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MIGRATIONS, MULTIETHNICITY, ADAPTATION, AND ASSIMILATION: AN ARCHAEOGENETIC STUDY OF THE MEGALITHIC CULTURE IN TELANGANA

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Abstract

Megalithic cultures of peninsular India have often been interpreted through models emphasizing singular migrations, homogeneous ethnic identities, or externally introduced cultural traditions. This study re-examines the megalithic culture of Telangana through an integrated archaeogenetic framework to reassess population history, multiethnicity, and cultural interaction during the Iron Age. Ancient DNA analysis of human remains recovered from securely excavated megalithic burial contexts at Khammam and Pullur reveals multiple mitochondrial haplogroups, including M3, U4, and M30, indicating a biologically heterogeneous population structure. These genetic patterns reflect strong indigenous continuity within South Asia alongside limited incorporation of external genetic elements through long-term interaction networks.
Archaeological evidence points to mortuary traditions that transcended biological differences and promoted social integration across megalithic communities. The absence of correlation between genetic lineages and burial architecture underscores that megalithic identity was socially constructed rather than biologically determined. The combined evidence supports a model of gradual mobility, episodic gene flow, environmental adaptation, and cultural assimilation, contributing to a nuanced understanding of protohistoric population dynamics in South India.

Keywords: Megalithic Culture; Archaeogenetics; Ancient DNA; Migration; Multiethnicity; Cultural Assimilation; Iron Age; Telangana; Population Structure; Mortuary Practices

Introduction

Megalithic monuments represent one of the most widespread and enduring archaeological traditions of the prehistoric world. Characterized by monumental stone-built burial structures and associated ritual practices, the megalithic phenomenon extends across large parts of Europe, Africa, and Asia, suggesting complex patterns of cultural transmission, regional adaptation, and social expression. In the Indian subcontinent, megalithic remains are predominantly concentrated in peninsular India and are generally dated to the Iron Age, forming a crucial component of protohistoric cultural developments (Singh, 2008, pp. 242–255).

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Fig. 1. Map of Telangana depicting the study area and the megalithic sites of Khammam and Pullur selected for sample collection.

Among the peninsular regions, Telangana occupies a position of particular archaeological importance due to the density, diversity, and architectural variability of its megalithic monuments. Stone circles, cists, pit burials, cairns, menhirs, dolmens, and dolmenoid cists—often associated with sarcophagi, anthropomorphic statues, stone vats, and burial goods such as pottery, skeletal remains, and iron objects—reflect a complex mortuary tradition that integrates technological innovation with symbolic and social significance. (Milton, 2022, pp. 380–390; Kennedy, 1975, pp. 1–27). Despite extensive documentation and excavation since the nineteenth century, the cultural identity and population history of the megalithic communities of Telangana remain subjects of debate. Traditional archaeological approaches, relying primarily on typology, stratigraphy, and material culture analysis, have been insufficient to resolve fundamental questions regarding the origins, mobility, and ethnic composition of these communities.

Central to these debates are issues concerning migration, multi-ethnicity, biological adaptation, and processes of cultural assimilation. The structural similarities observed in megalithic architecture and burial customs across wide geographical areas raise questions about whether these patterns reflect large-scale population movements, shared ideological systems, or localized adaptations within a broadly interconnected cultural sphere (McIntosh, 1983, p. 203). Conversely, regional variations in monument form and burial assemblages suggest the presence of diverse social groups negotiating identity and tradition within specific ecological and cultural landscapes (Grau Mira, 2016, pp. 110–124).

Recent advances in archaeogenetics have transformed the study of past human populations by enabling direct investigation of genetic ancestry, population structure, and biological adaptation through ancient DNA analysis (Reich, 2018, pp. 1–22; Renfrew, 2000, pp. 3–12). When integrated with archaeological context, archaeogenetic data offer powerful insights into patterns of migration, gene flow, and social interaction often invisible in the material record alone (Basu et al., 2003, pp. 2277–2290; Kivisild et al., 2003, pp. 313–332). Long-term human–environment interactions also shaped subsistence, mobility, and settlement patterns in South Asia (Fuller et al., 2016).In South Asia, however, the

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application of archaeogenetic methods to protohistoric contexts remains limited, and megalithic populations are still underrepresented in genetic studies.

This study adopts an archaeogenetic perspective to examine the megalithic culture of Telangana, focusing on migration dynamics, multiethnic composition, environmental adaptation, and cultural assimilation. By correlating genetic evidence with mortuary practices and material culture, the paper seeks to move beyond typological interpretations and contribute to a more integrated understanding of the biological and cultural identities of megalithic communities. In doing so, the study situates the Telangana megaliths within broader discussions of population history and cultural interaction in peninsular India and the wider protohistoric world.

Archaeological and Environmental Context of the Telangana Megaliths

The megalithic culture of Telangana developed within a varied ecological and geomorphological landscape shaped by the Deccan Plateau and its associated river systems. The region is traversed by major rivers such as the Godavari and the Krishna, along with their tributaries including the Munneru, Manjira, Kinnerasani,and Pranahita, which provided stable water resources, fertile alluvial tracts, and natural communication corridors. Archaeological surveys indicate that megalithic sites are frequently situated along river terraces, gently sloping uplands, and transitional ecological zones, suggesting a strategic selection of landscapes that balanced agricultural potential, pastoral mobility, and ritual visibility (Milton, *Megalithic Culture* 46-91).

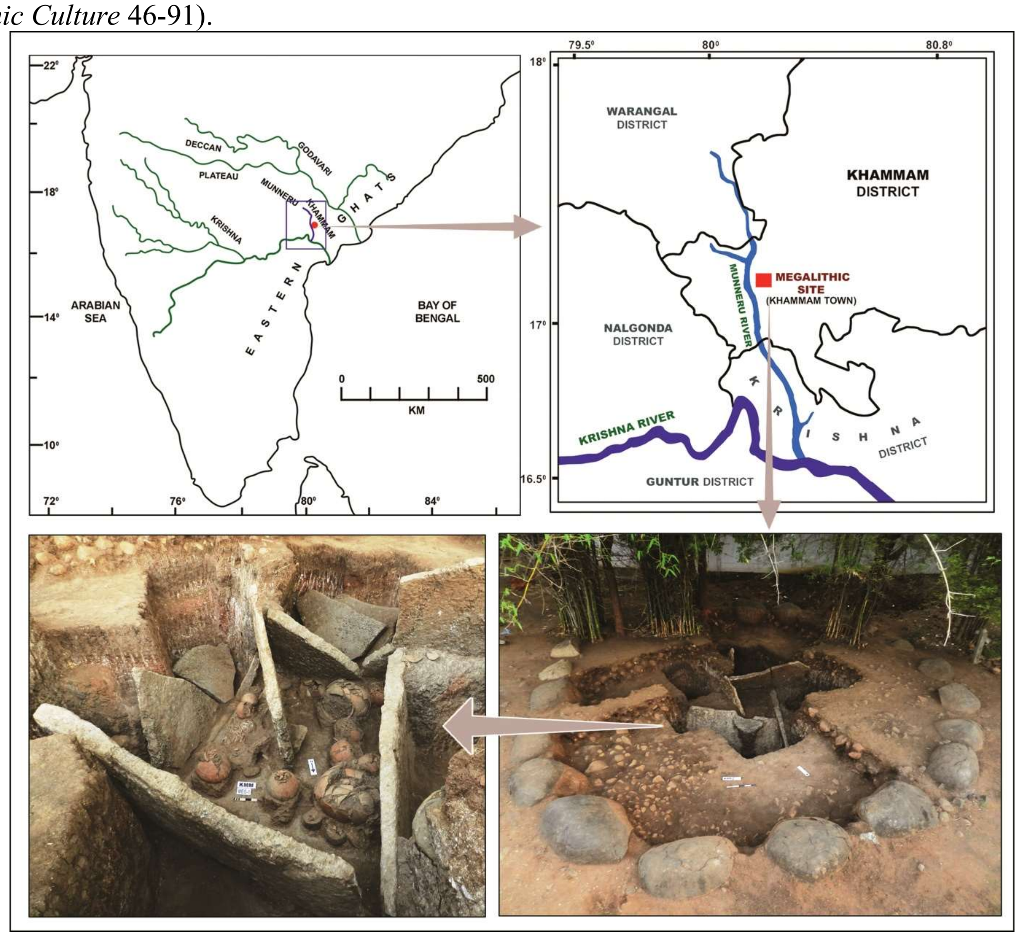

Figure 2. *Stone-circle megalith enclosing a centrally placed cist chamber exposed during controlled excavations at Khammam, on the left bank of the Munneru River, a tributary of the Krishna.*

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Figure 3. *Pit burial at Pulluru sealed with a large capstone, representing a non-cist megalithic mortuary form documented during excavation.*

Megalithic burial sites in Telangana exhibit substantial architectural diversity, reflecting both regional preferences and localized expressions of mortuary practice. Common monument types include stone circles with or without cairn packing, slab-built cists, dolmens, dolmenoid cists, and composite structures. Archaeological research has revealed that these monuments often occur in clustered cemeteries, indicating sustained ritual use of specific landscapes over extended periods. Variability in construction techniques, stone selection, and monument size suggests differential labour investment and possible social stratification within megalithic communities (Milton, *Megalithic Culture* 93-128).

The association of megalithic monuments with iron artefacts constitutes one of the defining characteristics of the South Indian Iron Age. In Telangana, burials frequently contain iron weapons such as swords, spearheads, and daggers, alongside pottery and agricultural implements including sickles and plough-related tools. The presence of such artefacts indicates not only technological proficiency but also the symbolic importance of iron in mortuary contexts, where objects associated with warfare, subsistence, and status were selectively deposited with the dead. These assemblages underscore the integration of economic life, social identity, and ritual practice in megalithic society (Milton, *Megalithic Culture* 109-114).

Ceramic assemblages recovered from megalithic contexts in Telangana further illuminate cultural practices and regional interactions. Typical pottery includes black-and-red ware, black burnished and polished ware, red slipped ware, and coarse utilitarian vessels. The standardized forms and firing techniques observed across multiple sites suggest shared technological traditions, while localized stylistic variations point to regional identities and workshop-level production. The occurrence of non-local ceramic types and exotic materials such as semi-precious stone beads indicates participation in wider exchange networks linking the Deccan with coastal and inland regions (Milton, *Megalithic Culture* 114).

Environmental and subsistence evidence from peninsular India suggests that megalithic communities practiced mixed economies combining agriculture, pastoralism, and foraging. Archaeobotanical studies demonstrate the cultivation of millets, pulses, and, in some regions, rice, reflecting adaptation to diverse ecological conditions. Zooarchaeological data

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indicate the management of cattle, sheep, and goats, alongside continued exploitation of wild resources. These subsistence strategies allowed megalithic populations to maintain flexible settlement patterns and sustain long-term occupation of varied landscapes, including the semi-arid tracts of Telangana. (Morrison 358–373, Milton, *Megalithic Culture* 188-246).
Taken together, the archaeological and environmental evidence indicates that the megalithic culture of Telangana emerged through long-term interaction between human communities and their ecological settings. Burial monuments, material culture, and subsistence practices reflect adaptive strategies rather than abrupt cultural intrusions. This contextual framework provides an essential foundation for integrating archaeogenetic data, allowing biological evidence to be interpreted within well-defined cultural, environmental, and economic parameters.

Materials and Methods: Archaeogenetic Study

Figure 3. *Skull and associated skeletal remains preserved inside a stone-circle cist burial at Khammam; the* ***petrous temporal bone****, noted for high DNA preservation, was selected for archaeogenetic study.*

Human skeletal remains from securely excavated megalithic burial contexts in Telangana were analyzed to assess genetic affinities and population history. The study includes (i) a cremated petrous bone sample from Stone Circle I, excavated in 2012 at SR & BGNR Government Arts & Science College, Khammam, and (ii) A petrous bone sample and skeletal remains were selected from two separate pit cairn-circle type of megalithic burials excavated in 2015 at Pullur, Medak District. The specimens were derived from well-documented archaeological contexts, ensuring stratigraphic reliability and chronological integrity. Laboratory-based analyses, including ancient DNA extraction and AMS radiocarbon dating, were conducted in controlled facilities at the Centre for Cellular and Molecular Biology (CCMB), Hyderabad, in coordination with Beta Analytic Laboratories. The integration of archaeological context with biomolecular analysis provides a robust framework for investigating population structure, migration patterns, and biological adaptation among the megalithic communities of Telangana.

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Figure 4. *Skeletal remains recovered from a pit burial context at Pulluru;* ***bone material from the burial assemblage*** *was sampled for ancient DNA analysis.*

Figure 5. *Skeletal remains from a pit burial at Pulluru;* ***one cranial element (petrous temporal bone)*** *was selected for archaeogenetic analysis, representing an additional aDNA sample from the site.*

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Ancient DNA Extraction

Ancient DNA (aDNA) extraction refers to the recovery of DNA from biological specimens dating from several centuries to several millennia old and provides direct evidence for past genetic variation and biological change through time. The development of paleogenetics has also highlighted methodological challenges such as molecular degradation, contamination, and enzymatic misincorporation, which necessitate stringent laboratory protocols and cautious interpretation of results (Paabo, 1985; Stiller et al., 2006). Approximately 1 g of bone powder was obtained from each specimen. Prior to powdering, the bone surfaces were mechanically cleaned using sandpaper to remove potential contaminants, followed by drilling. The powdered bone was dissolved in 4.0 ml of extraction buffer consisting of 0.5 M EDTA (pH 8.0), 0.5% SDS, and 500 µg/ml proteinase K. Samples were incubated overnight at 55 °C in a shaking incubator, followed by an additional 12 h incubation at 37 °C to ensure effective decalcification and protein digestion.

DNA purification was carried out using the QIAquick PCR Purification Kit (Qiagen). This method selectively captures DNA fragments larger than 100 bp and smaller than 10 kb, while excluding salts, proteins, and free nucleotides. Given the highly degraded nature of ancient DNA and the small size of target amplification regions (typically 100–250 bp), this protocol is suitable for aDNA recovery. DNA fragments exceeding 10 kb are more likely to represent postmortem microbial contamination or modern DNA rather than authentic ancient genetic material (Paabo 1985; Stiller et al. 2006).

The extraction solution was centrifuged at 10,000 g for 10 min, and 4.0 ml aliquots of the supernatant were transferred to 50 ml tubes and mixed with five volumes of QIAquick PB buffer. Aliquots of 750 µl were loaded onto QIAquick columns and centrifuged at 12,800 g for 1 min. This step was repeated until the entire extract passed through the column. The bound DNA was washed with 750 µl of QIAquick PE buffer and eluted using 40 µl of elution buffer.

DNA Quantification and Fragment Analysis

Quantification of extracted DNA was performed using real-time quantitative PCR (qPCR) prior to amplification. A Human DNA Quantification Kit was used, with 2 µl of DNA in a final reaction volume of 10 µl, following the manufacturer's protocol. Real-time PCR amplification, data collection, and analysis were carried out using the ABI Prism 7500 Sequence Detection System and SDS software (version 1.0; Applied Biosystems, Foster City, USA). All necessary precautions were taken to minimize contamination with exogenous DNA.

Further assessment of DNA quantity and fragment size distribution was conducted using the Agilent 2100 Bioanalyzer (Agilent Technologies). One microlitre of genomic DNA was loaded onto a size-selection and quantifier chip following the manufacturer's guidelines. Due to the advanced degradation of the bone samples, the majority of DNA fragments were observed within the 100–200 bp range, consistent with authentic ancient DNA. Size selection and quantification were subsequently used to guide PCR primer design.

Mitochondrial DNA Analysis and Haplogroup Assignment

Mitochondrial DNA (mtDNA) analysis was employed to determine genetic affinity, owing to the higher copy number and improved preservation of mtDNA in ancient skeletal material. Haplogroup assignments were derived from mtDNA sequence data and are summarized below:

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Genetic affinity of skeletal materials excavated from megalithic sites in Telangana

Library ID	Individual ID	Archaeological ID	Location	Damage (%)	mtDNA Coverage	Haplogroup
S3414.E1L1	I3414	KHM	Khammam	34.7	10	M3
S3415.E1L1	I3415	PULL	Pullur	4.9	83	U4
S3416.E1L1	I3416	PULL	Pullur	40.4	22	M30

Genetic origin of observed haplogroups and their geographical distribution

Haplogroup	Genetic Affinity
M3	Present throughout India, but mostly concentrated in the North West of India.
U4	Observed at 2–6% in most regions of Europe. Highest frequencies are reported among the Chuvash (16.5%), Bashkirs (15%), and Tatars (7%) of the Volga-Ural region of Russia, followed by Latvia (8.5%), Georgia (8.5%), Serbia (7%), and southern Daghestan (6.5%). U4 is generally more common in Baltic and Slavic countries and around the Caucasus.
M30	Detected in Palestinians, likely due to recent gene flow from India. Also found in Eastern Yemeni populations, Upper Egypt, and Kesra (Tunisia). In Hadramawt (Yemen), M30 individuals constitute approximately 7.5% of the total population.

Haplogroup M3 is widely distributed across India, with a higher frequency reported in north-western India and among Dravidian-speaking tribal populations of southern India, including the Chenchu and Koya of Telangana and Andhra Pradesh. Haplogroup U4 is predominantly associated with populations of eastern Europe, the Baltic region, and the Caucasus, while haplogroup M30 exhibits a broader geographic distribution extending from India to parts of West Asia and North Africa, reflecting gene flow beyond the Indian subcontinent (Basu et al. 2003; Kivisild et al. 2003; Thangaraj et al. 2006).When integrated with radiocarbon dating evidence, the genetic data support the antiquity of the megalithic remains and indicate occupation of the Khammam region from at least the sixth century BCE. The results provide a methodological foundation for assessing migration, multiethnicity, adaptation, and assimilation within the megalithic populations of Telangana.

Genetic Affinities and Ancestral Diversity

Archaeogenetic analysis of human remains recovered from megalithic burial contexts in Telangana reveals a complex pattern of genetic diversity indicative of heterogeneous population composition. Mitochondrial DNA (mtDNA) sequences obtained from cremated and inhumed skeletal material demonstrate the presence of multiple maternal haplogroups rather than a single dominant lineage. This genetic variability suggests that megalithic communities were not biologically homogeneous but comprised individuals drawn from diverse ancestral backgrounds, reflecting sustained interaction and gene flow across regions rather than isolated population development (Basu et al., 2003, pp. 2278–2280; Kivisild et al., 2003, pp. 313–332).

Samples from the megalithic site at Khammam yielded mtDNA haplogroup M3, a lineage widely distributed across the Indian subcontinent with particularly high frequencies among northwestern Indian populations and several Dravidian-speaking tribal groups of southern India. The presence of M3 in the Khammam assemblage indicates genetic continuity within South Asia while also pointing to broader regional connectivity extending beyond the immediate local landscape

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(Kivisild et al., 2003, pp. 319–321; Thangaraj et al., 2006, pp. 151–153). Radiocarbon dates associated with these remains situate the burial contexts firmly within the mid–first millennium BCE, corroborating their attribution to the Iron Age megalithic horizon.

Genetic material recovered from megalithic burials at Pullur (Medak District) revealed additional haplogroups, including U4 and M30. Haplogroup U4, although relatively rare in South Asia, is more commonly associated with populations of Eastern Europe, the Volga–Ural region, and parts of the Caucasus. Its detection within a Telangana megalithic context suggests limited but significant long-distance genetic inputs, potentially mediated through gradual migration, interregional interaction networks, or marital exchanges rather than mass population movements. Haplogroup M30, by contrast, represents a South Asian lineage with evidence of historical gene flow extending westward into regions such as the Near East and northeastern Africa, underscoring the bidirectional nature of prehistoric population movements (Thangaraj et al., 2006, pp. 155–157).

Patterns of mtDNA damage and fragment length distributions are consistent with authentic ancient DNA signatures, supporting the reliability of haplogroup assignments. Quantitative PCR results indicate low but sufficient endogenous DNA preservation, typical of protohistoric skeletal material from tropical environments. The co-occurrence of multiple haplogroups within geographically proximate burial sites highlights the absence of strict biological segregation among megalithic communities and aligns with archaeological evidence for shared mortuary practices across diverse social groups.

Importantly, no direct correlation is observed between specific burial types—such as stone circles, cists, or dolmenoid structures—and particular genetic lineages. This pattern indicates that monument form and mortuary architecture were shaped predominantly by shared cultural conventions rather than by biological ancestry. The uniformity of funerary practices across genetically diverse individuals suggests that megalithic monuments functioned as integrative social institutions, emphasizing collective identity over exclusive ethnic or biological distinctions.

Taken together, the genetic evidence supports a model of population history characterized by strong regional continuity alongside episodic external inputs and sustained interaction among neighboring groups. Rather than reflecting abrupt migration events or population replacement, the archaeogenetic data point toward gradual mobility, admixture, and cultural assimilation within a biologically heterogeneous yet socially cohesive megalithic landscape.

Discussion: Multiethnic Interaction and Cultural Assimilation

The archaeogenetic evidence derived from megalithic burial contexts in Telangana provides a critical lens through which long-standing debates on migration, ethnicity, and cultural interaction in protohistoric South India can be reassessed. Traditional archaeological interpretations have often oscillated between diffusionist models, which attribute megalithic traditions to intrusive populations, and indigenist frameworks emphasizing local cultural development. The recovery of multiple mitochondrial haplogroups within spatially confined and chronologically coherent burial clusters challenges both extremes, instead pointing toward a socially integrated yet biologically heterogeneous population structure. These findings underscore the necessity of moving beyond monocausal explanations and toward models that emphasize long-term interaction, demographic fluidity, and cultural negotiation.

The presence of haplogroup M3 in the Khammam assemblage strongly supports arguments for regional continuity within the Deccan and broader South Asian landscape. M3 is widely regarded as an ancient and autochthonous South Asian lineage, with deep roots among tribal and marginal populations across both northwestern and southern India. Its appearance within Iron Age megalithic contexts suggests that locally established populations were not merely passive recipients of new cultural practices but were active agents in the development, transmission, and reproduction of megalithic traditions. This evidence weakens hypotheses that view megalithism as the cultural imprint of externally

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arriving groups and instead highlights the role of indigenous demographic substrates in shaping protohistoric social formations (Basu et al., 2003, pp. 2279–2280; Kivisild et al., 2003, pp. 320–322).

At the same time, the identification of haplogroup U4 in the Pullur burial assemblage introduces a significant external dimension to the population history of the region. U4 is most commonly associated with populations of Eastern Europe, the Volga–Ural zone, and regions adjacent to the Caucasus, and its occurrence in peninsular India remains rare. Rather than indicating a direct or large-scale migration from these distant areas, the presence of U4 is more plausibly interpreted as the result of low-level gene flow operating over extended periods. Such gene flow may have been mediated through intermediary populations, exchange networks, or gradual mobility associated with pastoralism, trade, or marriage alliances. This pattern aligns well with archaeological evidence for expanding interregional connectivity during the late prehistoric and early historic periods, when South Asia increasingly participated in wider Eurasian interaction spheres.

The detection of haplogroup M30 further complicates simplistic narratives of inward migration. While M30 is a South Asian lineage, its documented distribution beyond the subcontinent—particularly in parts of the Near East and northeastern Africa—suggests outward population movements from South Asia as well. Its presence within the megalithic dataset reinforces the interpretation of population dynamics as bidirectional rather than unilinear. Together, the coexistence of M3, U4, and M30 within a single cultural horizon points to a mosaic pattern of ancestry, shaped by both local continuity and selective incorporation of external genetic elements (Thangaraj et al. 155–57).

Crucially, the genetic diversity documented in this study does not correspond to variation in burial architecture or monument form. Stone circles, cists, dolmenoid structures, and associated funerary assemblages do not map onto specific genetic lineages. This lack of correlation strongly suggests that megalithic mortuary architecture was governed by shared cultural norms rather than by biological ancestry or ethnic exclusivity. Such decoupling of genetic identity from material expression supports broader theoretical perspectives that conceptualize ethnicity as a socially constructed and context-dependent phenomenon, rather than a fixed biological category (Renfrew, 2000, pp. 11–12). Megalithic monuments, in this sense, functioned as cultural signifiers of participation within a shared ideological system rather than as markers of descent.

Processes of cultural integration and assimilation therefore emerge as central to understanding the social dynamics of megalithic Telangana. Participation in standardized mortuary rituals, monument construction, and symbolic practices would have provided powerful mechanisms for integrating individuals and groups of diverse biological origins into cohesive social units. These shared practices likely facilitated the negotiation of identity, reinforced social cohesion, and enabled the incorporation of newcomers without necessitating the erasure of biological diversity. Megalithic landscapes can thus be interpreted as arenas of social synthesis, where cultural affiliation outweighed genetic differentiation.

Environmental adaptation also played a significant role in shaping these integrative processes. The varied ecological zones of Telangana—ranging from riverine plains to upland plateaus—would have encouraged flexible subsistence strategies and mobility patterns. Such ecological contexts are conducive to sustained interaction among neighboring groups, fostering demographic mixing while simultaneously promoting shared cultural responses to environmental constraints. The persistence of megalithic traditions over several centuries suggests that these adaptive strategies were both resilient and socially embedded.

In sum, the combined archaeological and archaeogenetic evidence favors a model of population history characterized by gradual mobility, multiethnic coexistence, and long-term cultural convergence. Megalithic culture in Telangana should not be understood as the material signature of a single migrating population, nor as a purely local phenomenon isolated from wider interaction networks. Instead, it represents a dynamic and integrative tradition shaped by indigenous continuity, episodic external inputs, environmental adaptation, and sustained processes of cultural assimilation operating across generations.

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Conclusion

This study demonstrates that the megalithic culture of Telangana cannot be adequately explained through interpretive models that privilege singular migrations, biologically homogeneous populations, or exclusive cultural origins. By integrating archaeogenetic evidence with detailed archaeological analysis, the research reveals a complex social landscape characterized by biological diversity, regional continuity, and sustained cultural interaction. The identification of multiple maternal haplogroups—M3, U4, and M30—from megalithic burial contexts at Khammam and Pullur clearly indicates that these communities comprised individuals of heterogeneous ancestry, reflecting both deep-rooted indigenous lineages and limited incorporation of external genetic inputs.

Archaeological evidence further reinforces this interpretation. The diversity of megalithic monument types, their spatial organization, and the consistency of associated mortuary assemblages suggest that shared funerary practices functioned as inclusive cultural frameworks rather than expressions of biologically defined or ethnically exclusive groups. The absence of any systematic correspondence between genetic lineages and specific burial forms underscores the decoupling of biological ancestry from material and ritual expression, emphasizing that megalithic identity was shaped primarily through socially constructed cultural norms.

Taken together, the combined genetic and archaeological data support a model of population history defined by gradual mobility, episodic gene flow, and long-term processes of cultural assimilation, rather than abrupt migration or population replacement. Environmental adaptation, intergroup interaction, and participation in shared ritual practices appear to have played central roles in fostering social cohesion within a biologically diverse population. Megalithic traditions in Telangana thus emerge as dynamic, integrative systems that accommodated diversity while maintaining cultural continuity over several centuries.

Future research incorporating expanded ancient DNA datasets, improved chronological resolution through high-precision dating, and broader regional comparisons across peninsular India will further refine our understanding of protohistoric population dynamics. An archaeogenetic perspective, when firmly embedded within archaeological context, offers a powerful interdisciplinary framework for reconstructing population history, social identity, and cultural trajectories in Iron Age South Asia and beyond.

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