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E-mail: claroscuro.cedcu@gmail.com

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Autor(es): Florian Klimscha

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Cultural Diversity in Prehistoric Western Eurasia: How were Innovations diffused and re-invented in Ancient Times?

Diversidad cultural en la Eurasia occidental prehistórica: ¿Cómo se difundieron y reinventaron las innovaciones en tiempos antiguos?

*Florian Klimscha**

Resumen

El discurso arqueológico ha destacado durante mucho tiempo las grandes narrativas de difusión. Desde los centros culturales de Egipto y Mesopotamia, las ondas culturales emitían e inundaban las regiones circundantes. Fue con el advenimiento de la datación en C14 que muchos de esos modelos difusionistas no pudieron ser sostenidos ya que las supuestas periferias de repente disponían de fechas más antiguas para muchos fenómenos técnicos, sociales o religiosos que se suponían originados originalmente en el Cercano Oriente. Hoy, por primera vez, la arqueología es capaz de rastrear tales difusiones sin tener un modelo subyacente que deba ser aceptado. En cambio, la arqueología moderna es capaz de ayudarse a sí misma a comprender la complejidad y los problemas de los procesos de difusión y, por lo tanto, permite una nueva y profunda comprensión histórica. Este trabajo explorará los registros arqueológicos de Europa y Asia Occidental, con alguna mención al norte de África, y estudiará cómo la diversidad cultural del "Viejo Mundo" también influyó en los procesos, que a menudo se simplifican como una evolución de la complejidad, es decir, la difusión del conocimiento técnico y el surgimiento de sociedades complejas.

Palabras Claves

Difusión de innovaciones, Neolítico de Eurasia, Rueda y carro, Tracción por vacunos, Diversidad cultural

*Niedersächsisches Landesmuseum Hannover. Das WeltenMuseum. Willy-Brandt-Allee 5, 30169 Hannover, Germany. E-mail: florian.klimscha@landesmuseum-hannover.de

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Abstract

The archaeological discourse has for a long time stressed great narratives of diffusion. From the supposed centres of Egypt and Mesopotamia cultural waves emitted and flooded through the surrounding regions. It was with the advent of C14-dating that many of those diffusionistic models could not be upheld anymore since the assumed peripheries suddenly disposed of older dates for many technical, social or religious phenomena that were thought to have initially originated in the Near East. Today, for the first time, archaeology is able to trace such diffusions without having an underlying model which is also needed for dating the finds. Instead modern archaeology is able to help itself understand the complexity and problems of diffusion processes and thus allows a new, deep historical understanding. The paper will explore the archaeological record of Europe and Western Asia, with some mentions on Northern Africa, and study how cultural diversity of the "Old World" also influenced processes, which are often simplified as an evolution of complexity, namely the diffusion of technical knowledge and the rise of complex societies.

Keywords

Diffusion of Innovations, Neolithic Eurasia, Wheel and Wagon, Cattle Traction, Cultural Diversity

Introduction

Innovations and talk about them are omnipresent. Yet, there is little known about how the process of innovation starts and what will be its ultimate effects. Modern research on innovations is largely based on an economic perspective, going back to the ground-breaking works of Joseph Alois Schumpeter (1961:95-109, esp. 105). There is indeed plenty of research on the economic potential of new technology, including impact-assessment of new developments or methods to speed up the experimentation-phase or enhance the diffusion of technology (inter alia Degele 2002). However, innovations are not only an economic phenomenon but have far-reaching consequences for many aspects of social life and future technical developments:

Locomotives, as an example, not only changed the pace of overland travel, which had remained constant since the domestication of horses in the 4th millennium BC, but they were responsible for the introduction of wage-labour in rural societies, the expulsion of native people, a new perception of "speed" as well as the beginnings of industrialized warfare

(Schivelbusch 2000). Textile-production, to give another example, faced major changes only with the introduction of the spindle in the Neolithic, wool in the 4th millennium and the spinning wheel in the Middle Ages. The invention and economic exploitation of steam-powered looms enhanced the speed of cloth-production, but thereby was responsible for the pauperization of large population-groups. It resulted in massive social unrest, for instance with the Luddites in 19th century Britain and the Silesan weaver-uprising in 1844 in Prussia (today Poland) (e.g.: Hodenberg 1997).

Innovations also cause some people to be on the losing side and they do not always change society for the better. Radical positions, like that of Jacques Ellul (1964), even claim that the concentration camp is in large parts the result of long-term effects of technical innovation processes started with the Industrial Revolution in the 18th and 19th century. Ellul's book is one of the most eloquent techno-phobic statement made in the course of innovation studies, and it foreshadowed many arguments of modern anti-globalist movements. Technology ("technique" in Ellul's jargon) is unifying. It slowly but steadily changes human societies; bends them to be more and more dependent. The necessities of technique force societies to conform. The more technique is diffused, the more it synchronises societies. While this kind of thinking has largely been overcome in modern innovation studies, it has had a renaissance in archaeology lately. Globalization has entered the Bronze Age discourse ("Bronzization", c.f. Vandkilde 2016) and new evolutionistic narratives put the nascent bond and dependence of humans and technology in their centre (e.g.: Hodder 2012; Hodder 2014; cf. Pollock et al. 2013 for a critical review). Technology, it seems, decided how and into which direction human societies evolved.

Researching Innovations

Technical change was a constant factor in human prehistory. Its existance is the reason why early researchers were able to develop relative chronologies and for a long time this was its main use in archaeology: The similarity of technical artefacts and stages allowed to compare the relative chronological sequences of various regions. Already in the late 19th century Gabriel Tarde (1899) based his famous theory of diffusion heavily on the similarity of archaeological finds over large regions and argued that technology was spread by imitation.

Change in prehistory was the translation of new techniques, thought to be developed in a core-region largely identical to the later state civilisations in Egypt and Mesopotamia, into more primitive contexts. V. Gordon Childe (1951) combined the relative chronological schemes and the evolutionistic classification of pre-industrial societies identified by anthropologists (cf. Lubbock 1865), and thereby for the first time conceptualised elaborate socio-technical stages. For him social change was created by technical innovations within the relations of productions (*Produktionsverhältnisse*). Yet, Childe still had no way to escape the Ex Oriente-paradigm, because as long as artefacts had to be typologically chained to the Orient to establish an absolute age, it was impossible to prove older datings in the still illiterate "periphery". Thus he imagined the diffusion of key technologies originating in the Egypt/Mesopotamia. From there innovations were diffused via a multitude of small exchange system organised along river streams and coasts. Successively implementing key technologies would in the long run result in a new social order in those societies accepting them. The combination of these key technologies in the Near East and Egypt was one of the reasons for the rise of cities and ultimately the first states. Technology thus shaped society.

The paradigm of social change resulting from the diffusion of oriental innovations was not challenged before radiocarbon-dating made it possible to date archaeological finds independent from diffusion-theory. Colin Renfrew (1969; 1973) highlighted the theoretical implications resulting from the application of this newly developed method to date archaeological finds. Essential for Renfrew's argument was the Copper Age cemetery of Varna at the Bulgarian Black Sea coast, nowadays dated to the time around the middle of the 5th millennium BC, where different categories of graves could be differentiated by the wealth of their inventory – ranging from elite burials with more than 1.5kg of gold as well as copper and stone artefacts to the poorest furnished only with pottery vessels (Cf. Fol/Lichardus 1988). According to Childe's model, such dimensions of social inequality were only expected during the Bronze Age, after the formation of complex chiefdoms, where technology had allowed the establishment of permanent rank differences.

Renfrew, however, emphasized the C14-datings proved that Varna did not belong into the late 3rd, but into the 5th millennium BC, which made it significantly older than any comparable finds from Western Asia. He therefore argued that internal changes independent from Mesopotamia and Egypt were responsible for the innovations. In his narrative, the production of graphite pottery, which required high-temperature firing, was thought to have resulted en passant in the smelting of copper ores. Further on, he concluded that, the mastery of metallurgy did not necessarily lead into urbanism and state-systems as Childe had previously claimed, because the societies of South-eastern Europe remained in prehistory until the military expansions of Macedon Greeks and Romans included them into the Empires of Classical Antiquity. Thus, not only was the connection between society and technology loosened, but also human actors were given a much more prominent role in the scientific discourse.

Yet, these human actors were difficult to trace with purely archaeological means, and the concept of "autochthonous" evolution remained rather vague and was often taken as an argument ex nihilo. As soon as new datings had resulted in new "oldest evidence", it was claimed to be the proof for another independent invention. One of the more extreme positions, for instance, argued that wheeled vehicles were invented five times;in the North European Plain and the Carpathian Basin, around the

Alps, in the northern Black Sea region, in Mesopotamia and the Americas (Vosteen 2002)!

A major concern in the scientific work on ancient technology and ancient innovations is that until today the theoretical background is not adequate to the archaeological record. While studies on modern innovations offer huge potential, they do not take the specific background of the pre-modern world into account. Innovations do not enforce themselves upon a society, and even if they are adopted, they are often exploited quite differently from what could be expected. Steam-power was known in ancient Greece, but the cheapness of slave labour never made anyone consider constructing machines for industrial purposes (Cf. Humphrey/Oleson/Sherwood 1998 and Greene 2000 with recent perspectives on technology in Classical Antiquity).

The short-termed perspectives as well as the lack of empirical data are two other significant shortcomings of modern studies on innovation. The process of innovation-diffusion as it has been popularized by E. Rogers (2003) is a long-term process that is actually infinite and can evolve into totally unforeseen and unanticipated directions (cf. Klimscha 2017a with such a perspective on metallurgy). Based on a large number of case-studies, Rogers deduced his famous S-shaped logistic function, which is often seen as a model for a successful innovation-diffusion (**Fig. 1**). Yet, the absence of big data sets in his study highlights that even this is rather an informed guess than the result of empirically founded research.

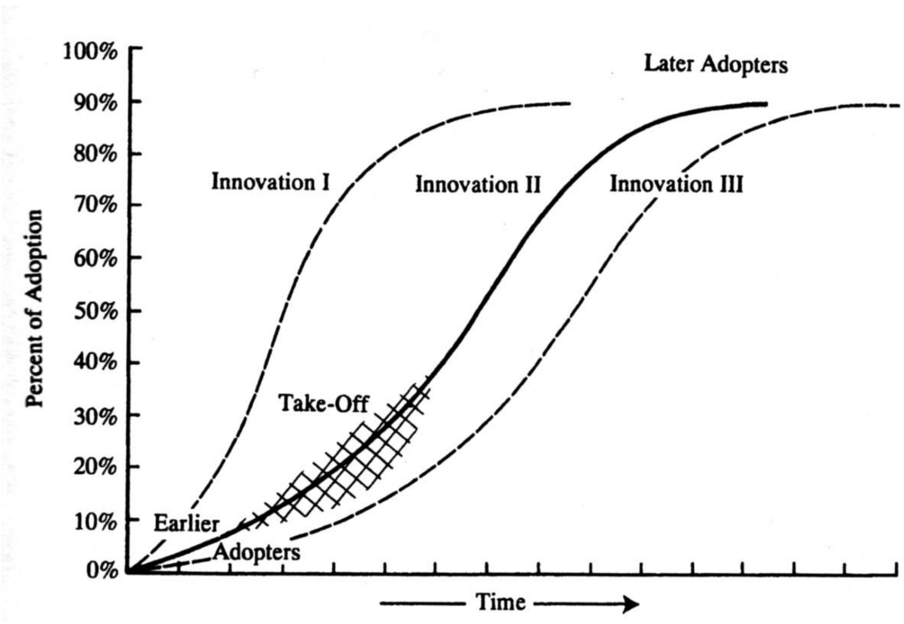

Fig.1: The Diffusion of Innovations modelled as an S-shaped curve according to Rogers 2003.

While it is impossible to create sufficiently large data-sets for modern innovations, archaeological sources offer just such an insight. Within the archaeological record ancient innovation-processes can be investigated over several centuries while they diffuse over whole continents and are continuously re-invented. This opens up a perspective to understand innovations not as self-contained events, but as part of a continuous and undetermined process with constant socio-technical change.

Ancient Innovations and their Impact

Archaeological sources, though less detailed can offer a unique long-term perspective, and thereby make it possible to understand social consequences of innovations as well as their consecutive effects on the technical evolution itself. Prehistoric archaeology traditionally starts with the study of the first tools in the Lower Palaeolithic.

While tool use is well documented already in animal cultures (Becker 1993; Waal 2005), even the relatively simple pebble tools found at Olduvai Gorge, Tanzania that date back to ca. 1.9mya (million years ago) are not replicated by apes or other mammals in their natural environment. A series of experiments, however, did demonstrate that the ability to work stone is greatly enhanced after primates have been taught basic language (Savage-Rumbaugh/Rumbaugh 1993). Once a basic concept of tools could be conveyed, choppers and chopping tools allowed the sharpening of organic materials and the cutting of animal hide. Apes can learn to communicate with iconographic symbols. Teaching them to communicate with humans is a technical quality ("symbolic technology" *sensu* Rammert 2007,16). Teaching apes symbolical technique enables them to perform better also in other areas of technique. The impact of stone tools, therefore, should not be underestimated, but rather considered as a catalyst for new habitual, symbolical and mechanical innovations.

With the help of simple toolkits, early hominids were able to create their own ecological niche and survive by feeding on cadavers left by predators. The tools helped to process meat quickly and from areas, which the teeth of carnivores could not penetrate (cf. a good overview in: Baales 2006). Yet, *homo habilis*-groups were not able to leave this ecological niche at will, but moved with a specific ecosystem for instance into the Caucasus, as the finds from Dmanisi, Georgia, ca. 1.8mya, demonstrate (Bosinski et al. 1995; Jöris 2008). *Homo erectus* on the other hand left Africa permanently and developed highly elaborate strategies to survive in different environments and the same is true for *homo neanderthalensis*,travelling through large parts of Eurasia. Apart from fire-use (Goren-Inbar et al. 2004), abstract thinking (Marshack 1997; D'Errico & Novell 2000; Bednarik 2004) and early sea-going vessels (Bednarick 2008), the wooden hunting spears from Schöningen in Lower Saxony (Thieme 1997; Thieme 2007) show impressively that already the interaction of pre-sapiens humans with the environment resulted in a new quality which involved the active exploitation of resources and organized hunts.

The advent of *homo sapiens sapiens* in Europe (from 40.000 BP onwards) seems to be connected with a number of impressive technical achievements. Apart from the famous cave art in Western Europe, hunting weapons like the spear-thrower and harpoons allowed completely new subsistence strategies; the sewing-needle and the braiding of fibres allowed new forms of clothing, and the chipped stone industries now include regular blades which could be changed into a variety of specialized tools (Terberger 2009). There is convincing evidence that *homo sapiens sapiens* dug vertical shafts of several meters to find water and flints (Vermeersch et al. 2002: 220 fig. 8.18), and within the semi-permanent campsites of the specialized hunter/gatherers of the Gravettian, the first evidence for socially induced inequality in higher primates can be found (e.g. Sungir, cf. Trinkaus 2014). Nevertheless, the life of hunter-gatherer-fisher-groups was still heavily determined by climatic changes and therefore cultural systems shifted between various degrees of technical and also social complexity (e.g.Baales & Street 1996).

After more than 2 million years of living as foragers, the Neolithic Revolution in the Fertile Crescent is the most drastic change in the evolution of human societies. Nearly all its key components (like domesticated grains, grinding stones, houses etc.) were already invented in the Palaeolithic. Still, only after creating a new ideology (Cauvin 2000; Schmidt 1996), were human groups able to use this know-how in conjunction with climatic change to begin to transform their subsistence by becoming animal herders and farmers. The Neolithization was a lengthy and difficult process: The domestication of cattle, sheep, goats and pigs from their wild into their domestic form required extensive know-how, which involved complex long-term breeding plans to avoid sterility (caused by inbreeding, and thus also making large networks necessary). The new way-of-life allowed completely new techniques to emerge, but this also took several millennia. Only in the 7th and 6th millennium, the Neolithic culture begins to move outside of the Fertile Crescent and arrives both via ship and via the land bridge of Anatolia in Europe, where it quickly spreads through the Balkan Peninsula, and then in a second phase into Central Europe (Hauptmann & Özdoğan 2007). By now, the "Neolithic Package" consisting of stone axes, pottery, domestic plants and animal, longhouses, weaving, wells and from 6000 onwards also high-temperature kilns has helped to create the first artificial environment (Çilingiroğlu 2005). Humans begin to thin out the primeval forest of Europe to build villages and agricultural fields. Within these villages, new techniques are developed during the 5th and 4th millennium, like the smelting of metals, wheeled vehicles, woolly sheep and ploughing, while in Western Asia and North Africa a different dynamic leads to pristine state systems in which also the beginnings of writing, bureaucracy and balance systems can be found (cf. Childe 1951; Sherrat 1981; Rahmstorf 2006; Hansen 2014).

The adoption of tin-bronze over large parts of Western Eurasia takes place between the middle of the 3rd and the middle of the 2nd millennium BC. Bronze tools are an efficient improvement over the pure copper and arsenical bronze objects of the 5th and 4th millennium and their repartition is much greater than that of the latter two. Their greatest advantage seems to have been the replication of large numbers of identical objects and they were the result of a growing demand of metal.Once societies adopt tin-bronze, it makes regular long-distance trade necessary and leads to the rise of complex chiefdoms in areas controlling the tin-trade; the city-states of the Eastern Mediterranean create monumental architecture and complex economic systems of distributing goods (Sherrat 1993; Frank/Gills 1993). On Crete and in Greece developed the first European state-systems. The domestication of horses, from the late 4th millennium onwards, allows for a shared elite and violence culture, which is based on chariots, while horseback-riding and new wagon-types using spoked wheels helped to establish more frequent contacts via the Eurasian steppes as far as China in the 2nd millennium BC (Kohl 2006). The growing urban centres make elaborate irrigation necessary, and around 1000, iron metallurgy starts to revolutionize the settlement patterns and trade-networks. Iron does not need alloying and is available in greater quantities than copper and tin. In the Mediterranean new clusters of innovations, including new balances, the use of waterpower for mining etc., emerge in Hellenistic and Roman times and allow state-systems to grow to Empires and connect huge territories for the first time by military innovations, like the Macedonian phalanx from the 4th century onwards. Aqueducts play a major role in the growing of metropolises by providing enough water for bathing houses, fountains, drinking, and domestic use (cf. Klimscha et al. 2012 and the papers therein).

The Complexity of Ancient Innovation-Processes

Ancient innovations have long foreruns. The do not appear out of chance, but are the result of extensive socio-technical evolutions. Sword-blades, for instance, are the result of a long tradition of alloying, going back to the 5th millennium (Klimscha 2013a) and technical improvements in creating thinner copper objects (Klimscha 2014) incorporated into the idea of bladed weapons going back to the Mesolithic. They do not appear at random, but the earliest sword-blades appear in the Caucasus, in an area where a long tradition of making copper daggers existed.

Early copper swords are the result of long experimentation and the desire to produce shiny and deadly new weapons. They appear in the archaeological record around or in the last centuries before 3000 BC (maybe even a little earlier – since the chronology of the early Majkop-culture is still worked on; cf. Hansen 2013). Neither the region nor the age is coincidence. The innovation starts where there has been a long tradition of casting bladed weapons, and only after metallurgists had become proficient with alloying and forging thin, long metal objects. Their diffusion is limited to the Caucasus, Mesopotamia and the Southern Levant. Technical difficulties are probably a reason, why the production of similar weapons in Europe started only in the 2nd Millennium BC with a time lag of more than a millennium. Still, these cannot be taken into account for all of Europe. Other bladed weapons like the halberd (Horn 2014) were known around the Alps and the Carpathian basin from the 4th millennium onwards and some of these did reach considerable lengths (**Fig. 2**). These, too, are regions with a long tradition of making copper daggers and therefore could develop improvement-innovations. In Western Europe and the North European Plain, the innovation failed, andonly a handful of copper daggers are imported (Klassen 2000; Müller 2013). It is only in the late 3rd Millennium BC that this technological barrier dissolves and similar weapons are found in Ireland and southern England (Horn 2014). Proficiency in alloying seems to have been the decisive factor that allowed Western European societies to upgrade their armament. This, in turn, was widely diffused and anchored the socio-technical substructures, which allowed the production of swords. Technology could not be transported freely, but needed knowledge, training and organisation. The case of bladed weapons highlights how these are actually developed parallel in Southern Europe and the Caucasus and Near East. Yet, the development is not completely autochthonous, but was improved from a common metallurgical tradition that took a different route and several reinventions over several hundred years.

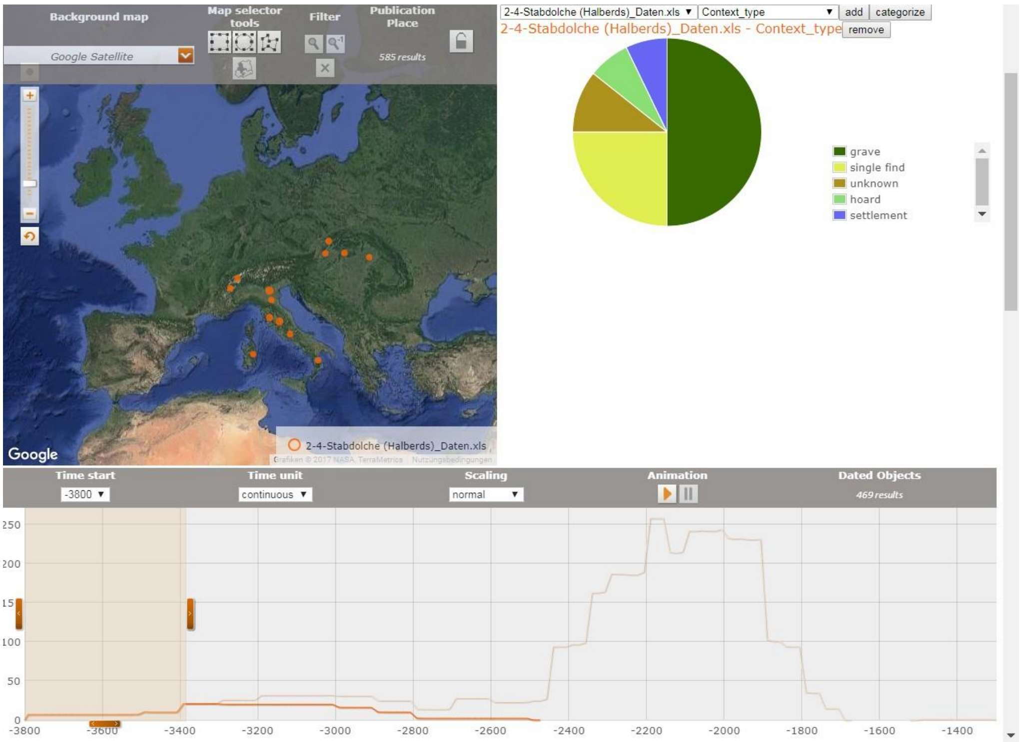

Fig.2: Repartition of copper halberds ("Stabdolche", dagger-axes), ca. 3800-3000 BC (from: C. Horn, Halberdas (Stabdolche). In: Hansen/Klimscha/Renn, The Digital Atlas of Innovations)

The diffusion of spearheads and early swords over large distances did not happen around 3,000 BC. Instead different ways of using the technology were developed. Halberds in Western Europe, swords and spearheads in the Caucasus and Upper Mesopotamia and "axes" with thin, long Epsilon-shaped (or crescent) blades between the Egypt, Anatolia and the Persian Gulf (Quenet 2004). Technology needed substructures and know-how to build upon, but this necessity for technology needed to be socially constructed, for instance by institutionalising warrior-hood. The halberds mainly derive from the modern countries of Austria, Belgium, Czech Republic, Germany, France, Portugal, Spain, Switzerland, Ireland, Italy, Poland, Denmark, Great Britain, Slovakia, with a few finds as far east as in Bosnia-Herzegovina, Hungary, Lithunia, Romania, and Sweden.

Another myth of prehistoric technology is the idea that it is basically only used to show off status and for ritual activity. While this may be true in some cases, like the "standards" or "crowns" from the famous 5th millennium hoard in the Nahal Mishmar, Israel (Bar-Adon 1980), there is also an economic component in ancient innovations. Resources were rare. The common misconception of the "Stone Ages" is that stone was everywhere and therefore available in abundance. Yet, already in the Late Upper Palaeolithic human groups invested time to dig vertical shafts to gain flint (Vermeersch et al. 2002). The quality necessary for tool making was not (or not always) given in surface material and evidence for mining activity is plentiful also before the metal ages (cf. the papers in: Weisgerber 1999). Another line of evidence in this regard is the recycling of stone artefacts. A recent study on the flint tools of the 5th millennium Copper Age lake settlement of Pietrele in Muntenia, Romania could demonstrate how even small fragments of stone axes were re-sharpened and used as new tools (**Fig. 3**). What is striking is the fact that this did not only happen with large cutting edge fragments, but with all kinds of fragments and even small splinters (Klimscha 2016, 79-104). The availability of good raw materials directly affected the reduction strategies of stone tools; in some cases this created assemblages where, for instance, axes were recycled so heavily that they can only be identified by refitting the waste from recycling (Hassmann 2000). Of course, no currency systems were available in prehistory, but the amount of time, resources and favours spent to gain new raw material was an important factor in gaining and defending one's status in ancient societies. Innovations like metallurgy therefore had a greater fascination in regions with poorer lithic resources. It is therefore not by chance, that the North European Plain relies on flint axes until the middle of the 3rd millennium (cf. Brandt 1967), while Egypt and the Near East already substituted the same tool with copper axes from 3500 onwards (Rosen 1997).

Fig.3: Reduction of Stone axes into smaller adzes shown with finds from the Copper Age (ca. 4,600-4,200 BC) site of Pietrele, Muntenia, Romania (Klimscha 2016: 90, Pl.98)

Different adoption strategies had unintended and unanticipated effects, and in the long run the inability to cast copper swords (and daggers) is also a consequence of the denial of metallurgy in the 5th millennium. Daggers were imitated in the thousands in flint, and give evidence of the desire to show off the same weapons as southern neighbours (Frieman 2012) combined with non-existent knowledge of how to make them. In the

Eastern Mediterranean, on the other hand, the substitution of flint axes with copper axes was one of the reasons for establishing regular long-distance trade, for instance, between the Levant and the Nile that resulted in bureaucratic institutions to control it, but also to guarantee its regularity (Klimscha 2013b). Innovations also bring with them a destructive potential. The new replaces the old, but this creates a dependency on the new. Once technical substructures ceased to exist they necessitated to build up new ones. With the lack of flint axe workshops, copper trade was essential for many daily tasks. Copper is traded from ca. 3600 BC onwards in the form of ingots over Sinai and the Red Sea (Khalil/Schmid 2009) to Egypt and maybe also along the Mediterranean.

Ancient innovations diffused rapidly, if they were seen as desirable. One of the most important innovations, the wheel, was for a long time seen as being transmitted during the 3rd millennium into Europe, while Near Eastern societies possessed knowledge of wheeled vehicles already in the late 4th millennium. However, new research has dramatically changed this picture and currently the distribution of the earliest wheeled vehicles spans the area from the North Sea to the Euphrates (Burmeister 2004a). High-precision dating showed that, indeed, there is very littlemeasurable chronological difference between wheeled vehicles in the North European Plain and Mesopotamia (Mischka2011; Zich1993; Bakker et al. 1999). New data suggests even more drastic changes as the earliest secure evidence for wheels in the Near East is pushed back as late as 3100 BC (Pruß 2011). That, in turn, would make the invention of wheeled vehicles in Mesopotamia less probable and favours an emergence in the zone between the Northern Pontic area and the Carpathian basin (**Fig. 4**).

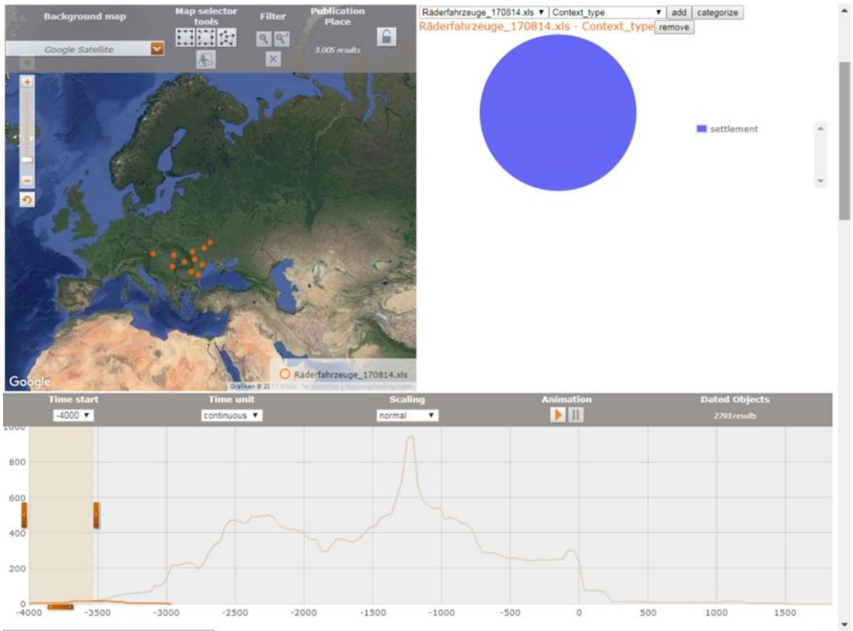

Fig. 4: Repartition of early wheeled vehicles, ca. 4000-3600 BC (from: F. Klimscha, Räderfahrzeuge ("wheeled vehicles"). In: Hansen/Klimscha/Renn, The Digital Atlas of Innovations).

After 3,500 the wheel is known from the shores of the Baltic to the Euphrates and beyond. Yet, there are regions which did neither use it initially nor in the next millennium (**Fig. 5**). The lengthy denial to adopt the wheel in regions like Greece, southern Italy and Egypt is striking; wheeled vehicles were obviously not the prime choice of moving everywhere (Klimscha 2017b). There is also a similar resilient barrier in Western Europe, where only the development of the spoked wheel and the domestication of horses seem to have made the wagon attractive enough to be adopted. However, the picture is more complex and in contrast to metallurgy, the available knowledge to produce wagons was available in all Neolithic societies and while there is good evidence for ploughing and the use of cattle-teams used for labour in the Southern Levant (Hill 2011, and assumedly this was also the case in larger parts of the Near East), it was not combined with the wheel (**Fig. 6**). The same knowledge reservoirs are used in different ways and create differences in the archaeological record – also in regions that quickly adopted the same technology:

Evidence of early wagons appears in the 2nd half of the 4th millennium in regional-specific deposition patterns, but also in find groups, specific to certain regions and time: For instance, in the Hessian-Westphalian region as pecked depictions on the wall stone slabs of the gallery graves of the Wartberg Culture (Günther 1990), in Northern Germany as tracks under a burial mound of the late Funnelbeaker Culture (Zich 1993), in Poland as depictions on Funnelbeaker pots (Kruk & Milisauskas1982) and as cast copper sculptures (**Fig.** 7, Matuschik 2002), in the Carpathian basin as ceramic models (Maran 2004), in the northern Pontic region as wagon-burials (Trifonov 2004), in the lakeside settlements of the circum-Alpine region and the moors of north-western Germany and the Netherlands as chance finds from wooden wagon parts, and, finally, in the north-western Pontic region as animal figurine on wheels (cf. the papers in: Burmeister & Fansa 2004).

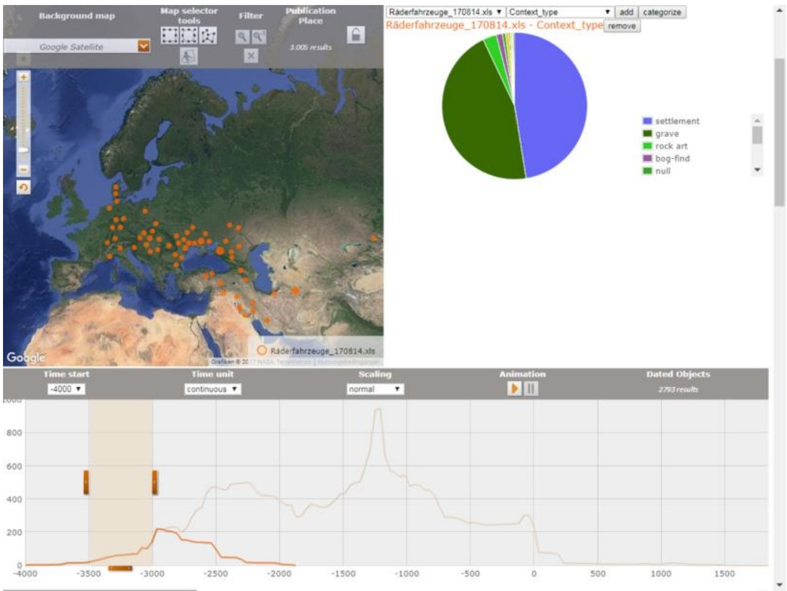

Fig. 5: Repartition of wheeled vehicles, ca. 3500-3000 BC (from: F. Klimscha, Räderfahrzeuge ("wheeled vehicles").
In: Hansen/Klimscha/Renn, The Digital Atlas of Innovations)

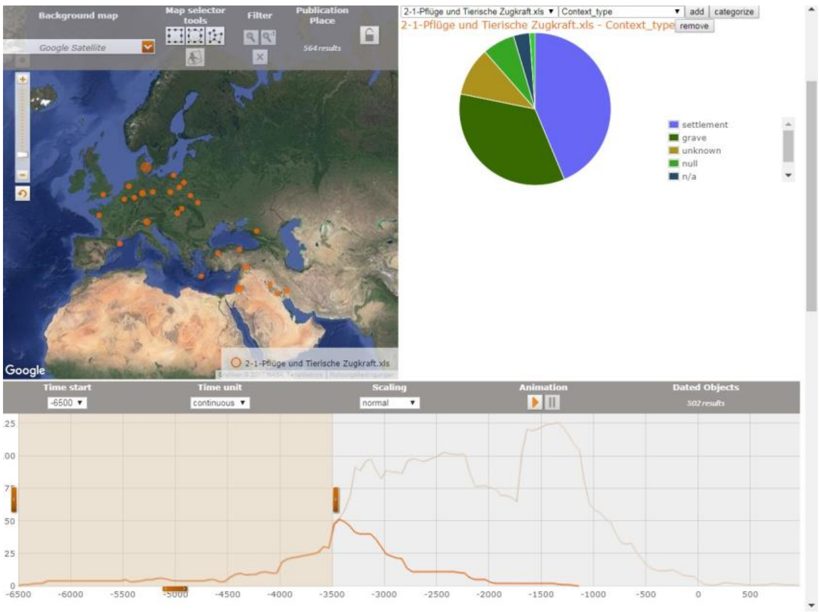

Fig. 6: Repartition of ploughs and zoological evidence for cattle traction, ca. 6,000-3,500 BC. (from: F. Klimscha/A. Hill, Pflüge und die Nutzung tierischer Zugkraft ("ploughing and animal traction"). In: Hansen/Klimscha/Renn, The Digital Atlas of Innovations)

Different wagon designs were in use simultaneously. There existed two-wheeled (Günther 1990) and four-wheeled (Kruk & Milisauskas 1982) vehicles, and the wheels could either move freely or were fixed to the axle (Schlichterle 2004). Different traditions of wheel making were established in the North European Plain, the Alps and the Caucasus, and this determined the improvements of the wheel until the spoked wheels became widely spread around 2,000 BC. The northern find group consisted of wheels made from a single piece of wood with a round centre bore, while the Alpine wheels were made of two pieces with a square shaped centre bore and outer battens and in the Black Sea area tripartite wheels with internal bowels were developed.

While there can be assumed economic reasons for this development, like the better availability of large trees and/or the desire to save wooden resources, the different states of technical know-how are not to be neglected, either. That is to say, the construction of wheels with internal bowels necessitated narrow chisels with bevelled edges, which are an innovation based on extensive metallurgical know-how (especially alloying and the making of bladed tools and weapons). As has been demonstrated already with the non-diffusion of early swords, this knowledge was limited to the Near East, the Black Sea region, the Carpathian basin and the Alps. Thus, the development of wheels is also related with the spread of early metallurgy. Finally there were also practical elements and previous technical traditions involved: The alpine wheels, on the other hand, belonged to two-wheeled wagons that are assumed to have had an A-shaped chassis and, if this is right, must have been a development of the travois. The wheels were fixed on the axle and thus driving curves with such a vehicle was only possible if it features only one such pair. Depictions of A-shaped carts with two wheels are also known from contemporary rock art and strengthen this point (Schlichterle 2004, 302 Abb. 9). Thus the creation of different wheel types reflects the different technical know-how as much as environmental advantages or economic pressure.

The take-off of wheeled vehicles as well as improvements on the innovation can be connected with the introduction of new technologies or the better understanding of technical principles on the one hand, but they were still translated into local technical and ritual traditions. The *châine opératoire* was simple enough to be moved between societies with significantly varying social complexity and technical knowledge, but onlyrequired technical components which were widely known. Once established in a number of communities, the innovation could be transformed according to the requirements of different environments and social rules.

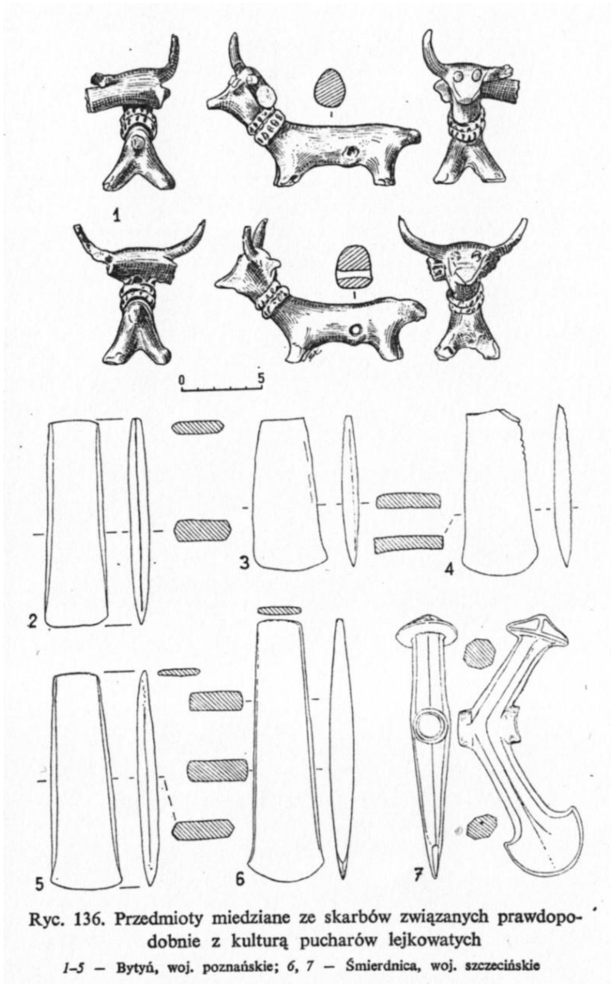

Fig.7: The hoard from Bytyń, west of west of Poznań, included a fragment of a wagon model (?) made from copper consisting of two yoked cattle (Wislanski 1979: 237, Pl. 136).

Conclusion: Ancient Innovations and the Creation of Diversity

What was the effect of innovations? How did innovations create Cultural Diversity? This paper is far too short to give an elaborate answer for every single case, but can trace some of the developments starting from the middle of the 4th millennium onwards. At first, there is evidence for a more frequent use of secondary animal products. After a few generations, this intensification must have resulted in a dependency on such animal-technology, and this, in turn, would explain the social innovations of using wagons in the funeral rite, which is actually shown in the maps of the early evidence of wagons. Animal traction and the wheel has now become part of socio-economic systems.

Yet, this was not the end, but started new innovation processes, which were connected with other innovations: In the Near East, for instance, the combination of wagon technology, the domestication of the donkey (Milevski 2011: 177-197) and specialized close-combat weapons (Klimscha 2014) were integral for the building of the first battle-carts and a transformation of warfare.

These manifold changes were, of course, not caused by the wagon, but the wagon was one part of a larger long-term process, which radically transformed Eurasia (Hansen 2011; Hansen 2013): The industry of heavy copper weapons and tools in the Balkans and the Carpathian basin ceases to exists, as well as the production of clay figurines. Writing, sealing and balance systems appear only in the Eastern Mediterranean (Ramstorf 2006; 2011; 2012), and the same is true for, or the domestic donkey (Milevski 2011: 177-197; Klimscha 2013).

Contacts and small-scale change does not stop at the end of the 4th millennium. It is only from a modern, *etic* perspective that we value innovations like animal traction, wheels and ploughing higher than we do copper daggers or new axe-types. In recent years a number of innovations have been identified by researchers connecting Central Europe either with Italy, like the halberds (Horn 2014) or stone stelae (Vierzig 2017). It is, therefore, impossible to clearly divide time-spans in which innovation processes took place from those in which they stopped. The process is infinite.

The implementation of key innovations, like animal traction, the plough and the wheel did have decisive long-term consequences as Peter Bogucki has shown (Bogucki 1993). Social units which were able to monopolize the control of such innovations were able to accumulate food, wealth and possibly also political power. The following transition from the

Funnelbeaker ideology to the Corded Ware in Europe is connected with a shift from technical to social innovation, and it might therefore be another worthy adventure to closely analyse the long-term effects of technical change in the 3rd millennium in a similar manner.

It is striking that huge blank areas still appear on the map. Early wheeled vehicles were not used in western Europe, Greece, northern Scandinavia, or North Africa – with the exception of Egypt and large parts of Eurasia – for as long as 1,500 years after the first appearance of the wagon. Various regions adopt innovations considerably slower than others or even not at all. This was, however, not only an economic disadvantage, but had massive effects on the means of social distinction, transport of goods and therefore how farming is organised, long-range communication, infrastructure, cattle breeding patterns and many other facets of a society's structures.

Humans decide if and how to use an innovation, but if they do so this will affect their social system – sometimes in unanticipated even unwanted ways. Ancient innovations thereby changed human cultures and by the differing pace of adaption they created cultural diversity. Innovations had short-term effects, like a new way of showing off one's status or the ability to work more efficient on a farm, but there is also another story. Innovations were no stories that had a definite end, but the process is infinite. The adaption of an innovation created the necessary sociotechnical substructures to develop or adopt improvement-innovations related to the original innovation, it may create necessities which can motivate societies to change, and finally in the long run may have changed societies in such a way that they can adapt new innovations which other societies cannot even appropriate and produce themselves because they lack several generations of technical expertise embedded into social rules.

Innovations may not always have led to progress and they were rarely necessary. Innovations could emerge in nearly every cultural setting and they usually diffused extremely quickly, but not everyone chose to adapt them. Different adaption-strategies created different technical histories, and thereby different cultures. Humans rarely were forced to adapt or perish, but adaption or decline changed human societies at different times and different places and with different speeds and into different directions. Socio-technical variety was the result, even though the spread of the innovation itself might suggest uniformity. Thus in contrast to Ellul (1964) and modern techno-pessimists, ancient innovations created cultural diversity and not cultural *Gleichschaltung*.

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