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Crossing the Wallace Line: A New Look at the First Australians in Laili Cave

Biology * DNA * Genetics

The Biogeographical Barrier of Wallacea and the Laili Paradigm Shift

The Pleistocene colonization of Sahul -- the combined paleocontinent uniting Australia, New Guinea, and Tasmania -- marks the first time Homo sapiens crossed deep-water oceanic trenches beyond the continental shelves of Africa and Eurasia.[1] Between the Asian mainland extension of Sunda and the landmass of Sahul lies the biogeographical transition zone of Wallacea, bounded on the west by the Wallace Line.[1] Even during the Last Glacial Maximum, when eustatic sea levels dropped by up to 120 meters, deep marine straits such as the Lombok Strait isolated the Wallacean islands, restricting terrestrial placental mammals and requiring deliberate watercraft navigation for hominin dispersal.[2][3]

For decades, archaeologists debated two primary maritime corridors into Sahul: a Northern Route traversing Sulawesi and the Moluccas into the Bird's Head Peninsula of West Papua, and a Southern Route stepping through the Lesser Sunda chain (Java, Bali, Lombok, Flores, Alor, and Timor) onto the northwestern Australian shelf.[1][6] Because Madjedbebe rock shelter in Northern Australia indicates human presence by ~65,000 years ago (65 ka), proponents of the Southern Route long predicted equally ancient occupation layers in Timor-Leste.[7][8] However, high-resolution excavations at Laili Cave in northern Timor-Leste have overturned this expectation: the site documents an abrupt "arrival signature" of modern humans at ~44,000 years ago directly atop archaeologically sterile sediments dating from 59,000 to 54,000 years ago.[8][9] This 20,000-year chronological gap demonstrates that Timor was not the primary gateway for the initial 65 ka peopling of Sahul, pointing instead toward the Northern Route for initial entry followed by a major secondary demographic expansion across southern Wallacea around 45 ka.[2][9]

Stratigraphy, OSL Chronometry, and the "Arrival Signature" at Laili Cave

Situated 4.3 kilometers inland overlooking the Laleia River in northern Timor-Leste, Laili Cave acted as a protected limestone sediment trap throughout the Late Pleistocene.[3][12] To test whether earlier colonizers preceded the ~42,000 BP layers previously recorded at nearby Jerimalai, researchers from the Australian National University, Flinders University, and Griffith University excavated Laili down to its basal fluvial silts.[8][9][14]

The deposit reveals three distinct chronostratigraphic units established through paired Radiocarbon (14C) dating of charcoal and marine shell and single-grain Optically Stimulated Luminescence (OSL) analysis of ~17,000 individual quartz grains:[9][10][13]

* The Sterile Basal Unit (59,000 - 54,000 BP): Yellow-brown sandy silts deposited

when the cave was geologically open and accumulating sediment, yet containing zero stone artifacts, anthropogenic charcoal, or processed fauna.[8][9]

* The Late Pleistocene "Arrival Signature" (44,600 - 11,200 BP): Rather than a gradual "colonization flicker" of transient campfires, human occupation begins abruptly at ~44,000 BP with dense, charcoal-darkened living floors packed with thousands of chert lithics, burnt animal bones, and transported marine shellfish -- indicating settlement by a large, permanent maritime community.[9][13]

* The Terminal Pleistocene and Holocene (11,200 - 0 BP): Dense shell middens, late-phase ceramics, and introduced domesticates.[3]

Reevaluating Migration Corridors and Archaic Hominin Encounters

The absence of human occupation in Timor between 59 ka and 44 ka reshapes regional dispersal models.[2] Least-cost pathway modeling and inter-island visibility analyses indicate that the initial 65 ka colonizers of Sahul most likely traveled via the Northern Route from Sulawesi through the Moluccas into West Papua, traversing continuous equatorial rainforest habitats before subsequent waves back-migrated or swept southward through the Lesser Sundas ~45,000 years ago.[6][9][11][16]

| Archaeological Site | | Geographic Location | | Earliest Secure Date | | Stratigraphic & Paleogenetic Significance | | Source |

| Madjedbebe | | Arnhem Land, N. Australia | | ~65,000 BP | | Earliest documented human occupation in Sahul; precedes Timor sites by ~20 kyr | | [7] |

| Ivane Valley | | Papua New Guinea Highlands | | ~49,000 BP | | Early high-altitude rainforest foraging and pandanus exploitation in northern Sahul | | [16][28] |

| Liang Bua | | Flores, Lesser Sundas | | ~46,000 BP (H. sapiens) | | Extinction of Homo floresiensis (~50 ka) followed by modern human hearths and chert tools | | [5][26][27] |

| Laili Cave | | Northern Timor-Leste | | ~44,000 BP | | Abrupt "arrival signature" directly overlying sterile 59-54 ka OSL-dated basal sediments | | [9][13] |

| Jerimalai | | Eastern Timor-Leste | | ~42,000 BP | | Pelagic tuna fishing, shell fishhooks, and pigment-stained Nautilus shell ornaments | | [14][15][23] |

This ~46-44 ka southern expansion pulse coincides closely with the disappearance of archaic hominins in Island Southeast Asia. On neighboring Flores, revised stratigraphy at Liang Bua places the extinction of the diminutive Homo floresiensis (~1 m tall, ~380 cc cranial capacity) at ~50,000 BP, shortly before modern humans appear with fire-making and chert technologies at ~46,000 BP.[5][17][18][27] High-resolution genetics of modern Flores pygmies confirm that insular short stature evolved independently via natural selection, with zero evidence of DNA introgression from H. floresiensis.[5][20] Conversely, modern Indigenous populations across Sahul, Wallacea, and the Philippines (such as Papuans and the Ayta Magbukon) carry up to 5-6% archaic gene flow from deeply diverged "Southern Denisovan" populations encountered as H. sapiens crossed Sunda and northern Wallacea.[1][19][21]

Broad-Spectrum Island Adaptation and Miniaturized Lithic Technology

Zooarchaeological and lithic analyses from Laili Cave illustrate how these 44 ka colonists rapidly mastered an oceanic island depauperate in large terrestrial game:[12][13]

* Endemic Giant Rodent Hunting and Forest Refugia: Lacking native ungulates, Laili hunters heavily harvested endemic murine rodents, including extinct giant rats of the genus Coryphomys weighing up to 6 kg.[3][4][12] Stable carbon (13C) and oxygen (18O) isotope analyses of rodent tooth enamel demonstrate persistent closed C3 tropical forest cover around Laili throughout glacial oscillations.[22]

* Maritime Foraging and Pelagic Voyaging: Laili inhabitants transported marine mollusks, crabs, and sea urchins 4.3 km inland from the coast, while contemporary deposits at Jerimalai preserve bone and shell fishhooks alongside fast-swimming pelagic scombrids (tuna) and energy-dense Canarium and Aleurites (candlenut) plant remains.[3][13][14][22]

* Bipolar Chert Reduction and Symbolic Culture: Working river-terrace chert nodules via anvil-supported bipolar reduction, Laili toolmakers produced miniaturized sharp flakes exhibiting silica "gloss" from processing bamboo and rattan into composite projectiles and traps (with abundant thermal "pot-lid" fractures reflecting hearth burning across dense living floors).[13][23][24] Worked Oliva and pigment-stained Nautilus shell beads alongside ground red ochre confirm a thriving symbolic material culture.[3][15][25]

A Multi-Wave Maritime Tapestry

By pairing single-grain OSL dating with microstratigraphy, the excavation of Laili Cave transforms the colonization of Wallacea and Sahul into a multi-wave maritime history.[8][9] While the earliest pioneers likely entered Sahul ~65,000 years ago via West Papua, the abrupt 44,000-year-old arrival signature at Laili records the expansion of specialized seafarers who colonized southern Wallacea, displaced archaic island hominins, and laid the cultural foundations of Island Southeast Asia and Oceania.[2][11][13]

Updates... (Nov 21, 2026): Replaced the encyclopedia entry on Homo floresiensis with Brown et al. (2004, Nature), added verified publication dates across all references, and converted journal links to canonical DOI URLs.

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