span of time (18). The claim that these industries provide evidence for an early arrival of modern humans from Africa before 74 ka rests crucially on analyses of two small samples of residual "core" forms recovered from below the Toba ash-fall deposits (at Jwalapuram sites 3 and 22), compared with those from a broadly contemporaneous range of Middle Paleolithic/Middle Stone Age (MSA) sites in other regions of Eurasia and Africa (1, 4, 6). For reasons discussed fully in *Archaeology*, we regard these analyses as seriously flawed on both archaeological and methodological grounds, and the interpretation originally offered for these assemblages has since been withdrawn by the author responsible for the lithic analyses, who "now thinks they might be the work of an unidentified population of archaic people" (ref. 11, p. 26).

In archaeological terms, the most remarkable feature of this model lies in the claims for a rapid and abrupt evolution from these initial "Indian Middle Paleolithic" industries into the immediately ensuing "Indian microlithic tradition", which appears over effectively all regions of India from at least 35–40 ka onward [in calibrated radiocarbon terms (19)]—a transformation that, according to the recently dated industrial sequences at Jwalapuram, occurred within a space of ∼3,000 y, between ∼38 and 35 ka (1–3) (Fig. 1 and *Archaeology*). According to the evidence recorded from the Jwalapuram 9 rock shelter and the two sites of Batadomba-lena and Fahien-lena in Sri Lanka (3, 20, 21) (Fig. 2), this allegedly in situ transformation affected virtually all aspects of the archaeological assemblages, including the sudden appearance of highly controlled microblade-producing techniques (and associated core forms), and the production of a wide range of highly shaped "microlithic" tools, typical end scrapers, extensively shaped bone tools, a variety of circular, rotary-perforated bead forms, and [at the site of Patne in northern India, radiocarbon dated to ∼30 ka calibrated (cal.) before present (B.P.)] a fragment of ostrich eggshell engraved with a complex "bounded criss-cross" design (2, 3, 20–22) (Figs. 3 and 4). At the site of Batadomba-lena in Sri Lanka these industries are associated with typically anatomically modern skeletal remains, dated to ∼30–35 ka cal. B.P. (21, 23).

In all other regions of Europe and western Asia, these ranges of technological and other cultural innovations are generally seen as the hallmarks of fully "Upper Paleolithic" technologies, which first appeared in the different regions in close association with the arrival of the first anatomically modern populations from Africa (and the associated extinction of the preceding "archaic" Neanderthal populations) ∼45–35 ka cal. B.P. (18, 24–26)—i.e., at a broadly

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GENETICS

ANTHROPOLOGY

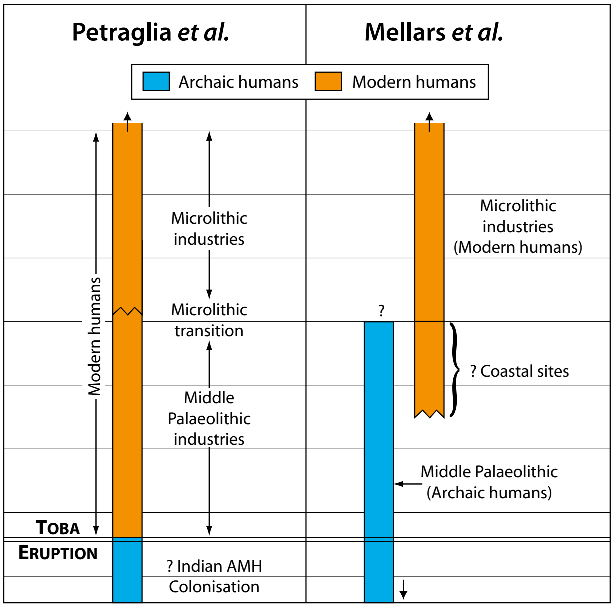

Fig. 1. Comparison of the two alternative models for the initial modern human colonization of South Asia discussed in the text. The graphs show the inferred correlations between "archaic" and "modern" populations and their associations with Middle Paleolithic vs. microlithic technologies in the two models. The date indicated for the initial, pre-Toba modern human colonization in the Petraglia et al. model is a minimum number (~74 ka), with other estimates ranging up to 120–130 ka (5). For relevant references, see main text. Graphic by Dora Kemp.

similar date to the earliest radiocarbon-dated occurrences of microlithic technologies within the Indian subcontinent. To suggest that these two closely similar and effectively synchronous patterns of technological development were the products of entirely separate and independent evolutionary trajectories in the two regions (introduction by intrusive, African-derived populations in the case of Europe and western Asia, vs. local evolution from the immediately preceding Middle Paleolithic populations in India) would seem to require a remarkable level of convergent, and broadly simultaneous, cultural transformations, within regions separated geographically by a span of over 3,000 km. It would seem to amount to what has been described in other contexts (26) as an almost "impossible coincidence" in cultural evolutionary terms.

In demographic terms the most central and critical implication of the pre-Toba model is that there was direct cultural, demographic, and therefore genetic continuity between the hypothetically modern humans who colonized the Indian subcontinent sometime before ~74 ka and the later populations characterized by the highly distinctive Indian microlithic technologies, known to have occupied effectively all areas of the subcontinent (including Sri Lanka) from at least 35–40 ka onward and continuing for a further 30,000–35,000 y into the ensuing Neolithic period (2, 3, 5, 20, 21). As discussed below, this proposal has radical implications for the interpretation of the genetic evidence (Fig. 1). Here we argue that this model of a pre-Toba colonization of South Asia encounters fundamental problems on both genetic and archaeological grounds and propose instead a later colonization of the Indian subcontinent by African-derived modern humans ~50–55 ka.

Genetic Evidence

The current genetic evidence for the modern human settlement of South Asia derives from three genetic systems: the maternally inherited, nonrecombining mitochondrial DNA (mtDNA), the male-specific part of the paternally inherited Y chromosome (MSY), and the bilaterally inherited X chromosome and autosomes. All three point to a broadly similar conclusion for the earliest plausible age estimate for the initial modern human colonization of the region (Fig. 5 and *Genetics* and *Archaeology*).

i) mtDNA: All extant human populations with deep maternal ancestry in Eurasia carry mtDNA lineages that fall within a single haplogroup, L3, which most likely originated initially in eastern Africa (8, 14, 27, 28). L3 diverged during the dispersal from Africa into Asia into the derived M, N, and R lineages (10, 15, 29, 30). Because the makers of the microlithic technologies of India are agreed to provide the demographic basis for most if not all of the present-day Indian populations (see above), they almost certainly carried the M and N/R lineages that today account for all known South Asian mtDNA lineages (excepting recent immigrants). In the context of the present discussion the critical issue is whether these lineages could plausibly have arrived in India before the Toba eruption (~74 ka).

The lineages have been dated in a number of ways, with varying assumptions, but the earliest plausible estimates currently fall at ~70 ka (95% range: 61.6–79 ka) for L3 in Africa (the upper bound for departure), 61 ka (50.4–72.1 ka) for the most ancient non-African haplogroup, haplogroup N, in Arabia, and 48 ka (39.6–56.5 ka) and 62.3 ka (54.7–70 ka) for M and R in South Asia [Fig. 5 and Table S1 (8)]. (Note that R must be slightly younger than N, because R nests within N, which is allowed for given the errors on these estimates.) An estimate for L3 that incorporates 10 almost complete prehistoric mtDNA genomes as calibration points totals 78.3 (62.4–94.9) ka (31). Recent global estimates for haplogroups M and R, respectively, are 49.6 ka (45.9–53.2 ka) and 56.2 ka (52.4–60.7 ka) (30). The arrival in South Asia for M and R could potentially be at any point between their ages and the age of the Arabian haplogroup N ancestor of R ~60 ka, the upper bound for which falls after the Toba eruption, with an absolute upper bound at the top of the 95% confidence interval for the age of L3 in Africa, at 79 ka [Fig. 5 and Table S1 (8)], or at 76.1 ka in another recent estimate (30). Furthermore, skyline plots indicate that the major Pleistocene expansions in India took place in two waves between 50 ka and 37 ka, in close agreement with current archaeological and anthropological evidence (32) (see below and *Genetics* and *Archaeology*). These estimates render the possibility of an initial modern human colonization of South Asia before the Toba eruption (~74 ka) at best highly implausible.

Fig. 2. Map of sites referred to in the main text. The zone of "high marine productivity" is inferred from Google Earth satellite images of chlorophyll concentrations in coastal waters. Graphic by Dora Kemp.

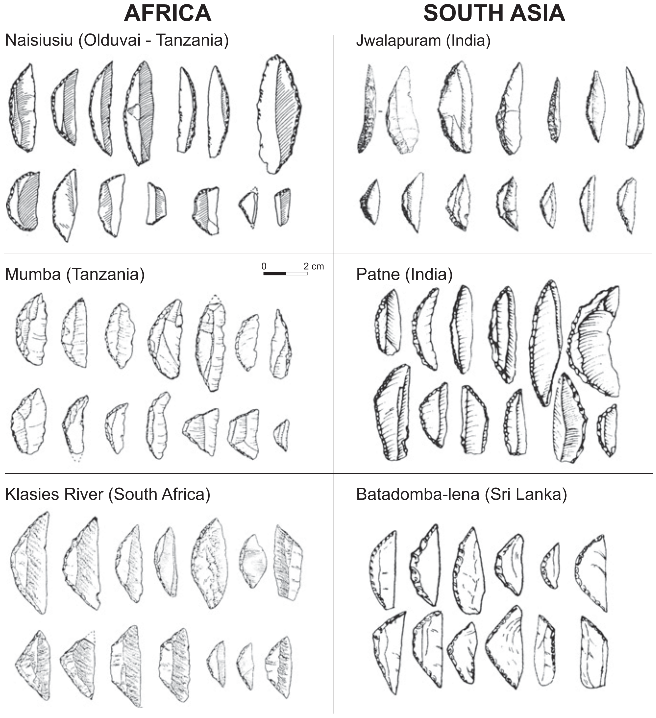

Fig. 3. Microlithic, "backed-segment" forms from Howiesons-Poort-like sites in South and East Africa (*Left*) and early microlithic sites in South Asia (*Right*). The illustrations show the close similarities in the range of "geometric" (crescentic, triangular, and trapezoidal) forms in the two regions (3, 20, 22, 41, 43, 46).

ii) Y chromosome: Although dating MSY lineages is less persuasive than that for mtDNA, current evidence nevertheless implies that non-African Y chromosomes again have a recent ancestry among African clades, with founder haplogroups C, D, and F dating to 40–60 ka (9, 15). In fact, MSY ages appear systematically somewhat younger than mtDNA estimates; estimates for coalescences in various South Asian populations center on 36–46 ka, with the highest 95% upper bound at 73 ka B.P. (15), and the most recent estimates for the dispersal from Africa support this (33) (*Genetics*). As with the evidence for female lineages, the most recent MSY evidence provides no support for the presence in South Asia of male lineages before the Toba eruption.

iii) X chromosome and autosomes: Autosomal genetic variation comprises the vast majority of the human genome and potentially provides evidence from many thousands of independent lines of descent, although the poor phylogeographic resolution of any given locus has so far limited detailed reconstructions such as those possible for the mtDNA and MSY markers. Even so, there is no indication from the existing data for more than a single dispersal into Asia. Autosomal microsatellite and SNP coalescence times are, as for the MSY and the X chromosome, negatively correlated with distance from Africa, suggesting a single dispersal and serial founder effects going east (34, 35). Using autosomal microsatellites, the expansion from Africa has been dated to ~56 ka, with a 95% upper bound of 67.4 ka, from an effective founder population size of ~1,000 individuals (similar to estimates from mtDNA and the MSY) (34). Recent reestimates of the autosomal mutation rate from whole-genome pedigree data suggest a European–Asian split time of 40–80 ka, although they do not, as has been suggested, lend any support to a dispersal from Africa before 80 ka (36) (*Genetics*). In short, the recent debates over autosomal mutation rates, however interpreted for the earlier ape/hominin time ranges, have no significant impact on the mtDNA age estimates we have used here—either for the initial out-of-Africa dispersal,or for the subsequent colonization of South and East Asia, which on current evidence most likely took place ~55 ka.

Archaeological Evidence and Models

On archaeological grounds there are equal if not greater problems inherent in the pre-Toba modern human dispersal model (for further details and references, see *Archaeology*):

i) The pre-Toba colonization model proposes an extremely rapid, in situ, evolution from assemblages of technologically and typologically characteristically Middle Paleolithic form to the dramatically different industries of the Indian Microlithic tradition, within ~3,000 y, with no convincingly documented occurrences of technologically intermediate or transitional industries (2–6) (*Archaeology*). Transitions of this scale and character are at present paralleled only in the rapid replacement of Middle Paleolithic by Upper Paleolithic technologies across western Eurasia, associated directly with the replacement of archaic Neanderthals by anatomically modern humans (18, 24–26), at a broadly similar date to that of the analogous transitions in South Asia.

ii) The suddenly appearing Indian microlithic technologies show a range of striking and detailed similarities with technologies documented over large parts of southern, central, and eastern Africa (Fig. 2), at the time when the current genetic data indicate that the initial out-of-Africa dispersal (across the mouth of the Red Sea) occurred—i.e., broadly between 65 and 55 ka

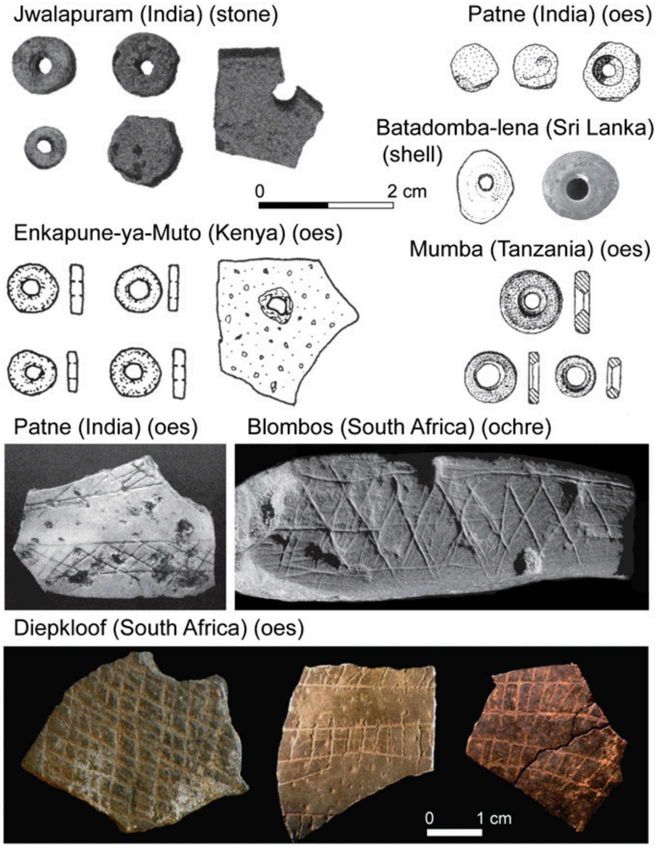

Fig. 4. Comparisons of ornamental "bead" forms and "symbolic" design motifs from later MSA (Howiesons Poort and Still Bay) sites in South and East Africa and early microlithic sites in South Asia (3, 7, 21, 22, 37, 39, 40, 42) (oes, ostrich eggshell). Patne oes and Blombos ochre reproduced from (7).

(see above and Fig. 5). This is reflected in both South and East Africa by industries belonging broadly to the so-called "Howiesons Poort" variant, which, although inevitably regionally variable over an area the size and with the environmental diversity of sub-Saharan Africa, collectively exhibit all of the most distinctive features that characterize the earlier stages of the Indian microlithic technologies (3, 37–53) (Figs. 3 and 4 and *Archaeology*). These include sophisticated blade and bladelet production, circular, rotary-perforated bead forms (and associated "preforms") manufactured from ostrich eggshell (39, 40), highly shaped bone tools, and incised bounded crisscross and analogous cross-hatched design motifs engraved in the African sites (Diepkloof, Klein Kliphuis, Apollo 11, Mumba, and the earlier site of Blombos) on fragments of either red ochre or ostrich eggshell (closely analogous to the Indian specimen from Patne) (22). Arguably most significantly, both the African and the Indian industries are dominated by a range of carefully shaped microlithic or larger "backed-segment" forms of precisely the same range of shapes as those documented in the South Asian industries (i.e., crescentic or lunate forms, triangles, trapezoids, and simpler obliquely blunted forms), which in both Africa and South Asia are frequently shaped by distinctively bipolar techniques of retouch (37–46) (Figs. 3 and 4). These forms are widely assumed to represent, primarily if not entirely, the armatures of composite, light-weight hunting missiles, most probably (by analogy with ethnographically documented examples) the tips and barbs of wooden arrows (37, 38, 47, 50, 53).

Ten separate occurrences of Howiesons Poort industries in southern Africa have been dated by single-grain OSL techniques to between ∼59 and 65 ka (54), with an apparently precocious occurrence of a similar industry recently dated to ∼71 ka at the site of PP5-6 at Pinnacle Point on the South African Cape coast (47). Although the occurrence of typically Howiesons Poort industries in eastern Africa has sometimes been questioned, the ranges of geometric microlithic and backed-segment forms recorded from the Naisiusiu Beds (Olduvai Gorge) and the uppermost Bed V levels at the Mumba rock shelter (Tanzania) are to all appearances of classic Howiesons Poort form (Fig. 3), recently dated to between 59 ± 5 and 62 ± 5 ka (Olduvai) and between 56.9 ± 4.8 and 49.1 ± 4.3 ka (Mumba) by ESR and OSL techniques, respectively (40, 45), broadly spanning the time range of the classic Howiesons Poort industries in South Africa (44, 47). These close similarities between the East African industries and the South African Howiesons Poort forms have frequently been noted in the earlier literature (38, 43, 45, 47, 54) and now seem effectively beyond dispute. The slightly later dating of some of the East African sites might well reflect a demographic displacement—or alternatively a process of between-group cultural diffusion—of the Howiesons Poort technologies northward, probably facilitated and precipitated by the end of the "great East African megadrought", dated in the Lake Malawi sedimentary records to around 60–70 ka (40, 55). The long cultural sequence in the Enkapune-ya-Muto rockshelter (Kenya) suggests that these industries evolved directly into the ensuing East African Later Stone Age technologies, over the period from ∼60 ka to 40 ka (47). The presence of bifacially flaked, leaf-shaped points ("Balangoda points") in the Sri Lankan microlithic sites provides a further specific link with the African later MSA technologies (21) (*Archaeology* and Fig. S5).

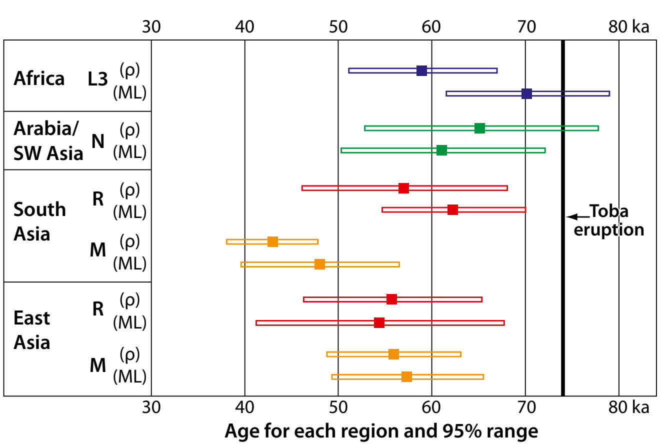

Fig. 5. Age ranges for mtDNA lineages in Africa and Asia. Ninety-five percent confidence ranges are shown for the coalescence times of mtDNA haplogroup L3 in Africa and founder ages for haplogroup N in Arabia/Southwest Asia and haplogroups R and M in South and East Asia, estimated using ρ and maximum likelihood (ML). For details, see *Genetics* and Tables S1–S5.

In both technological and other cultural terms this amounts to a remarkable range of relatively complex and highly distinctive features, which are equally diagnostic of both the African sites and the South Asian microlithic industries. The current dating evidence (as noted above) shows that these African industries span an age ranging from ∼70 ka to 50 ka (39, 40, 44, 45) (*Archaeology*), overlapping with the genetically estimated age of the initial out-of-Africa dispersal from East Africa to the immediately adjacent areas of Arabia and southern Asia. We assume that it was the progressive increase in population numbers fostered by the range of "advanced" technological, economic, social, symbolic, and other features developed initially in the rich coastal environments of southern Africa that eventually drove these populations out of eastern Africa and into the immediately adjacent areas of Asia (37, 47, 54) (*Archaeology*). Viewed in these terms it is difficult to imagine how any human dispersal from East Africa to western and southern Asia could have occurred without carrying with it technologies of essentially this form—unless all of these cultural features were in some way "lost in transit" during the short crossing from eastern Africa to Asia—only to be reinvented, independently and in almost exactly the same forms, within southern Asia, at a slightly later date. This might fairly be characterized as a further effectively impossible coincidence (26). The archaeological impossibility of deriving these highly distinctive "geometric" microlithic technologies from any alternative region of either Asia or Europe and the probable reasons for the absence of similar technologies to the east of India (7) are set out fully in *Archaeology*.

The only potential objection we can see to the model outlined above relates to the apparent time gap between the genetically estimated age of the initial modern human colonization of India (∼50–60 ka) and the earliest directly radiocarbon-dated occurrences of typical microlithic industries in South Asia (as in the Jwalapuram 9 rock shelter in southeastern India and the two sites of Batadomba-lena and Fahien-lena in Sri Lanka), in each case with methodologically minimal ^{14}C age estimates of around 35–40 ka cal. B.P. (3, 21). These dates are close to the effective limits of radiocarbon dating, where only 1% of contamination by modern carbon would reduce the measured age of a sample from 50 ka to ∼37 ka (56). The dates for the Jwalapuram 9 sequence (Fig. S6) should be viewed with special caution in view of their reliance on the notoriously problematic dating of snail-shell samples, which have been shown to yield dates that may be several thousand years younger than those from stratigraphically associated charcoal or bone samples (57) (*Archaeology*). Closer examination suggests, however, that this potential chronological lacuna between the genetic and the archaeological evidence for the modern human colonization of South Asia is more apparent than real.

First, we recall the very limited extent of systematic field surveys for later Paleolithic sites so far carried out in most areas of South Asia and the virtual lack of sites of any kind that have so far been reliably dated within the critical time range from 45 ka to 60 ka (5). In this situation it is statistically at best improbable that the occurrences recorded in the Jawalapuram 9 rock shelter and the two Sri Lankan sites document the very earliest appearance of microlith-using groups within an area the size of the Indian subcontinent—even allowing for the methodological uncertainties inherent in the current dating of these sites and the fact that at both Jawalapuram 9 and the Sri Lankan sites the earliest microlithic industries were underlain by either bedrock or archaeologically sterile deposits. Recent excavations at the Mehtakheri site in the Narmada Valley of north-central India have recovered a typical microblade and backed-microlith industry from sediments dated by multiple OSL and associated radiocarbon measurements to ~45–50 ka—at least 5 ka older than the analogous industries from Jawalapuram and the Sri Lankan sites (58). And if microlithic technologies persisted virtually unchanged in India for at least 35 ka after 40 ka (3), then why not for 5 ka or more before this date? Within this time range one might well expect some period of overlap between the latest occurrences of Middle Paleolithic and the earliest occurrences of microlithic technologies within an area the size of India, analogous to that documented between the final Middle Paleolithic (i.e., Neanderthal) and the earliest Upper Paleolithic (modern human) populations in western Eurasia (18, 24–26). As noted above, we should also remember that the genetic age estimates remain rather imprecise with current sample sizes (Fig. 5) and that some estimates of the mtDNA mutation rate would yield even younger ages for the initial modern human colonization of South Asia (59). Taking account of all these factors, the apparent discrepancy between the current archaeological and genetic ages for the earliest modern human settlement of southern Asia could evaporate.

Moreover, the settlement of most of the Indian subcontinent is likely to have been significantly later than that of the first arrivals. According to the widely accepted "coastal colonization" model for the initial dispersal of modern human groups eastward from East Africa to South and East Asia (14, 16, 17, 60), the initial "founder" settlements of the earliest modern human populations in South Asia are likely to have been tied closely to the contemporaneous coastlines, in locations now submerged ~50 m below present-day sea levels and at distances of up to 20–50 km or more from the present coastlines, as a result of the large rise in global sea levels over the past 20 ky (60) (Fig. 2 and Fig. S4). As discussed in *Archaeology*, the theoretical rationale underlying this coastal colonization model is that the expanding groups would be able to maintain a closely similar range of both coastal habitats and their associated range of exceptionally rich, diverse, and economically reliable marine food resources (fish, shellfish, crustaceans, sea mammals, sea birds, etc.) (60). They thus minimized the need for new economic and technological adaptations as they moved from one coastal location to another—in effect a process of repeated "beach hopping" from west to east, driven by steadily increasing population numbers and almost certainly facilitated by the use of boats or other watercraft (17, 60). This implies that the discovery of the initial founder settlements of the earliest modern human groups in South Asia, or in the intermediate regions of southern Arabia and the Persian Gulf, will be dependent on the development of effective techniques of underwater exploration of the kind that are currently being developed along the coasts of the Red Sea (60). The clear prediction of the model presented here is that such explorations will eventually reveal traces of the initial modern human settlements in South Asia, in association with African-derived microlithic technologies, extending back to at least ~50 ka.

This model receives further support from genetic analyses of Indian mtDNA (*Genetics*). The genetic estimates for the earliest arrival predate substantially the first major demographic expansion signatures from mtDNA in South Asia, shown by Bayesian skyline plots (Figs. S2 and S3) to take place 45–50 ka for the minor haplogroup R and 37–43 ka for the major haplogroup M. This reflects both the rapid proliferation of different subclades of the haplogroup M lineage from ~40 ka onward and a simultaneous increase in the numbers of directly dated microlithic industries in India over the same time range (2). In addition, the regional skyline plots for haplogroup M show progressively more recent founder ages and expansion times moving from the east of India into the interior—possibly reflecting the easier penetration into the eastern Indian interior via the many river valleys (including the Ganges and its tributaries) that flow into the east Indian coast (Figs. S1, S3, and S4). These expansion signatures correlate much more closely with the current radiocarbon-dated appearance of the microlithic industries in the interior areas of India, bridging the gap between the first arrival of modern humans and current archaeological visibility. The expansion of the initial coastal founder populations into the sharply contrasting environments and associated food resources within the Indian interior would inevitably have required the development of a range of new economic, and probably social, adaptations to these new and unfamiliar environments (2, 5), requiring significant lengths of time (probably several millennia) to develop—as recently proposed in relation to the analogous Australian evidence for a potentially substantial time gap between the initial colonization of the continent and the earliest archaeological evidence for the settlement of the Australian interior (17). Following the initial out-of-Africa dispersal, there could of course have been further, secondary dispersals northwards into the central or northern regions of Asia, possibly dispersing via the eastern coastline of the Red Sea, or within the Persian Gulf region.

Conclusion

We find no evidence, either genetic or archaeological, for a very early modern human colonization of South Asia, before the Toba eruption. All of the available evidence supports a much later colonization beginning ~50–55 ka, carrying mitochondrial L3 and Y chromosome C, D, and F lineages from eastern Africa, along with the Howiesons Poort-like microlithic technologies (see above and *Genetics* and *Archaeology*). We see no reason to believe that the initial modern human colonization of South and Southeast Asia was distinct from the process that is now well documented for effectively all of the other regions of Eurasia from ~60 ka onward, even if the technological associations of these expanding populations differed (most probably for environmental reasons) between the eastern and northwestern ranges of the geographical dispersal routes.

How far one can make a case for potentially much earlier expansions (in mtDNA terms, pre-L3) from Africa into adjacent areas of Asia is a separate issue, for which the current evidence remains more debatable (*Archaeology*). The skeletal evidence from Skhul and Qafzeh in Israel (Fig. 2) demonstrates that for a limited period around 100–120 ka, populations of anatomically modern form dispersed from northern Africa into the immediately adjacent areas of the Levant (at the extreme northern limit of the East African Rift Valley system), apparently in response to an episode of sharply increased humidity, alongside other elements of Afro-Arabian fauna (18, 25). As discussed in *Archaeology*, the same case can be made (with rather less confidence) for the western parts of the Arabian peninsula at around the same time, on the basis of the distinctive forms of "Nubian" technology of presumed (although still not demonstrably so) northeast African origins (61) (*Archaeology*). With this precedent in mind, one could suggest that the same, or a similar, dispersal, could have carried these intrusive African populations farther to the east, conceivably as far as India, and potentially well before the Toba eruption (5).

However, this scenario encounters major problems on both archaeological and genetic grounds. The archaeological evidence initially advanced to support an earlier (pre-Toba) dispersal of African-derived populations to southern Asia has since been withdrawn by the author responsible for the original lithic analyses, who now suggests that they are most likely "the work of an unidentified population of archaic people" (ref. 11, p. 26). Meanwhile, the genetic evidence outlined earlier indicates that any populations dispersing from Africa before 74 ka would predate the emergence of the mtDNA L3 haplogroup, the source for all known, extant maternal lineages in Eurasia (8, 28) (Fig. 5). The size of the mtDNA database is very substantial: currently there are almost 13,000 complete non-African mtDNA genomes available, not one of which is pre-L3. One would therefore need to postulate the complete extinction of these earlier, non-L3 lineages over a vast region of Asia, from the Near East to southern India (a distance of at least 5,000 km), despite the populations in question belonging to anatomically modern *Homo sapiens* form, for which intermixture and interbreeding with the subsequently dispersing L3-carrying groups would presumably have been inevitable and widespread. The present lack of any discernible evidence for these pre-L3 lineages in any surviving Eurasian population or for any similarly ancient Y chromosome lineages (8, 9, 14, 15, 30) argues against substantial intermixture with earlier resident groups and poses a final obstacle to the hypothesis of an early, pre-Toba modern human colonization of South Asia.

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