



How old are the oldest *Homo sapiens* in Far East Asia?

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There is abundant genetic and paleontological evidence supporting the African origin of our species. At some point in its evolution, *Homo sapiens* spread out of Africa into Eurasia, replacing or partially absorbing local populations of other hominin forms. Ultimately, it colonized regions where no humans had ever lived before. Although extant humans display some physical variations resulting from adaptation to local conditions and isolation, they all share a recent African ancestry. How many times, when, and why this dispersal out of Africa occurred have been a matter of continuous debate in the field of paleoanthropology. In the past decade, research efforts have intensified in Far East Asia to elucidate the timing of the arrival of our species and have produced several notable publications. In PNAS, Sun et al. (1) question the dating of some of the foremost Chinese hominin sites that have been central to these discussions. They also raise important questions about the way the archeological and fossil records in this region can be interpreted.

The initial dispersal of our species out of Africa seems to be mostly driven by environmental changes. In the course of the last half million years, our planet experienced spectacular climatic fluctuations. In Africa, contrasting with a broad trend of growing aridity, humid pulses of several millennia periodically turned large portions of the Sahara into huge surfaces of savannas crossed by a network of rivers and lakes sometimes the size of Germany. Importantly, these “green Sahara” episodes also affected the Arabian Peninsula (2), and African populations that were adapted to this type of biotope likely expanded into these newly inhabitable territories. The earliest undisputable traces of our species in Asia are found at the margin of Africa, in the southern Levant 177,000 to 194,000 y ago (3), but paleogenetics provides signals of possibly older contacts between African populations and Neandertals peopling the western part of Eurasia (4, 5). However, the main phase of *H. sapiens* expansion started 50,000 y ago or a little before. By then, social,

cultural, and demographic changes made groups of hunter-gatherers of African origins able to colonize totally new environments at the expense of local archaic groups. In the midlatitudes, they were already present before 45,000 y ago in eastern Europe (6). They also rapidly expanded eastward up to 57° northern latitude in Siberia (7), and along a “northern route” avoiding the Himalayan range, they may have reached Mongolia and northern China (8).

In the south, the central issue is whether the expansion of our species across tropical Asia was just the continuation of its early arrival in southwest Asia or resulted from a much later phase of dispersal along a so-called “southern route.” Unfortunately, with the noticeable exceptions of China and Java Island, the hominin fossil record in this part of the world is very slim and often simply nonexistent. Therefore, one must generally rely on indirect arguments based on population genetics and archeology. Dating the diversification of present-day lineages of mitochondrial DNA—a part of our genome maternally transmitted—supports a single and rapid dispersal of all ancestral non-African populations less than 55,000 y ago (9). However, it has often been argued that pioneer groups could have been totally replaced by later demographically dominant waves and thereby, left no genetic trace in extant populations. As for archeology, in the absence of skeletal remains, it is difficult to ascertain the biological nature of the makers of particular types of artifact assemblages. This is particularly true when clear connections with sites where human fossils are represented cannot be established. Australia is of special interest as one assumes that no other hominins than recent forms of *H. sapiens* peopled the continent. One site from Australia’s north (Madjedbebe) yielded archeological material dated to 65,000 y ago (10). If accepted, this age inevitably implies an older peopling of Southeast Asia. Still, the site is not considered compelling by some (11), and unless it documents a failed early colonization of Australia,

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Fig. 1. The Tam Pà Ling cave in northeast Laos is one of the many examples of dissolution cavities open in the tower karsts of tropical and subtropical Asia. Generally, these types of sites have complex sedimentary histories. In this case, however, more than 6 m of deposits seem to represent a rather continuous accumulation documenting the last 70,000 y or so. They trapped remains of some of the oldest representatives of *H. sapiens* in this part of the continent. Image credit: Fabrice Demeter (Lundbeck Foundation GeoGenetics Centre, Copenhagen, Denmark).

its age is difficult to reconcile with the genetic evidence (9, 12).

Sites from central and south China with human remains in datable contexts are particularly relevant to this discussion. China has a long research tradition in paleolithic archeology and human paleontology, and the wealth of its fossil record is in sharp contrast with that of surrounding countries. In several sites, fossils anatomically close to extant humans were unearthed and claimed to document a very early occurrence of our species in the region. Among the first discoveries, one should mention the well-preserved skull of Liujiang found in 1958 near Tongtianyan (Guangxi) with other human bones by farmers collecting fertilizer in a cave. Despite these problematic contextual circumstances, the dating of different layers of flowstone in the cave suggested a minimum age of 68,000 y for these remains and potentially, an even much greater antiquity (13). When formed of calcite with few impurities, solid flowstones represent an ideal material to apply a very reliable dating method (“U series”) based on the known speed of decay of uranium trapped at the time of mineral deposition. Other presumed early *H. sapiens* were found in the course of organized excavations in subtropical China, and the dating by U series of flowstones covering them has been extensively used to support unexpectedly old

geological ages for these fossils. The discoveries at the caves of Zhiren (14, 15) and Luna (16) in Guangxi, Huanglong (17) in Hubei, and Fuyan (18) in Hunan are among the most notable. All these hominins have been claimed to be older than 70,000 y and sometimes even older than 100,000 y. These finds are primarily represented by teeth morphologically indistinguishable from recent dentitions, but at Zhireng cave, a mandible fragment displaying a mix of modern and more primitive features was also described.

The “law of superposition” is a basic axiom of geology and archeology according to which, in a stratigraphic series, the lower layers are the oldest and are covered by younger deposits. If this principle is easy to apply in undistorted sedimentary basins, in caves, there are a number of situations where it is more difficult. Deep caves are generally formed by water circulation through soluble rocks such as limestones. In these underground networks, water circulation is also the main agent of transport and filling, depositing carbonated concretions and bringing sediments from the outside. As the intensity of water circulation in the network largely depends on climatic conditions, through time, deep caves typically witness an alternation of erosive and depositional phases with some periods of rest. At times, depressions can be cut into existing

deposits and refilled with younger material ending up at a greater depth. Fossils and archeological objects of any age can be reworked, transported, and redeposited away from their initial context. Solid deposits like cemented flowstones can resist erosion, while underlying older but softer sediments can be taken away and later replaced with younger deposits. In caves, deciphering the site formation processes is therefore as critical as obtaining absolute dates from different kinds of samples. A textbook case of these complications is offered by the Liang Bua cave (Flores) where the replacement date of *Homo floresiensis*, a locally evolved diminutive hominin of the island, by *H. sapiens* populations on their way to Australia had to be revised from 18,000 to 50,000 y ago (19).

By using several dating methods including ancient DNA analysis on human teeth in three of the above-mentioned sites (Luna, Huanglong, and Fuyan) and two other similar sites (Yangjiapo and Sanyou caves, Hubei), Sun et al. (1) demonstrate a common pattern in all these caves. Ancient flowstones of diverse ages but generally formed around 100,000 y ago top sediments that can be of any possible age but are obviously not in primary position. These underlying sediments are reworked and include mammal bones and sometimes human remains that can be directly dated by the radiocarbon method to ages much younger than those of both the flowstones and the sediments. In fact, none of these finds are older than 30,000 y, and often, they date to only a couple of millennia ago.

Confirming the doubts raised by other scholars (20), these results seriously challenge some of the current arguments supporting

the occurrence of *H. sapiens* in east Asia before 70,000 y ago. If we put aside the caves from central and south China, we are left with only two sites in Southeast Asia that yielded *H. sapiens* remains possibly close to this age and deserve scrutiny. In the cave of Tam Pà Ling (Laos) (Fig. 1), several modern looking mandibular and cranial fragments were found in a thick stratigraphy that provided a series of coherent dates (21). The oldest anatomically significant specimen comes from a layer dated with two variants (optically stimulated luminescence and infrared stimulated luminescence) of a method that assesses the time of last exposure of sediments to daylight. Technical issues suggest the age of 48,000 y produced by the former is underestimated. The latter indicated an antiquity of 70,000 y but with a very large uncertainty. In Sumatra, at the cave of Lida Ayer, two human teeth were assigned to an age between 73,000 and 63,000 y ago (22), but they were found in 1880, and one can legitimately question their original context. To date, therefore, one can speculate that our species possibly reached east Asia before 55,000 or 50,000 y ago but maybe not much before.

Once more, we learn that whenever possible, the direct dating of hominin remains by radiocarbon and now by paleogenetics is essential. Furthermore, if ages established by so-called absolute dating methods seem to have the whole weight of hard science behind them, at the same time all these methods do not offer the same level of reliability and accuracy. Ultimately, in archeology like in other sciences, only coherence of the results obtained by different methods and replication of the observations can guarantee the validity of our models.

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