The earliest modern human colonization of Europe

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The expansion of modern humans over the planet is one of the most spectacular events in the course of human evolution. During millions of years, distinctive forms of hominins evolved in parallel and sometimes coexisted in the same regions. Between 60,000 and 40,000 y ago, one species expanded out of its African birthplace and replaced all others. The Neanderthals are the best-known archaic humans to go extinct at this time. In PNAS, Lowe et al. (1) resolve pending issues surrounding the mechanism of this evolutionary drama. Their study also fuels an increasing number of questions on the antiquity of the modern human colonization of Eurasia.

Scenarios accounting for the demise of the Neanderthals are much debated. For some, their replacement resulted from intrinsic biological and behavioral differences with our species (2). For others, external causes precipitated their decline at the time of modern human expansion. Of these, climatic disasters are most often envisioned (3) but a mega-volcanic eruption (4), and even an inversion of the magnetic field resulting in a brutal increase of deleterious radiation (5), have also been proposed. Epidemics devastating Neanderthal populations represent an intermediate category of explanations (6). Crucial to demonstrating any of these scenarios is the establishment of accurate chronologies for each region and their synchronization on a continental scale.

For this time period, archeologists mostly use the decay of the radioactive ^{14}C isotopes in organic matter to assess the ages of sites and human remains. Other methods are less precise or are not easily applied in archeological contexts. However, ^{14}C isotopes virtually disappear from bones and charcoal more than 50,000 y old, which makes the application of this technique increasingly delicate beyond 40,000 y. Only recently have some improvements in the pretreatment of the dating samples (7), and in the conversion to calendar dates (8), started to produce reliable ^{14}C dates for this crucial time period.

A dramatic volcanic eruption surpassing anything known in the historical record took place in central Italy 39,300 y ago. It is known as the Campanian Ignimbrite (CI) eruption. Atmospheric circulation carried clouds of ash all over the eastern Mediterranean, and the products of the eruption reached regions as distant as southwestern Russia. The mineralogical nature of these ash deposits allows this event to be very accurately dated. It also has a distinctive chemical signature that can be recognized, even when the ashes themselves are invisible to the naked eye in sediments. This has allowed Lowe et al. (1) to accurately synchronize the chronologies of deposits between very distant areas and to compare archeological sequences in caves with more detailed geological sections in open air sites, lake, or even sea deposits. This method provides a precise chronological marker to relate cultural changes and human occupations to well-recorded environmental changes.

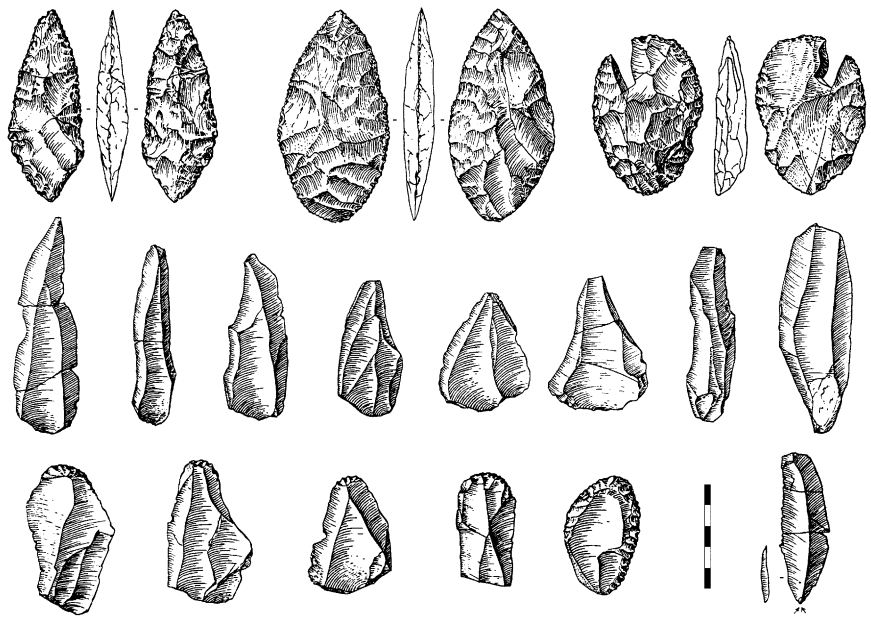

Fig. 1. The Bohunician and other initial Upper Paleolithic assemblages of Eurasia display the retention of Levallois blank production (*Middle*) and a large use of various types of points (*Top*). This pattern is reminiscent of North African assemblages predating the out-of-Africa exodus of modern humans. Upper Paleolithic-style tools such as end-scrapers and burins (*Bottom*) complete this toolkit. Unfortunately, at most Bohunician sites, sediments do not allow the preservation of human remains, bone tools or body ornaments. (Scale bar: 5 cm.) [Reprinted with permission from ref. 20 (Copyright 2008, Elsevier).]

This large-scale study demonstrates that lithic assemblages of the Upper Paleolithic associated with the spread of modern humans predate the CI eruption in several European sites. This applies in particular to some forms of the Aurignacian, a lithic industry with sophisticated art objects and musical instruments (9) and associated with modern human remains (10). This observation falsifies the hypothesis proposing that the CI eruption itself, and/or the short but intense cooling episode known as Heinrich event 4, which started 40,000 y ago, could have triggered the cultural changes or population replacements witnessed around this time. Rather, it suggests that the main threat to indigenous populations were the modern human invaders themselves and not environmental hazards.

Several recent studies based on ^{14}C dating also support this conclusion. They assign diagnostically modern human remains (11), as well as early Aurignacian assemblages (9), to a period predating the CI and Heinrich event 4. This raises the question of when exactly the first modern humans reached Europe. A major difficulty in answering this question comes from the extreme scarcity of human remains from this time period. The makers of most lithic assemblages dated to between 50,000 and 40,000 y ago remain unknown.

Long have archeologists recognized the Aurignacian as a proxy for the first expansion of modern humans into Europe. Thus, discussions of a possible chronological overlap between these modern invaders and late Neanderthal populations have

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mostly focused on the age of the first Aurignacian (12). An early form of this assemblage, the Protoaurignacian, spread over southern Europe from Ukraine to southwestern France. Among other novelties, Protoaurignacian people produced flint bladelets that armed light projectile weapons. This assemblage is rooted in a broader group of lithic industries known all over central and western Eurasia and characterized by an explosion in the use of these artifacts. In the Levant, this group is represented by the early Ahmarian, beginning 47,000 y ago. Although virtually no human remains have been discovered in the European Protoaurignacian, the Ahmarian yielded a fully modern immature human skeleton at the site of Ksar Akil (Lebanon) (13).

The limit between the Middle Paleolithic, produced in Europe by Neanderthals, and the genuine Upper Paleolithic, produced by modern humans, is not always clear-cut. So-called "transitional assemblages" separate the Middle and Upper Paleolithic in many sites. These assemblages display tools reminiscent of those found in the later Upper Paleolithic, and often technological features inherited from the Middle Paleolithic, e.g., the Levallois technique of blank production (Fig. 1). This mix has suggested to many that a local evolution of late Neanderthals took place and resulted in these innovations, either under the influence of the modern newcomers (14) or independently (15). Indeed, in western Europe, one of these transitional assemblages, the Châtelperronian, has yielded Neandertal remains (14, 16), and a Neandertal origin is also suspected for others (17).

Lithic assemblages of the Upper Paleolithic associated with the spread of modern humans predate the CI eruption in several European sites.

However, modern humans might also have produced transitional assemblages. Before they left Africa, they indeed used technologies such as Levallois. Assemblages identified in southwestern Asia as "initial" Upper Paleolithic display this combination of older methods to produce blades alongside remarkable novelties. At the Üçağızlı I cave (Turkey), these include shell beads and bone artifacts (18). A series of initial Upper Paleolithic assemblages spread from the Levant (Emirian) to Bulgaria (Bacho-Kirian) and Moravia (Bohunician). This may well document an early episode of modern colonization of Europe as old as 50,000 y (19, 20).

Such an early arrival of modern humans in western Eurasia better matches what we know of the dispersal of modern humans to the east, into Asia and toward Australia. It also implies a patchy pattern of colonization. Modern humans would have initially been unsuccessful in replacing the Neanderthals throughout the entire extension of their geographical domain. On a continental scale, there was likely some overlap in time between the two groups. Thus, any innovation observed in the Neandertal world around or after 50,000 y ago may have resulted from cultural diffusion triggered by modern population influxes into western Eurasia (14, 21).

Although modern human expansions out of their African cradle were irresistible, a full understanding of the complex processes that drove indigenous humans and portions of the local fauna to extinction still stands ahead of us. Confirming the biological identity of the makers of the initial Upper Paleolithic in eastern and central Europe is crucial to this understanding.

1. Lowe J, et al. (2012) Volcanic ash layers illuminate the resilience of Neanderthals and early modern humans to natural hazards. *Proc Natl Acad Sci USA* 109: 13532–13537.
2. Klein RG (2009) *The Human Career: Human Biological and Cultural Origins* (Univ Chicago Press, Chicago), 3rd Ed.
3. Tzedakis PC, Hughen KA, Cacho I, Harvati K (2007) Placing late Neanderthals in a climatic context. *Nature* 449: 206–208.
4. Golovanova LV, et al. (2010) Significance of ecological factors in the Middle to Upper Paleolithic transition. *Curr Anthropol* 51:655–691.
5. Valet JP, Valladas H (2010) The Laschamp-Mono lake geomagnetic events and the extinction of Neanderthal: a causal link or a coincidence? *Quat Sci Rev* 29: 3887–3893.
6. Wolff H, Greenwood AD (2010) Did viral disease of humans wipe out the Neandertals? *Med Hypotheses* 75:99–105.
7. Talamo S, Richards MP (2011) A comparison of bone pretreatment methods for AMS dating of samples >30,000 BP. *Radiocarbon* 53:443–449.
8. Reimer PJ, et al. (2009) Intcal09 and marine09 radiocarbon age calibration curves, 0–50,000 years cal BP. *Radiocarbon* 51:1111–1150.
9. Higham T, et al. (2012) Testing models for the beginnings of the Aurignacian and the advent of figurative art and music: The radiocarbon chronology of Geißenklösterle. *J Hum Evol* 62:664–676.
10. Wild EM, et al. (2005) Direct dating of Early Upper Palaeolithic human remains from Mladec. *Nature* 435:332–335.
11. Benazzi S, et al. (2011) Early dispersal of modern humans in Europe and implications for Neanderthal behaviour. *Nature* 479:525–528.
12. Zilhão J, d'Errico F (2000) La nouvelle « bataille aurignacienne ». Une révision critique de la chronologie du Châtelperronian et de l'Aurignacien ancien. *Anthropologie* 104:17–50.
13. Bergman CA, Stringer CB (1989) Fifty years after: Egbert, an early upper Palaeolithic juvenile from Ksar Akil, Lebanon. *Paléorient* 15:99–111.
14. Hublin J-J, Spoor F, Braun M, Zonneveld F, Condemi S (1996) A late Neanderthal associated with Upper Palaeolithic artefacts. *Nature* 381:224–226.
15. d'Errico F (2003) The invisible frontier. A multiple species model for the origin of behavioral modernity. *Evol Anthropol* 12:188–202.
16. Lévêque F, Vandermeersch B (1980) Découverte de restes humains dans un niveau castelperronien à Saint-Césaire (Charente-Maritime). *C.R. Acad Sc Paris* 291:187–189.
17. Semal P, et al. (2009) New data on the late Neandertals: Direct dating of the Belgian Spy fossils. *Am J Phys Anthropol* 138:421–428.
18. Kuhn SL, et al. (2009) The early Upper Paleolithic occupations at Uçağızlı Cave (Hatay, Turkey). *J Hum Evol* 56:87–113.
19. Müller UC, et al. (2011) The role of climate in the spread of modern humans into Europe. *Quat Sci Rev* 30:273–279.
20. Richter D, Tostevin G, Škrdla P (2008) Bohunician technology and thermoluminescence dating of the type locality of Brno-Bohunice (Czech Republic). *J Hum Evol* 55:871–885.
21. Nigst PR (2012) *The Early Upper Palaeolithic of the Middle Danube Region* (Leiden Univ Press, Leiden, The Netherlands).