

ANCIENT DNA

Out-of-Anatolia: Cultural and genetic interactions during the Neolithic expansion in the Aegean

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West Anatolia has been a crucial yet elusive element in the Neolithic expansion from the Fertile Crescent to Europe. In this work, we describe the changing genetic and cultural landscapes of early Holocene West Anatolia using 30 new paleogenomes. We show that Neolithization in West Anatolia was a multifaceted process, characterized by the assimilation of Neolithic practices by local foragers, the influx of eastern populations, and their admixture, with their descendants subsequently establishing Neolithic Southeast Europe. We then coanalyzed genetic and cultural similarities across early Holocene Anatolian and Aegean Neolithic villages using 58 material culture elements. Cultural distances among villages correlate with their spatial distances but not with their genetic distances after controlling for geography. This suggests that cultural change was often decoupled from genetically visible mobility.

The emergence of sedentism and agriculture in West Eurasia was the outcome of a long social and economic process known as the Neolithic Transition, which started in Southwest Asia around 11,000 to 7000 BCE (1, 2). Paleogenomic studies suggest that this transition largely emerged through cultural exploration by local foraging communities in different parts of the Neolithic core zones, namely the Levant, Upper (North) Mesopotamia, Zagros, and Central Anatolia, and their cultural exchanges, accompanied by limited levels of interregional mobility and genetic mixing (3–6). By contrast, the spread of Neolithic lifestyles and practices into Central and South Europe after 7000 BCE was driven by large-scale mobility, possibly originating from the Aegean (7–11). Cultural interactions prevailed in other areas, such as Baltic foragers adopting pottery (12) or North African indigenous populations embracing agriculture through cultural exchanges with Neolithic communities (13).

West Anatolia (i.e., the East Aegean coasts, East Marmara, and the Pisidian Lakes District) has a distinct trajectory in this picture. By ~9000 BCE, Aceramic or Pre-Pottery Neolithic (PPN) villages of sedentary

foragers had emerged in the Fertile Crescent, including in Central Anatolia. However, despite a lack of major geographic borders between Central and West Anatolia, there were no comparable developments detected in West Anatolia between ~9000 and 7000 BCE apart from evidence for modest interregional contacts attested from changes in the stone tool assemblages (14–17). In fact, we know little of West Anatolia during the initial Holocene, except that its coastal areas (East Aegean and Marmara littorals) harbored forager groups with cultural connections to neighboring regions, as inferred from their stone tools (18–22).

The mid-8th millennium (mil.) BCE was a demographic turning point in the Neolithic development of Anatolia, when an episode of eastern mobility possibly of Upper Mesopotamian origin arrived in Central Anatolia (23, 24). By the early 7th mil. BCE, villages with pottery, full-scale agriculture, and animal husbandry were being established across the Fertile Crescent. These agricultural villages, along with their material culture package, then continued to spread beyond the core zones into West Anatolia and, eventually, into Europe (2, 8, 25).

The emergence of multiple “Neolithic package” elements across West Anatolia between ~7000 and 6000 BCE has been interpreted as indicative of large-scale emigration from the Southwest Asian Neolithic core zones (26). Analysis of archaeological data has suggested various possible routes of human mobility or interaction that linked the emergence of West Anatolian Neolithic with its neighbors: one originating in Central Anatolia and/or Upper Mesopotamia and reaching Central-West Anatolia through Southwest Anatolia, another reaching North-west Anatolia directly from Central Anatolia and/or Upper Mesopotamia, and also a maritime route connecting the Levant with Southwest or Central-West Anatolia (2, 27, 28). These models of West Anatolian demographic transformation have not yet been tested owing to the scarcity of representative paleogenomes.

Another hypothesis is that the Neolithization of West Anatolia involved only local groups (29) or cultural interactions and possibly admixture between eastern migrants and local foragers (2, 16, 30–33). This idea is inspired by the remarkable variation in their cultural preferences and subsistence strategies observed among 7th mil. BCE West Anatolian sites. Some villages had simple round huts, whereas other communities built more sophisticated rectangular buildings; some groups herded sheep and cattle, whereas others relied heavily on fishing; some villages used obsidian from Greece, some used obsidian from Central Anatolia, and some used nearly no obsidian but only local flint (2, 27, 31, 34–41). These patterns have often been interpreted as the varying impact of local hunter-gatherers on different communities, but this notion has also not yet been tested genetically.

Overall, both the material culture and the limited paleogenomics data remain equivocal as to the origins of the West Anatolian Neolithic (29). The genetic affinities of the populations who lived in West Anatolia and the Aegean before 7000 BCE and how and whether they might have changed during the establishment of Neolithic settlements remain unclear. To what extent the observed material culture variation among Anatolian and Aegean Neolithic villages after 7000 BCE was driven by large-scale mobility and admixture processes (as was the case with the European Neolithic transition) is also unclear. In this work, we address these points using new paleogenomes from West and Central Anatolia, which allow us to describe the pre-~7000 BCE population of West Anatolia, its continuity and transformation through

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