Proceedings of the EUROPEAN ACADEMY of Sciences & Arts PEASA

*Proceedings of the European Academy of Sciences & Arts, 2022;1:17*

*Open Access. Online.*

**doi: 10.4081/peasa.17**

**Topic: Academic Engegement**
**Category: Natural Sciences/ Interdisciplinary**

# THE ANCIENT DNA OF THE N.E. MEDITERRANEAN/EURO-ASIAN CULTURES AND THE POSITION OF THE MYCENAEAN GREEKS AMONG THE FIRST CULTURES

**Ioannis Liritzis**

*Editor-in-Chief of PEASA, Dean of Class IV (Natural Sciences) European Academy of Sciences & Arts,*
*St.-Peter-Bezirk 10*
*A-5020 Salzburg, Austria*
*(ionnis.liritzis@euro-acad.eu)*

**Received: 02/08/2022**
**Accepted: 27/08/2022**

**ABSTRACT**

Alerted by a trio of papers that appear in the journal SCIENCE today (26th August 2022) I present briefly the essential findings with some extension on the hot subject of ancient DNA studies over all the World but mainly the SE Mediterranean and Euro-Asian neighborhood. These three papers summarize the results of a remarkable Ancient DNA project and involving 202 co-authors. These studies draw on published archaeogenetic records and new DNA analysis of 727 individuals who lived during the Copper and Bronze Ages. These people populated the "Southern Arc," a swath of land connecting Europe to West Asia through Anatolia including coastal Levant. The findings are critically discussed in the wider frame of aDNA results, the migration and mobilities for the past about 8000 years ago and linked with the non-linear evolution processes of ancient cultures. Particular emphasis here is given to the 2016 expedition at the Late Helladic site of Kastrouli near Delphi in Greece, that contribute to these studies.

*KEYWORDS: Yamnaya, Minoans, Greeks, Anatolians, Balkans, non-linear, Indo-Europeans, tomb, archaeological excavation, civilization, archaeogenetic*

## 1. INTRODUCTION

Some of the first civilizations[1] emerged and flourished in the "Southern Arc", a geographical area stretching from the Caucasus and the Levant, through Anatolia and the Aegean to the Balkans forming a bridge between Europe and Asia (Fig.1).

In this arc, various ancient human civilizations formed and spread. These civilizations, which have either been lost to history or have survived to this day, are not only the legacy of the inhabitants of the present-day region they left behind but have had a profound effect on human civilization as a whole.

**Figure 1. The sketched approximate southern Arc (Greece-Balkans-Black Sea-Anatolia-Caucasus-Armenia-Levant)**

At present, our knowledge of the people of many of these cultures, their movements, their admixtures, and their languages is fragmentary. Paleogenetic research can shed new light on the lives of people in earlier societies and the spread and diversification of their languages. However, addressing big questions about the past with Paleogenetics requires large-scale systematic research that fills many of the current geographic and temporal gaps with which we can piece the puzzle together (Kristiansen 2022)

Three scientific papers were published on 27th August simultaneously in the world-class and one-of-the-top journals the *Science* (Lazaridis et al.,2022 a,b,c)[2] and report genome-wide data from the skeletal remains of 727 different ancient individuals - more than doubling the volume of ancient DNA data from this SE Mediterranean region (of the Southern Arc as it is called) and filling large gaps in the paleogenetic record. A team of researchers led by Ron Pinhasi at the Department of Evolutionary Anthropology and Human Evolution and Archaeological Sciences (HEAS) at the University of Vienna, Songül Alpaslan-Roodenberg at the University of Vienna, and Greek Iosif Lazaridis and David Reich at Harvard University—together with 202 co-authors—worked through their data to explore long-standing archaeological, genetic, and linguistic hypotheses. They presented a unique in the annals of science a systematic picture of the interconnected histories of the peoples in this region from the beginnings of agriculture (7th to 8th millennium BC) to late medieval times.

Being a part of the group of 202 researchers I present here below the discussion of the novel results of high historical value, which is based on a team's summary serving as a Press Release with some expansion on the Greek data. The current data contain a 'witness testimonials' for the ancient mobilities, generic affinities from admixtures, presenting important scientific development in the field of archaeogenetics and in relation to current understanding.

[1] We recognize that there is no universally recognized definition of "civilization". Culture is a term used to denote the manifestation of the manner in which we think, behave and act. Civilization refers to the process through which a region or society, outstretches an advanced stage of human development and organization (Botz-Bornstein 2012).

[2] You can download the papers from here:
https://www.dropbox.com/sh/25gnxe0ork988un/AAAH01hPo_uyhcfjfrkD2xXaa?dl=0

## 2. INTRODUCTION TO THE NEW MEASUREMENTS CONCERNING ANCIENT DNA IN RELATION TO THE ORIGIN AND SPREAD OF ANATOLIAN AND INDO-EUROPEAN LANGUAGES.

The genetic results concerning the Chalcolithic[3] and Bronze Age[4] periods, presented in the first of our three papers entitled «*The genetic history of the southern arc: a bridge between Western Asia and Europe*» (Lazaridis et al., 2022a), suggest that the homeland of the Indo-Eastern language family was in West Asia, with only minor dispersals of non-Eastern Indo-Europeans from the steppe. In the first stage, about 7,000-5,000 years before today, people originating from the Caucasus moved west into Anatolia and north into the steppe. Some of these people may have spoken ancestral forms of Anatolian and Indo-European language.

All spoken Indo-European languages can be traced back to the shepherds of the Yamnaya (or Yamna) steppe, descended from Caucasian hunter-gatherers and Eastern hunter-gatherers, who 5,000 years ago began a chain of migrations across Eurasia, connecting Europe in the west with China and India in the east. Their southern expansions into the Balkans and Greece and east along the Caucasus into Armenia left a mark on the DNA of the Bronze Age people of the region (Fig.2). As they expanded, the descendants of the Yamnaya pastoralists mixed differently with the local populations. The appearance of the Greek, Paleo-Balkan and Albanian (Indo-European) languages in Southeast Europe and the Armenian language in Western Asia was formed by Indo-European migrants from the steppe interacting with the locals (natives) and this can now be traced to different forms of genetic evidence[5].

In Southeast Europe, the Yamnaya impact was evident, and people of almost complete Yamnaya descent came soon after the Yamnaya migrations began. Fellow professor David Reich at Harvard University specifically states that: "*We find in Albania, Bulgaria, Croatia, Serbia people who genetically appear to have been transplanted from the steppe,*" and further he says that "*The connection is undeniable and as time passed, the newcomers merged with the natives, leaving more of their genetic imprint (origin) in the northern part of the Balkan Peninsula than in the south, but having a linguistic impact throughout.*"


[3] name derived from the Greek: χαλκός khalkós, "copper" and from λίθος líthos, "stone" or Copper Age and precedes the Bronze age.

[4] The Bronze Age, which spanned from around 3300 BC to 1200 BC, is known for its use of bronze, certain areas' adoption of writing, and other earliest elements of urban civilization. It either exchanged other goods for bronze from production centers abroad or made bronze by melting its own copper and alloying it with tin, arsenic, or other metals.

[5] In any case the coming from the Yamnaya culture has been considered as the last stage of the linguistic unity (Meier-Brugger 2013); and this hot topic has been reviewed by Rouard through an interdisciplinary approach if Indo-European languages stem from a trans-eurasian original language (Rouard 2022).

**Figure 2. Map of the Yamnaya culture, based on map printed at page 651 in Encyclopedia of Indo-European Culture, which was edited by J. P. Mallory and Douglas Q. Adams, and published by Taylor & Francis in 1997. Created: 31 October 2021 (CC BY-SA 4.0)**

No steppe connection can be established for the speakers of the Anatolian languages due to the absence of an eastern origin of hunter-gatherers in Anatolia, in contrast to all other areas where Indo-European languages were spoken.

Yamnaya herders also crossed the Caucasus about 4,000 years ago, and the Armenian plateau was a pocket of low but pervasive influence in western Asia. Fellow Greek Iosif Lazaridis, the team's statistician and member of Harvard University, specifically says, "*We often think of the Yamnaya as spreading around their home regions, but sometime around 4,500 years ago they were replaced on the steppe by a new people coming from the North Europe. Soon after, their descendants appear in Armenia, one of the few places where many men once were and still are directly descended from their paternal line from the Yamnaya people*". "*It's a very good coincidence*," says Iosif Lazaridis, "*Modern Armenians are literally the last male descendants of the Yamnaya people, who found a new home among the inhabitants of the Armenian plateau*".

Some of our most striking results are in the Southern Arc core region of Anatolia, where large-scale data paint a rich picture of change—and lack of change—over time.

"*Anatolia was home to diverse populations that came from both local hunter-gatherers and eastern populations from the Caucasus, Mesopotamia and the Levant*," says team collaborator Prof. Songül Alpaslan-Roodenberg of the University of Vienna, "*The people of Marmara region and Southeast Anatolia, the Black Sea and the Aegean region all had variants of the same ancestral species*" Alpaslan-Roodenberg continues. European or steppe ancestry was absent until the 1st millennium BC, but even then it was not obvious. To the surprise of our research team, a contrast was even seen between the people in the Urartian Kingdom of the Eastern Anatolia region of Turkey who did not have steppe origins, while their neighbors across their geographical border in Armenia did.

The absence of a steppe origin in Anatolia suggests that the spread of the Anatolian languages cannot be explained using the same mechanism of migrations from the steppe as with all other Indo-European languages. "*There is an idea that steppe migrants entered Anatolia from either the Balkans or the Caucasus, but if they were there, they were a drop in the bucket. The origin is from the Caucasus, and not from the steppe, which transformed Anatolia*", says Iosif Lazaridis.

In contrast to Anatolia's amazing imperviousness to steppe migrations, the southern Caucasus was affected many times, even before the Yamnaya migrations. "*I did not expect to discover that the Armenian Areni 1 cave of Chalcolithic[6] period individuals recovered 15 years ago in the excavation I co-supervised would come from gene flow from the north into areas of the southern Caucasus more than 1,000 years ago by the Yamnaya expansion, and that this northern influence would disappear in the region before reappearing a few millennia later. This shows that there is much more to be discovered through new excavations and fieldwork in the eastern parts of West Asia*," says Ron Pinhasi of the University of Vienna.

## 3. FROM THE RESULTS OF THE THREE PUBLICATIONS IN SCIENCE, HOW ARE THE FIRST AGRICULTURAL SOCIETIES POSITIONED AND WHAT ARE THEIR INTERACTIONS?

The answer to this issue essentially refers to our 2nd article titled: "*Ancient DNA from Mesopotamia suggests distinct pre-pottery and pottery Neolithic[7] migrations into Anatolia*" (Lazaridis et al., 2022b). These measurements sought to understand how the world's first Neolithic populations formed. Presents the first ancient DNA data for Neolithic pre-Pottery farmers from the Tigris side of northern Mesopotamia—both in eastern Turkey and northern Iraq—a major region of the origin of agriculture

It also presents the first ancient DNA from pre-ceramic period farmers (before 7000 BC) from the island of Cyprus, which witnessed the earliest maritime expansion of farmers from the eastern Mediterranean. In addition, it provides new data on early Neolithic farmers from the northwestern Zagros, together with the earliest data from Neolithic Armenia. By filling in these gaps, the co-authors could study the genetic history of these societies for which archaeological research has documented complex economic and cultural interactions, but has been unable to identify systems of admixture and interactions that leave no visible material traces. The

[6] The Late Chalcolithic (ca. 4,300–3,500 Cal BC) or ~6,000 years ago.

[7] The wide-ranging set of developments regarding "neolithic period" appear to have arisen independently in several parts of the world. It is seen about 12,000 years ago when the first developments of farming appeared in the Epipalaeolithic Near East (20,000-10,000 years BP) of nomadic hunters-gathers. Neolithic phase of Greek history begins with the spread of farming to Greece in 7000–6500 BC to ~3,200 BC. The Mesolithic in the Greek area covers a period from 11,000 BP to 6800 BC) (see, http://www.fhw.gr/chronos/01/en/index.html)

results reveal admixture of pre-Neolithic groups (before 7000 BC) related to Anatolian, Caucasian and Levantine hunter-gatherers and show that these early agricultural cultures formed a continuous ancestral substrate reflecting the geography of West Asia. The results also record at least two waves of migration from the heart of the *Fertile Crescent*[8] to the first Anatolian farmers.

"*The genetic results support a scenario of a web of pan-regional contacts among early agricultural communities. They also provide new evidence that the Neolithic transition was a complex process that did not just happen in one central region, from one core, but across Anatolia and the Near East*," says Ron Pinhasi.

"*The varied ancestral links between Pre-Pottery Neolithic groups across Anatolia, Mesopotamia and the Levant are consistent with archaeological research into long-distance Neolithic exchange networks, especially of exotic raw materials*," says my colleague Prof Songül Alpaslan-Roodenberg, whose natural anthropological research focuses on the early farmers of this region.

It is an indisputable fact that archaeogenetics, the scientific field of biomolecular archeology enables us to map the movements, migrations, and admixtures of people. Ancient DNA data, based on decades of research in physical anthropology, biology and archaeology, contribute to a qualitatively richer and more complete picture of the origins of the first farmers at least in the Southern Arc of the SE Mediterranean but more generally in other parts of the World, and the degree of complexity in the admixtures that led to the present genetic condition of the peoples.

The admixture as deduced from archaeogenetics presumes movements, migrations, due to several factors (mostly social, climatic, environmental disasters, and eventually economic and political sovereign); the latter causes have also been attested from textural, archaeological and geoarchaeological record and archaeometric analysis (e.g. early navigation in the Aegean to acquire obsidian from the island of Melos, as well as geoarchaeology in old cities and cultures, Laskaris et al.,2011 ; Liritzis et al., 2019; Westra et al., 2022).

## 4. WHAT ARE THE RESULTS OF OUR TEAM FOR THE HISTORICAL TIMES?

As said above, our research repositions and unravels the origin of the first agricultural societies in our wider region and establishes their interactions, during the prehistoric period.

The Historical times is dealt with our third article entitled: "*A genetic probe into the ancient and medieval history of Southern Europe and West Asia*" (Lazaridis et al., 2022c) which reveals how the polities of the ancient Mediterranean world retain contrasts originating in the Bronze Age, which however were associated with immigration. There were migrations, in the ancient Mediterranean world as we find migrants from different places in different regions. The basic structure had been formed by the Bronze Age, but then there was movement of people across the Mediterranean (such as Greek colonization, Orientalist colonization of Imperial Rome, and various extremes discussed in the paper).

Our analyses support the theory that the ancient "Mycenaeans"[9] of Greece can be modeled as a roughly 1-to-11 (9%) mixture of a Yamnaya-type steppe-derived population and an Aegean-like "Minoan" /Early Bronze Age, on average, but with an unknown earlier variant clarifying social aspects of this mixing process: "*The Mycenaean gene pool was not monolithic*," notes Iosif Lazaridis. Steppe ancestry was common, at low levels, among both elite and non-elite individuals. Some elite Mycenaean men have been traced back to steppe populations, but others, such as the "Warrior Griffin" in a tomb near ancient Pylos (discovered in 2015) from whom we recovered DNA, had no steppe ancestry at all "*We must imagine the steppe migrants as a population element that was integrated, both socially and genetically, into Aegean societies, and not as peoples who dominated them*".

The results also show that the ancestry of the people living around Rome during the Imperial period (1st century BC to 3rd century AD) was almost identical to that of the Roman/Byzantine people from Anatolia both in terms of average as well as in the manner of their variation, while the Italians[10] before the Imperial

[8] It is a crescent-shaped region in the Middle East, spanning modern-day Iraq, Syria, Lebanon, Israel, Palestine, Jordan, Egypt, along with the southeastern region of Turkey and the western regions of Iran, while some authors they also include Cyprus.

[9] The Mycenaeans settled all of mainland Greece up to Thessaly, and throughout the Aegean islands. There is evidence of extensive Mycenaean acculturation in Western Anatolia, Italy and Cyprus and trading relations with Egypt and the Near East. The Mycenaeans were literate and used for accounting purposes a syllabic script, Linear B, written in an early form of the Greek. They introduced this script into Crete after they occupied the island (Dickinson 1994).

[10] The Italians in and around Rome had begun to expand shortly after the founding of the republic in the 6th century BC, although it did not extend beyond the Italian peninsula until the 3rd century BC. The "Roman Republic" was not a nation-state in the modern sense, but a network of cities that were left to govern themselves. Back then, it was an "empire" but without an emperor. Imperial Rome/Italy as such started then from the 1st century BC. (Cornell 1995)

period had a very different distribution. This suggests that the Roman Empire in both its short-lived western part and its longer-lived Anatolian-centered eastern part had a diverse but similar population that plausibly drew significantly from pre-imperial Anatolian sources.

"*We knew from our previous research that the people living around Rome during the Imperial period were from different regions and that many were of Near Eastern origin*," says Ron Pinhasi, who co-led another scientific study by 2019 in the journal SCIENCE that studied ancient DNA data from Rome. "*But it was quite surprising to find such a specific and clear link (of the Italians) with Anatolia itself and not with other eastern parts of the Roman Empire such as the Levant*"

"*This finding is another example of how archaeogenetic results can provide a layer of information that is missing and cannot be obtained from other sources*," says my colleague Songül Alpaslan-Roodenberg from the University of Vienna.

## 5. THE GREEK CIVILIZATION HAS LAID THE FOUNDATIONS OF EUROPE. HOW DID THE BONE RESULTS FROM KASTROULI -THE MYCENAEAN[11] SITE AT DESFINA ACROSS DELPHI- CONTRIBUTED TO THE PROJECT WITH THE 202 RESEARCHERS?

First of all, I should note that the interdisciplinary project in Kastrouli began on my initiative, with the granting of a license by the Ministry of Culture, Greece, from 2016, where I formed the international interdisciplinary research team in which Prof. A. Sideris participated as appointed director of the archaeological excavation by the Ministry of Culture, and co-PI and financial sponsorship by the member of EASA Prof. T. Levy (Center for Cyber-Archaeology and Sustainability, Qualcomm Institute, University of California, San Diego, USA-University of California) with the participation of more scientists and University students, with whom we have written several articles in scientific journals.

Kastrouli is near Delphi southern Greece and seems to be a major center in the Mycenaean peripheral world. Several articles have been published which document its value (see www.kastrouli.org) (Levy et al, 2018; Sideris et al., 2017, Sideris & Liritzis 2018; Sideris 2022). Some selective few photos of the findings and the site are shown in Fig.3-8).

**Figure 3. Aerial photo of Kastrouli, Greece, by Drone (Dr D.Stefanakis, https://ucd.digia.gr/) and processing for ortho photo and AutoCAD (by Prof A.Gergopoulos, National Technical University of Athens), Scale: x15 meters.(Liritzis, I (2021) Kastrouli fortified settleme (Desfina, Phokis, Greece): a chronicle of research. SCIENTIFIC CULTURE, Vol. 7, No. 2, pp. 17-32, DOI: 10.5281/zenodo.4465472. For another version of aerial view at Kastrouli taken by Helium balloon, see: Howland, Tamberino, Liritzis, Levy (2022), Digital Deforestation: Comparing Automated Approaches to the Production of Digital Terrain Models (DTMs) in Agisoft Metashape. Quaternary 2022, 5, 5. https://doi.org/10.3390/quat5010005). Credit by Ministry of Culture & Sports, Greece.**

[11] The Mycenaeans, named after the type-site of that civilization, Mycenae in Peloponnese, Southern Greece


**Figure 4. The high stemmed conical kylix from Building 1 restored. (see, Sideris 2022). Credit by Ministry of Culture & Sports, Greece.**


**Figure 5. Figurine Psi tomb A, locus 121, sq.6/19, 2016 (K109) (see Fig 20 Sideris, A., I. Liritzis, B. Liss, M.D. Howland, T.E. Levy (2017). At-risk cultural heritage: new excavations and finds from the Mycenaean site of Kastrouli, Phokis, Greece. Mediterranean Archaeology and Archaeometry 17 (1), pp. 271-285; Bratitsi M., I. Liritzis, A. Vafiadou, V. Xanthopoulou, E. Palamara, I. Iliopoulos, N. Zacharias (2018). Critical assessment of chromatic index in archaeological ceramics by Munsell and RGB: novel contribution to characterization and provenance studies. Mediterranean Archaeology & Archaeometry 18(2), pp. 175-212 (DOI: 10.5281/zenodo.1297163). Credit by Ministry of Culture & Sports, Greece.**

**Figure 6. UP: The hydria & the oenochoe during the excavation of Building 1, 2017 (Photo A. Sideris, Sideris& Liritzis, 2018). LOWER: The objects after the first maintenance (conservation-restoration) work (under the supervision of Dr P. Manti, Ionion University, Greece).**


**Figure 7. Tom Levy and Ioannis Liritzis at the annual presentation of the summer findings from the Kastrouli excavation (2016) in the central square of the Desfina town. This Project embraced the local society and students making them communicant with the progress of the research.**

**Figure 8. The first team in 2016 (colleagues, students, workers) besides the helium balloon for aerial photos.**

As I mentioned above, the expansion of the pastoralists of the Yamnaya steppe about 5,000 years ago, invaded and imprinted its origin in Eastern Europe in the west, in the Balkans and Greece, and in the east - across the Caucasus to Armenia. However, they did not affect Anatolia – they bypassed it. Eastern hunter-gatherer ancestry drops to less than 4% in Mycenaean Greece where Kastrouli is located. Thus, our data from Kastrouli help document the final process of Yamnaya extension in the southern arc.

Ancient texts, archeology and now the archaeogenetic record – AncDNA – provide interdisciplinary data (a first-of-its-kind scientific team effort in archaeology) to help us understand how ancient cultures formed and spread. The excavation at Kastrouli contributes directly to this section of the trio of recent articles in archaeogenetics in the journal SCIENCE.

Ancient DNA analyses resolve the question of the origin of the Late Bronze Age population by strongly supporting one of two previously proposed hypotheses - that the Mycenaeans were the result of admixture of steppe migrants bearing little resemblance to the Yamnaya and a Minoan substrate, rather than the alternative hypothesis of substratum admixture resembling Neolithic Anatolia with Armenian populations from the east (Lazaridis et al., 2017). The fact that the Mycenaeans can be modeled as a ~1:10 mixture of a Yamnaya-like steppe-derived population of about 9% and an Aegean and Early Bronze Age Minoan population of about 91% shows the small contribution of intermediate populations from Anatolia (Asia Minor).

There are pitfalls of confusing genetic ancestry with interpretations of social dominance. There is a patrilineal connection (from the father) with the Yamnaya as most commoners had steppe origins. However, the elite tomb of the "Warrior of Griffin" at Pylos had no evidence of its steppe origin. While the tomb of the Griffin warrior is a notable high-hierarchical Mycenaean tomb, at Kastrouli the elucidation of the social order of the approximately 15+ individuals of various ages (adult male and female along with 2 adolescents, an infant and a fetus) in the Late Helladic Vault Tomb A in Kastrouli is more difficult. Many well-made Mycenaean jars, vases, figurines and some gold leaf were found there. The large-scale construction of this tomb at Kastrouli and these burial offerings may indicate a group of high-ranking individuals buried in this comingled tomb.

More tombs need to be excavated at Kastrouli to help us understand the social variability in their location and genetic origin. Finally, I think it is worth mentioning as a preliminary look at the demographic patterns associated with the Greek colonial period (8th to 6th century BC) referring to people both from the "Southern Arc" we mentioned above, but also outside what was genetically similar to Mycenaean Bronze Age individuals (as reported in our 3rd article Supplementary Text S1 and Figure S3). In this context, an Archaic period adult from the Kastrouli was determined to have the same DNA as individuals from the Spanish city of Empúries (the ancient Greek city of Emporion in northeastern Spain), that is, genetically very similar to Mycenaean.

## 6. THE LATEST DATA TO WHAT EXTENT INDICATE THAT THE MODERN GREEKS ARE RELATED TO THE MYCENAEANS AND MINOANS?

The relationship rates between Mycenaeans and Minoans were not in the purpose of the three articles, beyond what we mentioned before. But from a previous scientific article in the journal *Nature* by the Greek Iosif Lazaridis and others (*Genetic origins of the Minoans and Mycenaeans,* NATURE, Lazaridis et al. 2017), the ancient Mycenaeans and Minoans were more closely related to each other and took three quarters (3 /4) of their DNA from early farmers living in Greece and southwestern Anatolia, Greek Ionia and Aeolian and ¼ from the eastern Caucasus, a percentage that is close to our current findings in *SCIENCE* magazine. The 2017 paper compared 1.2 million letters of genetic code in these genomes from the teeth of nineteen people at various archaeological sites in mainland Greece and Crete with those of another 334 ancient people from around the world and 30 modern Greeks. These include ten Minoans from Crete dating from 2900 BC. to 1700 BC, four Mycenaeans from the archaeological site at Mycenae and other cemeteries in mainland Greece dating from 1700 BC. to 1200 BC, and five individuals from other Early Agricultural or Bronze Age cultures (5400 BC to 1340 BC) in Greece and Turkey.

The researchers of the 2017 paper were able to interpret how the individuals were related to each other. The modern Greeks are similar to the Mycenaeans, but with some additional dilution from inhabitants of the Early Neolithic in Greece, i.e. from inhabitants of the 7th to 8th millennium BC. These results support the idea of continuity but not isolation in the history of the Aegean populations, before and after the era of its early "civilizations."

Both cultures - Mycenaean and Minoan[12] - inherited additional DNA from people from the eastern Caucasus near modern Iran as finally established in more detail in our three articles, ultimately suggesting an early migration of people from the east after the first farmers settled there, but before the Mycenaeans separated from the Minoans.

DNA evidence proves that the Greeks are indeed descendants of the Mycenaeans, who were the inhabitants of mainland Greece and the Aegean Sea from 1,600 BC. to 1,200 BC

The continuity between the Mycenaeans and modern people is "*particularly impressive given that the Aegean has been a crossroads of cultures for thousands of years*", as the Greek co-authors of that article I. Lazaridis and G. Stamatogiannopoulos emphasize for their co-authored paper (Lazaridis et al. 2017).

But the Mycenaeans did have one important difference: They had some DNA (4% to 16%) from northern ancestors who came from Eastern Europe or Siberia. This percentage appears to be limited in our three articles to 9%, and the Greek area appears to be the southernmost limit of penetration from the north of the Yamnaya. This occurred in a very small flow since Yamnaya mainly (by 75-80%) moved to Central Europe. These results have also been suggested by previous linguistic and archaeogenetic research as described by a long article by Professor Ruard (2022). It should be noted that other previous limited studies have shown that the early genomes of the early Bronze Age i.e. around 3000-2500 BC are homogeneous and derive most of their ancestry from the local Neolithic Aegean and mainland, in contrast to earlier assumptions that the Neolithic-to-Bronze Age cultural transition was due to mass population movement. This movement did happen but to a minimal extent as we said with our latest results.

## 7. EPILOGUE

### *7.1 The non-linear process in cultural evolution*

As an epilogue and bridging to the present era, it appears an imperative inhered globalization-like procedure throughout humanity initiated by a group of peoples sharing same genetic affinity at those remote and ancient times due to causes referred to earlier. But in contemporary time it sadly emerges often an unimpeded and enforced by intention "globalization" simultaneously into the three major areas with priority into the economic globalization but cultural globalization, and political globalization too, following thus a complex development based on non-linear dynamics (Mainzer 2006; Mazlish 1998; Prigogine 1980).

The development of human societies and of human history in general does not follow a linear trend but instead depends mostly on interactions between various elements. The cultural evolution is viewed through

[12] We refer to the Minoan and Mycenaean 'civilizations' in the sense that these were complex archaeological cultures featuring elements of urbanism, hierarchical social organization, and written language, traditionally considered to be some of the characteristics of 'civilization'.

a complex system approach as a collective result of non-linear interactions making a series of successive transitional phases along a trajectory. This approach helps to identify the meanings of complexity in human processes that involve material, energy, and environmental factors. Three concentric circles or dynamical systems, including the internal (problems arising within a particular society), the external (problems arising from interaction with neighboring societies), and the environmental, are the sources of the interrelated multifactorial challenges (issues related to the context and other geological phenomena). Along this rationale the cultural evolution of the last 12,000 years has been considered in our earlier publication (Liritzis 2013). This is the Holocene which defines the onset of interglacial period until present era, where it was focus on some exemplary cases from Mesolithic to Roman period from Mediterranean and the world. The theory of chaos is intermingled with various identified attributes that define and affect the cultural evolution of a human organized system. The presented cases in Liritzis (2013) are sufficient to stress the naturalistic methodology, which serves as the basis of a synoptic and synthetic philosophy that involves art and science corresponding to classical techne and logos.

In an earlier work (Liritzis 2013), a rationale is applied to show that human prehistory did not develop in a linear path but rather that other steady states were attainable in every cladding, which, when active, coexisted and engaged in mutual interactions one with another (Fig. 9).

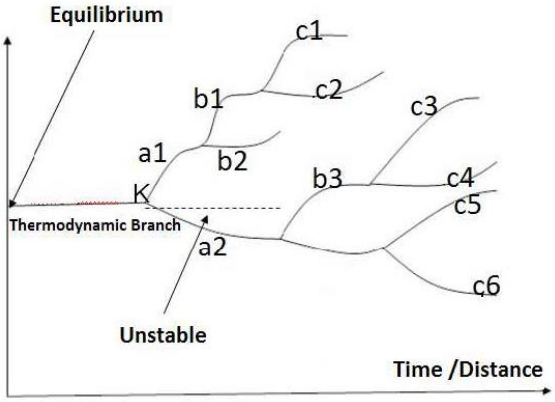


**Figure 9 The thermodynamic domain for a human system far from equilibrium, stable domains, bifurcations and the unforeseeable but determining potential courses of evolution in the next phase (stage) (Liritzis 2013).**

The main factor that causes a status to change is predicated on dramatic encounters and reciprocity between various elements, and primarily relied on the (type of) nomadic or settled human civilization or social system energy usage, level of organization, and intensity of the fundamental multi-level interactions. Using this strategy, the focus of the analysis's time scale in the beginning of the last 12,000 years ago, during the interglacial period, has been explored. In this earlier study various concrete phases are recorded from the hunter-gatherer to modern man that is outlined in Fig.10.

The energy change over time in a culture is reflected in the change of entropy dS = dSs + dSi + dSp, where dSs describes the transport through the boundaries of social systems, dSi the entropy generated within the social system, and dSp the entropy (of this social system) with the environment (+ or – depending on the type of exchange). The 2nd law of thermodynamics certifies that dS > 0 (dS=0 applies for equilibrium). In cultural evolution the entropy production rate dS/dt is of interest, in conjunction with the rates and forces of various irreversible processes (wars, floods, earthquakes, fires, pollution, epidemics, migration, trades, invasions and raids, etc.). But evolution is based primarily on mutual interactions of different components f ($t_i$), at variable time interval ($t_i$= $t_0$ to $t_1$) derived from the three concentric circles factors (internal, external, environmental).

Therefore, the cumulative result could be expressed as:

$$Y(t_i) = \int_{t0}^{t1} f(ti)d(t)$$

The parametrization of mathematical expressions is not an easy task, and one has to define quantitatively the attributes that define cultural level per time.

The hermeneutics of cultural evolution overviewed with archaeological but archaeogenetic terms too basically is founded upon the theory of complexity.

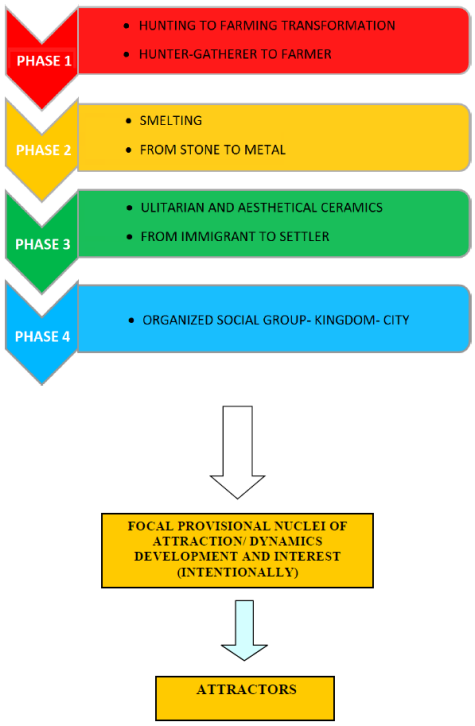


**Figure 10. Transitional stages in cultural evolution which, in the given space—time, act as attractors in further production, use and interaction (Liritzis 2013).**

The above archaeogenetic data reassert socio-culture(s) that can be defined, described and analysed in accordance with systems mechanics and through an holistic approach. These are supported e.g., by Bertanlanffy (1976) and von Weizsäcker's (1971) works, though both are rooted back to pre-Socratic and Platonic ideas.

### *7.2 The Greek case from Kastrouli (Delphi) data*

Our present results supported by the Late Mycenaean Kastrouli, near Delphi, coupled with earlier data supports the continuity between the Mycenaeans and modern Greeks which is undoubtedly impressive given that the Aegean has been a crossroads of cultures for thousands of years.

It has been shown from present and early studies that Minoans and Mycenaeans who developed two top cultures in Europe were genetically similar, as having at least 75% of their ancestry from the first Neolithic farmers[13] of western Anatolia and the Aegean and mainland Greece and most of the remainder from ancient populations related to those of the around Caucasus and Iran. In fact, it has been found that the Bronze Age genomes from Greece have shown that present-day northern-Greeks are genetically similar to ~2000 BCE Aegeans from the same region. Although they derive part of their ancestry from Neolithic farmers, a population homogeneity in Neolithic Greece, and a Neolithic Caucasus-like and Bronze Age Yamnaya Steppe-like gene flow that shaped the Aegean after the Neolithic period and may explain the population discontinuity observed in recent analyses (Broodbank 2008; Silva et al., 2022)). Yet the Mycenaeans little difference from Minoans derives from additional ancestry related to the hunter–gatherers of eastern Europe and Siberia, introduced via a proximal source related to the inhabitants of the Eurasian steppe and not from Armenia.

It is now proven that the minor 'northern'/"Yamnaya-like" ancestry in Mycenaeans around 3000 BC is due to sporadic infiltration of Greece, where this minority was culturally absorbed by the locals in Greece, rather than to a rapid migration as in Central Europe. In our new data the amount of Eastern hunter-gatherer ancestry to Balkans is ~15% and drops to ~4% in Mycenaean Greece and to negligible levels in Minoan Crete. Modern Greeks resemble the Mycenaeans, but with some additional dilution of the Early Neolithic ancestry.

[13] Archaeological evidence from Greek and Near Eastern and Anatolian Neolithic sites suggests that multiple waves of Neolithic migrants reached Greece and Southern Europe. Most likely multiple routes were used in these migrations but, as our data show, the maritime route and island hopping was prominent (Pashou et al., 2014).

Overall, a sporadic movement to the southern wing and Greece of a steppe intrusion of Indo-European speakers, with minor genetic admixture to local people in Greek mainland, creates a tapestry of diverse ancestry. This would support also that proto-Greek speakers may have formed a most likely semi-independent language from the Indo-European, a genetic-linguistic association of significant importance, that more future data may reconfirm.

The discovery of at least one migration event into Greece in addition to the first farming dispersal before the Bronze Age, and of additional population change since that time, supports the view that the Greeks form a major distinct genetic component fully shaped from the depths of prehistory, but evolved till present time in a process of becoming. Our results support the idea of continuity but not isolation, a human interaction process which prevails until our present time.

Present data from Kastrouli southern-central Greece coupled with earlier DNA evidence proves that the Greeks are indeed descendants of the robust Mycenaean group, who were the inhabitants of mainland Greece and the Aegean Sea from 1,600 BC. to 1,200 BC, continuing as same people in the later archaeological periods of Iron Age, Geometrical Classical etc. till today. They lived-in present-day Greece mainland and Aegean Sea including southwestern Aegean coast of Asia Minor (today Turkey) and spreading in a lesser degree into Sicily and possibly Spain; a reminiscent of these early migrations are testified by the beginning of 1st millennium BC colonization of Archaic/Classical Greeks into these regions and later in Euxinus Pontus (coastal regions of the Black Sea) (Petropoulos 2003).

At any rate, any statistically sound ancestry attribution would ideally require several well preserved bone samples from tombs uniformly distributed spatially and temporally in a geographical region of an ethnic identity. The ongoing work on archaeogenetics completes the puzzle of homogeneity, admixture, and continuity.

## ACKNOWLEDGEMENTS

I thank my colleagues Tom Levy and Iosif Lazaridis for useful discussion.

## REFERENCES

Botz-Bornstein, T (2012) What is the difference between culture and civilization?: Two hundred fifty years of *confusion*, *Comparative Civilizations Review*: Vol. 66 : No. 66 , Article 4. (https://scholarsarchive.byu.edu/ccr/vol66/iss66/4)

Broodbank, C. (2008) *The Early Bronze Age in the Cyclades*. In: The Cambridge Companion to the Aegean Bronze Age 47–76 (Cambridge University Press). https://doi.org/10.1017/CCOL9780521814447.003.

Cornell, T. J. (1995). *The Beginnings of Rome- Italy and Rome from the Bronze Age to the Punic Wars (c. 1000-264 BC)*. New York: Routledge

Dickinson, O.T.P.K. (1994) *The Aegean Bronze Age*. Cambridge University Press.

Pashou, P, Drineas, P, Yannaki, E (2014). Maritime Route of Colonization of Europe. *Proceedings of the National Academy of Sciences of the United States of America*. 111 (25): 9211–9216.

Kristiansen, K (2022) *Archaeology and the Genetic Revolution in European Prehistory*. Cambridge University Press. Series: Elements in the Archaeology of Europe.

Laskaris,N, Sampson,A, Mavridis, F and Liritzis, I (2011) Late Pleistocene/Early Holocene seafaring in the Aegean: new obsidian hydration dates with the SIMS-SS method, *J. Archaeological Science*, 38, 2475-2479

Lazaridis, I ...Liritzis,I....et al (202 authors) (2022a) The genetic history of the Southern Arc: A bridge between West Asia and Europe, *SCIENCE* 377, eabm4247 & 377, 939

Lazaridis, I.,… Liritzis, I…. et al (202 authors) (2022b) A genetic probe into the ancient and medieval history of Southern Europe and West Asia, *SCIENCE* (august) 377, 940–951

Lazaridis, I., Liritzis, I…. et al (202 authors) (2022c) Ancient DNA from Mesopotamia suggests distinct pre-pottery and pottery Neolithic migrations into Anatolia, *SCIENCE* (august) 377, 982–987

Lazaridis et al (34 authors) (2017) Genetic origins of the Minoans and Mycenaeans, *Nature* 548 (7666). DOI: 10.1038/nature23310.

Levy, T.E., T. Sideris, M. Howland, B. Liss, G. Tsokas, A. Stambolidis, E. Fikos, G. Vargemezis, P. Tsourlos, A. Georgopoulos, G. Papatheodorou, M. Garaga, D. Christodoulou, R. Norris, I. Rivera-Collazo, and I. Liritzis (2018) *At-Risk World Heritage, Cyber, and Marine Archaeology: The Kastrouli–Antikyra Bay Land and Sea Project, Phokis, Greece*, Springer International Publishing AG In T.E. Levy, I.W.N. Jones (eds.), Cyber-Archaeology and Grand Narratives, One World Archaeology, 143-230 (doi-org-443.webvpn.fjmu.edu.cn/10.1007/978-3-319-65693-9_9)

Liritzis. I (2013) Twelve thousand years of non-linear cultural evolution: The physics of chaos in Archaeology. *SYNESIS: a journal of science, technology, ethics and policy*, G19-31

Liritzis, I, Westra, A and Changhong, M (2019) Disaster GeoArchaeology and Natural Cataclysms in World Cultural Evolution: An Overview. *Journal of Coastal Research* 35(6), pp. 1307-1330. DOI: 10.2112/JCOASTRES-D-19-00035.1

Sideris, A, Liritzis, I (2018) The Mycenaean site of Kastrouli, Phokis, Greece: second excavation season, July 2017. *Mediterranean Archaeology and Archaeometry,* Vol. 18, No 3, pp. 209-224.

Liritzis, I., Polymeris, G., Vafiadou, A., Sideris, A., Levy, T.E (2018) Luminescence dating of stone wall, tomb and ceramics of Kastrouli (Phokis, Greece) Late Helladic settlement: case study. *Journal of Cultural Heritage.* Vol. 35, pp.76-85

Mainzer, K (2006) Complexity in nature and society: complexity management in the age of globalization *Complexus Mundi, pp*. 113-133, https://doi.org/10.1142/9789812774217_0010Cited by:1

Mazlish B. (1998) *The uncertain sciences*. Yale: Yale Univ.Press.

Meier-Brugger, M. (2013), *Indo-European linguistics*, De Gruyter.

Petropoulos E.K (2003) *Problems in the history and archaeology of the Greek colonsation in the Black sea*, In: Grammenos D.V. & E. K. Petropoulos, Ancient Greek Colonies in the Black Sea, Thessaloniki, 17-92.

Prigogine I. (1980) *From being to becoming: Time and complexity in physical sciences.* San Francisco: Freeman.

Rouard, X (2022) Did Indo-european languages stem from a Trans-eurasian original language? an interdisciplinary approach, *SCIENTIFIC CULTURE*, Vol. 8, No. 1, 15-49 DOI: 10.5281/zenodo.5717164.

Sideris, A, Ioannis Liritzis, Brady Liss, Matthew D. Howland, Thomas E. Levy (2017) At-risk cultural heritage: new excavations and finds from the Mycenaean site of Kastrouli, Phokis, Greece, *Mediterranean Archaeology and Archaeometry*, Vol. 17, No 1, (2017), pp. 271-285.

Silva, N.M., Kreutzer, S., Souleles, A. et al. (2022) Ancient mitochondrial diversity reveals population homogeneity in Neolithic Greece and identifies population dynamics along the Danubian expansion axis. *Scientific Reports* 12, 13474. https://doi.org/10.1038/s41598-022-16745-8.

von Weizsäcker C.F. (1971) *The unity of nature*. New York,1980 (first published 1971 in German).

Westra, A.J.D., Miao, C., Liritzis, I and Stefanakis, M (2022) Disasters and Society: Comparing the Shang and Mycenaean Response to Natural Phenomena through Text and Archaeology, *QUATERNARY* 2022, 5, 33.https://doi.org/10.3390/quat5030033