

GLOBALISATION OF STONE TOOLS AND BEGINNINGS OF MECHANICAL PROCESSING OF POLYMERS

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ABSTRACT

Based on research on influence of rubber and plastics on globalization, an interesting question arose: can we define the first globalization way of material culture? Manufacturing of first stone tools can be seen at the site of Gona, Ethiopia (dated to 2,6 million years ago), followed by several sites including the evidence from West Turkana in Kenya ($2,34 \pm 0,4$ million years ago), Olduvai in Tanzania and Sterkfontain in South Africa (2 – 1,6 million years ago). The products found at the sites were simple stone choppers, chopping tools and flakes.

We used synthesiological approach and combined the knowledge from archaeology, production technology and the field of polymers in order to approach the interesting question relating to the aforementioned finds: for which purpose these tools were used? Firstly, the manufactured stone tools were used for procedures such as breaking of the natural polymers: e.g. crushing of the larger bones in order to obtain the marrow, and for butchering of animals.

KEY WORDS

globalisation, *Stone tools Road*, mechanical processing, natural polymers

CLASSIFICATION

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INTRODUCTION

When preparing a paper entitled *Influence of rubber and plastics on globalization* [1, 2] authors realized that the definitions of globalization are not suitable for our purpose. So, we have developed our own method of studying this modern notion, based on the implementation of the theory of systems in general technology [3]. The three conclusions that stem from this text are of importance [1, 2]. First, globalization is a very old phenomenon. Second, we propose the existence of a *Rubber Road*, similar to the well-known *Silk Road*. Third, rubber and plastics strongly influence the information globalization by the global network of optical cables.

However, it is important to try to assess how old this phenomenon (globalization) really is. We will try to reconstruct this first globalization through the attempt to define the *Stone Tools Road*. We have based our conclusion upon Semaw's paper from 2000 [4] and defined the starting point of this *Stone Tools Road* at Gona, Ethiopia, about 2,6 million years ago.

It is our assumption that, alongside stone, the first materials used must have been natural organic polymers, such as animal bones, wood, skin and ivory as well inorganic polymers like some art of stones. Therefore, the globalization of the first stone tools as well as mechanical processing of polymers will be discussed.

Our intention is to find the first globalization way of material culture, and try to detect the spread of the production of these artefacts. We will also try to establish how old is mechanical processing of natural polymers, which can be linked to the production of stone tools.

GLOBALISATION AND SYNTHESIOLOGY

*When you have no idea what you must do,
make an analysis of the system*
I. Čatić, 2008

The ignition idea to study the influence of plastics and rubber on globalization comes from C. Gogos' lectures [5]. The term globalization is mostly described as a process. But based on a French definition *globalization is a phenomenon* [6]. Among the definitions of *mondialisation* we can read: "... Ce phénomène touche la plupart des domaines avec des effets et une temporalité propres à chacun..." [6]. The keyword here is *phénomène, phenomenon*.

Among numerous presentations at the Conference entitled *Philosophy and Globalization* [1], one word had a central status: the German word *Gleichschaltung*. How do we understand this word? [7] We all write papers in one language, and the value of our work is judged by few databases. What stems from this is that you can be accepted by the scientific community only if you follow certain trends. A paper such as this one is usually out of trends. However, this paper is based on another idea, a new scientific paradigm, *synthesiology* [8]. *Synthesiology* is a coined word combining *synthesis* and *-ology*. The term itself is not a new one and was coined by the German anatomist Martin Heidenhain in 1920 [9]. One of the definitions of *synthesiology* is given in a paper by Yoshikawa [8].

In our work [10], we define *synthesiology* in its broadest possible meaning. We believe that this science is based in the theory of systems and *culturology*. Under *culturology* we consider a science concerned with both material and spiritual cultures.

One of the aims of this paper is to describe one of the oldest globalization ways. To explain the dilemma whether the globalization is a very old (primeval) phenomenon, or a quite recent one, we will use one of the main supports in synthesiological research, the theory of systems.

GLOBALIZATION AS A SYSTEM

We use the idea from G. Ropohl's *System theory of Technology* (technical system of things, Fig. 1) [3] to present the globalization as an acting system [1, 2].

According to a postulate of cybernetics, all the phenomena of this world can be represented as information, energy or matter (mass) [3]. Each system acts in space and during certain time and the states of the system are: informatical, material, energetical, spatial and temporal. Information inputs into the system are data and command (goal of the system).

We call the attention to the fact that the information input into each system contains of two subsystems: *data* and *command* [3]. The most important for globalization is the definition of command, i.e. what the system must do. The aims of modern globalizations are determined by corporations and multinational companies and executed by politicians.

In general, there are three types of globalizations: globalization of plants, animals, and human globalization. Globalization of plants and animals is not within the scope of this work, and we will concentrate on human globalization as an active system (Fig. 2) [11].

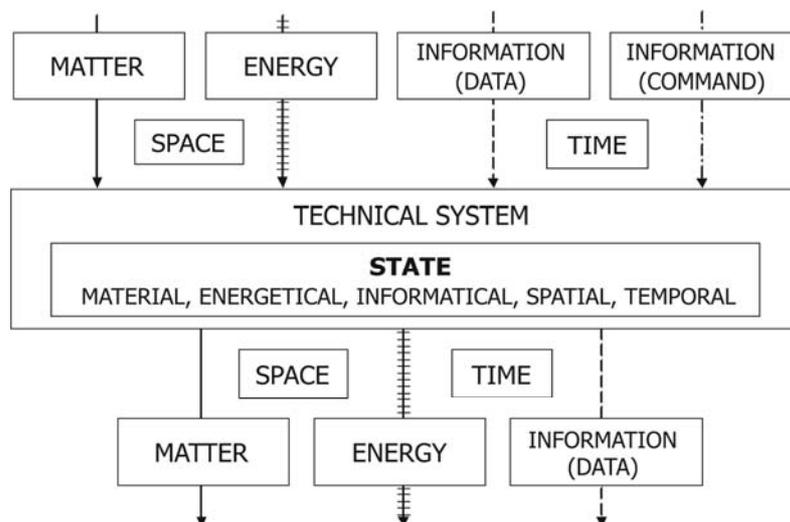


Figure 1. Technical system of things. After Ropohl [3].

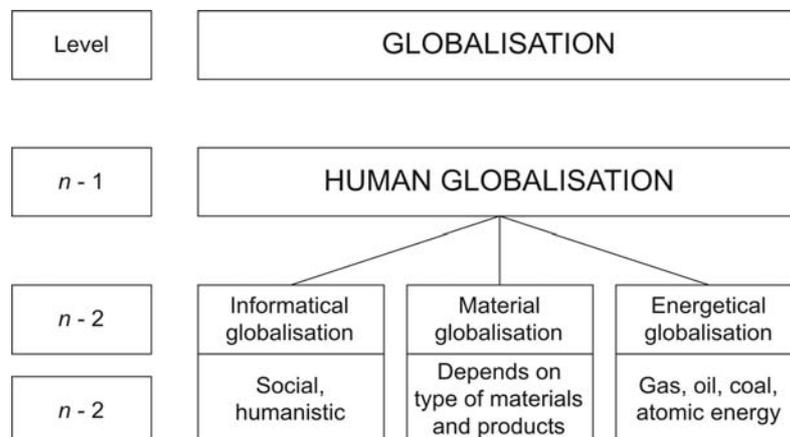


Figure 2. Globalisation as an active system. After Čatić and Rujnić-Sokele [1].

It is interesting to make a question: since when do human globalizations exist? Globalizations are very old phenomena. For example, some of the earlier material globalizations are spreading of indigo, *Silk Road* or *Rubber Road*, while the examples of early information globalizations include the spreading of Christianity, philosophy and the Roman judicial system. Today, it is the spreading of knowledge and cognition. An example of energy globalization comes from the wider use of atomic energy.

Space and time have an important role in globalization. All the globalizations spread their influence in the known world. For example, Christianity spread to the new world with its discovery in the 15th century. Globalizations had been spreading with the speed of transmitting information, energy and goods (mass). Today, thanks to the global network of optical cables (strong influence of plastics and rubber on this network) the information can be transmitted in real time, plus the time necessary for transport of signal. Thanks to modern transport means (e.g. aircraft) a big portion of goods can be transferred all over the world within 24 hours.

IMPORTANCE OF ARCHAEOLOGY

The oldest globalization processes are documented in the archaeological record and studied by Archaeology. Wikipedia defines it as follows: Archaeology, archeology, or archæology (from Greek *αρχαιολογία*, *archaiologia* – *αρχαῖος*, *archaios*, "primal, ancient, old"; and *-λογία*, *-logia*) is the science that studies *human cultures* through the recovery, documentation, analysis, and interpretation of *material remains* and environmental data, including architecture, *artefacts*, features, biofacts, and landscapes. Because the main aim of archaeology is to understand human behaviour, it is also a humanistic endeavour [12]. However, there is much disagreement among scientists how to define the scope of archaeology. The crucial question is whether we are talking about the so-called exact science, or archaeology is in its core more like art history and similar humanistic studies that are considered not to be exact in the same way as the natural sciences. The frontrunners of the so-called "new archaeology", the processualists, defined archaeology in the 1960s as a science, even more, an exact science, and have added a number of methods used previously by natural sciences. A more traditional approach to study in archaeology, based on empiricism, has been replaced by positivism and deductive approach. Postprocessualists, however, discard the limited, scientific definition of archaeology and see it as a social, not natural science, while emphasizing the subjectivity of the interpretation [13].

We understand that the word archaeology has a much broader meaning. For us, archaeology is a common name for *archaeology of nature* (natural science) and archaeology of humanistic endeavour, *archaeology of human culture*. Because two human cultures, *material* (human), and *spiritual* (human) culture exist, we are interested in the history of material culture, as seen in the process of production of artefacts [14]. This is really a study of the earliest history of material culture, starting with the production of the first artefact, such as stone choppers, chopping tools, and flakes (products) ~ 2.6 million years ago [15]. It is to the archaeologists, researches of ancient culture and technology, the contemporary production and material engineers must thank for the knowledge on the early technology.

GLOBALIZATION OF STONE TOOLS

Having in mind the knowledge collected during the analysis of the influence of rubber and plastics on globalization, we found some interesting points in Semaw's paper, such as locations where the first stone choppers were found [4].

Here we will briefly review the earliest data on stone tools and try to reconstruct *the first human globalisation road* i.e. the spreading of stone tool industry that took place in Africa between 2,6 and 1,6 million years ago. Further, we will mention the globalization of later stone tools that spread from Africa to Asia and Europe.

The evidence for the production of the first stone choppers (Fig. 3) comes from the site of *Gona* in Ethiopia (2,6 million years ago) [4], followed by several sites (see Fig. 4) including West Turkana in Kenya ($2,34 \pm 0,4$ million years) [16], *Olduvai* in Tanzania, *Kobi Fora*, West Turkana and *Chemoigut* (Chesowanja) in Kenia, Swartkrans and Sterkfontain in South Africa (between 2 and 1,6 million years) [17, 18]. The site of Olduvai gave a name to the earliest industry, the Oldowan. According to Google Earth, air distance between Gona and West Turkana is about 820 km, between West Turkana and Olduvai is about 620 km, and between Olduvai and Sterkfontain is about 2800 km. Therefore, *the first globalization road* that saw the spread of knowledge (i.e. the tool production tradition) from the East to the South Africa (about 4000 km air distance between Gona and Sterkfontain sites) took roughly half a million years [18].

The process of production of these tools is rather a simple one, in which one stone is struck by another, whether on one side only (production of choppers) or from both sides (production of chopping tools) [19]. It is another interesting question whether we can use the classification of manufacturing procedures according to the German standard DIN 8580 to describe the manufacturing process of first flakes and choppers [20].

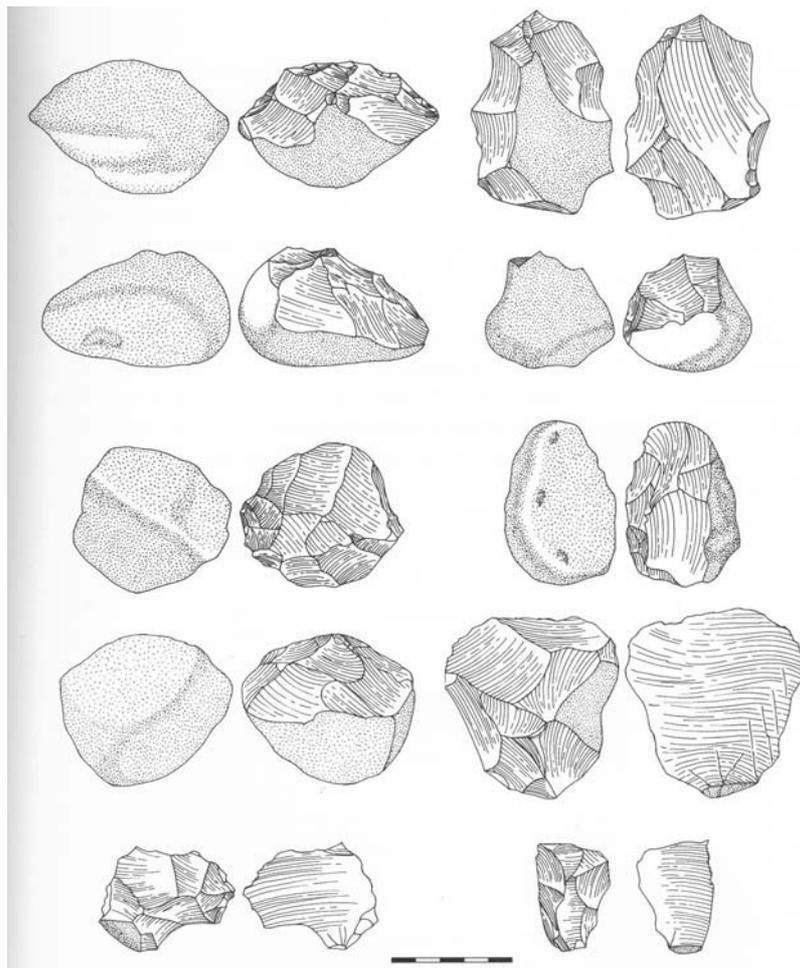


Figure 3. First stone tools from Gona, Ethiopia. Modified after Semaw [4], Fig. 8. Drawing by S. Kovačić. Scale is in mm.

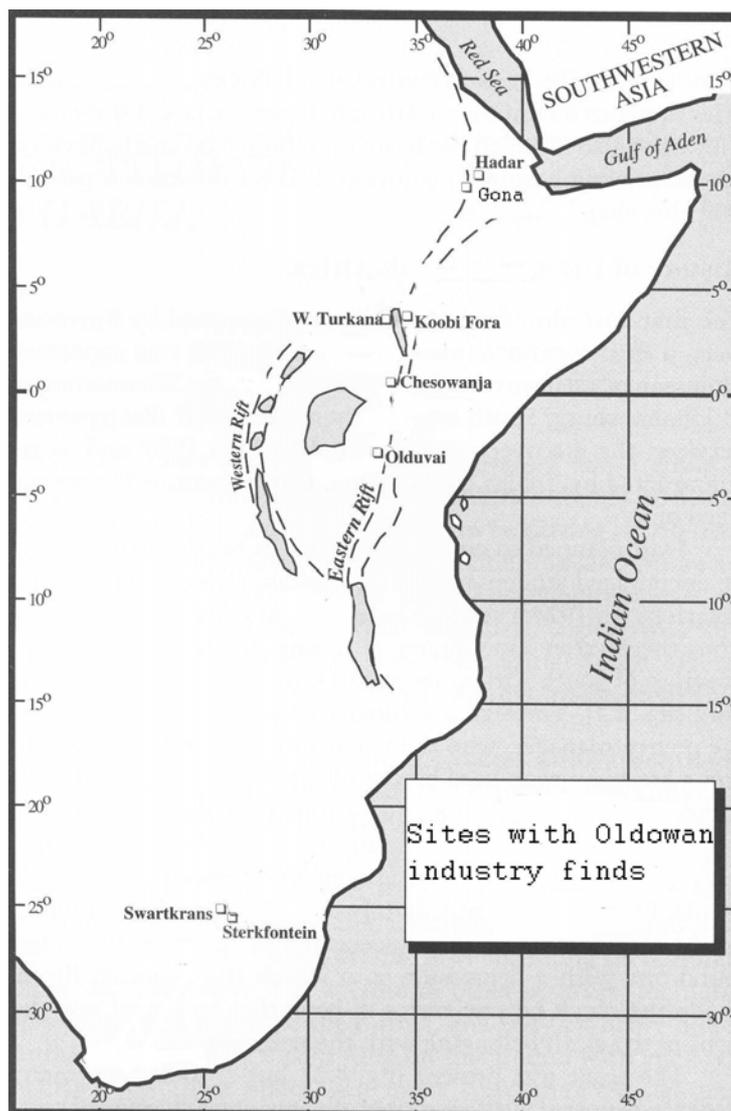


Figure 4. Location where some of the earliest stone tools were found. Based on [18], Fig 4.1.

According to DIN 8580 standard, the manufacturing processes are divided into six main groups. Here, we are more interested in the procedures of separation or mechanical processing. The separation can be divided into parting, cutting and ablating procedures, respectively.

The making of first tools consists of parting. First *hominin* toolmakers used pebbles as a *hard hammer* for knapping, while another pebble was used for the production of the tool itself [19, 21]. Later in time, during the *Acheulean culture* (named after the eponymous site of St. Acheul in France), at roughly 700 000 years before present it was realized that stone raw material can be also knapped using softer (organic) material, which led to the introduction of *soft hammers* (horn, bone, or wood) [22]. *Acheulean culture* developed within the framework of earlier Oldowan of the African continent, about 1.65 million years ago [18]. Typical tool type for this culture is the hand axe, a bifacial processed almond-shaped stone which could have been used for number of tasks (multifunctional tool) (Fig. 5) [23]. Interestingly, the first industry in Europe and Asia is Oldowan, not Acheulean. Later, Acheulean is found throughout Europe and Western Asia, representing second globalization of material culture, spreading on three continents. It is within the framework of this culture that the first successful processing of polymers can be seen (wood and bone) [24-27], although some simpler artefacts made of polymers can be found much earlier [18].



Figure 5. Acheulean hand axe from Spain. Photo by I. Karavanić. Scale is in cm.

SEPARATION STARTS WITH BIOPOLYMERS

We believe that the first use of manufactured stone tools was for parting, breaking of animal bones in order to obtain bone marrow, and for cutting of animal remains. However, we also

believe that the naturally broken stones with sharp edges were used for the mentioned purposes, at the same time or before the first tools were manufactured by *hominins*. For example, at the site of Bouri in Ethiopia, broken animal bones showing stone-tool cut marks were found, demonstrating that this type of behaviour was older than 2,5 million years [28]. Further more, bones showing stone-tool cut marks and percussion marks, older than 3,39 million years, were found recently at Dikika, Ethiopia [29].

Although the use of modified bones and antlers as tools is documented as early as 2 millions year ago [18], one of the oldest wooden artefacts, a 2,3 m long spear from Schöningen, Germany, is *only* 400 000 years old and is ascribed to the Acheulean culture [24, 25]. It was manufactured through the use of stone tool (Fig. 6). Wooden and bone artefacts from Lower Palaeolithic are rare [18, 25-27, 30], but one has to bear in mind that the organic materials rarely survive, therefore we can assume they were more abundant than we have data on.

We must stress here one very important thing. Both wooden and bone finds were made of natural materials, natural polymers, biopolymers. The term natural polymers is not sufficient to stress the distinction, as wood is a phytopolymer, the organic material plant origin, while bone is animal natural polymer.



Figure 6. Wooden spear II, 2.3 m long from Schöningen, Germany, dated to 400 000 years ago [25]. The throwing distance for this spear was 60 to 80 m [26].

CONCLUSION

Discovery and invention are not the same things, and the discovery always precedes the invention. The invention of how to produce first tools was preceded the experience gained from use of *natural tools*. This could mean that the early *hominines* first used naturally sharpened stones and other natural materials, before they realized (possibly through hitting one stone on another) how to produce these artefacts themselves. Therefore, we can assume that the mechanical processing, separation of natural polymers is a very old process, such as the production of the first stone tools, or even older (if natural stone pieces were used as tools for breaking of bones and cutting of animal remains).

Based on the theory of systems, we have analyzed the globalization as a very old phenomenon and found some of the answers to the question of how old the globalization is. We hypothetically define the first material globalization way as *the Stone tools Road*, indicating main points in the spread of the knowledge of how to make stone choppers and flakes: Gona (Ethiopia), W. Turkana (Kenya), Olduvai (Tanzania), Sterkfontain and Swartkrans (South Africa). Although the path of the spread of first stone tools, globally speaking, seems almost linear, it does not exclude radiational pattern of spread of knowledge between groups on smaller distances. Further more, it also does not exclude the possibility that the same inventions may have independently appeared among different groups of hominines in different regions and time periods.

Although production and use of organic materials is a very old phenomenon, the production of more sophisticated tools made of antlers, bone, and wood developed much later in time. However, scholars that discovered these ancient wood and bone artefacts did not describe them as polymers. While the discovery of these finds can be described in synthesiological approach as the *Type 1 basic research*, our conclusion that these artefacts were made of natural polymers, more precisely, of phytopolymer and animal polymer can be regarded as *Type 2 basic research*. This result suggests that we need to establish a new systematization of polymers, what is a subject of another paper [31].

This paper is just a starting point for a more detailed study of stone tools globalization ways and early Palaeolithic processing of polymers that require an active collaboration with archaeologists, more precisely, the researchers of early technology.

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REFERENCES

- [1] Čatić, I. and Rujnić-Sokele, M.: *Plastics and Rubber in Globalisation*. In Croatian. In: Kukoč, M., Ed.: Proceedings, 17th Days of Frane Petrić, 69-70. Croatian Philosophic Society, 2008,
- [2] Čatić, I.: *Influence of rubber and plastics on globalisation*. Materials World **16**(10) 3, 2008,
- [3] Ropohl, G.: *Allgemeine Technologie, Eine Systemanalyse der Technik*. 3rd revised edition. Universitätsverlag Karlsruhe, Karlsruhe, 2009.
- [4] Semaw, S.: *The World's Oldest Stone Artefacts from Gona, Ethiopia: Their Implications for Understanding Stone Technology and Patterns of Human Evolution Between 2.6-1.5 Million Years Ago*. Journal of Archaeological Science **27**, 1197-1214, 2000,
- [5] Gogos, C.: *Polymer engineering: taking stock of the past, a look at the present and pondering the future*. Plenary lecture. 2005 SPE International Award, Boston, May 2, 2005,
- [6] various authors: *Globalisation*. <http://en.wikipedia.org/wiki/Globalization>, accessed 17 September 2009,
- [7] various authors: *Gleichschaltung*. <http://de.wikipedia.org/wiki/Gleichschaltung>, accessed 5 September 2009,

- [8] Yoshikawa, H.: *Synthesiology as sustainability science*. Sustainability Science **3**(2), 169-170, 2008, <http://www.springerlink.com/content/w52h600744623372>,
- [9] Šikić, I.: *Synthesiologia*. www.synthesiology.com,
- [10] Čatić, I.: *Project Application of theory of systems in analysis of general technology*. Ministry of Science, Education and Sports of the Republic of Croatia (2007-2009).
- [11] Čatić, I. and Rujnić-Sokele, M.: *Globalisation of Tools*. ICIT&MPT 2009, TECOS, Ljubljana, October 5-7, 2009, Proceedings, 345-350, 2009,
- [12] various authors: *Archaeology*. <http://en.wikipedia.org/wiki/Archaeology>, accessed 30 October 2009,
- [13] Dark, K.R.: *Theoretical Archaeology*. Ithaca, Cornell University Press, 1995.
- [14] Čatić, I. and Rujnić-Sokele, M.: *Globalisation – ancient or modern phenomenon*. In Croatian. Public lecture, Europski dom, Zagreb, October 15th, 2008,
- [15] Semaw, S. et al.: *2.5-million-year-old stone tool from Gona, Ethiopia*. Nature **385**, 333-336, 1997,
- [16] Roche, H. et al.: *Early hominid stone tool production and technical skill 2.34 Myr ago in West Turkana, Kenya*. Nature **399**, 57-60, 1999,
- [17] Leakey, M.D.: *Olduvai Gorge*. Vol. III. London, Cambridge University Press, 1971,
- [18] Klein, R.G.: *Human Career: Human Biological and Cultural Origins*. The University of Chicago Press, Chicago and London, 1999,
- [19] Toth, N.: *The first technology*. Scientific American **256**(4), 104-113, 1987,
- [20] -: DIN 8589. <http://de.wikipedia.org/wiki/Fertigungsverfahren>, 2009,
- [21] Schick, K.D. and Toth, N.: *Making Silent Stones Speak*. New York: Simon and Schuster, 1994,
- [22] Inizan, M.-L., Roche, H. and Tixier, J.: *Technology of Knapped Stone*. Meudon, CREP, 1992,
- [23] Janković, I. and Karavanić, I.: *Dawn of humankind: beginnings of our biological and cultural development*. In Croatian. Zagreb, Školska knjiga, 2009,
- [24] N.N.: *Balanced spear*. In Croatian. Vjesnik, September 10th, 1997,
- [25] Thieme, H.: *Lower Palaeolithic hunting spears from Germany*. Nature **385**, 807-811, 1997,
- [26] Clark, J.D.: *Kalambo Falls Prehistoric Site*. Vol. 3. Cambridge, Cambridge University Press, 2001,
- [27] Inbar, N.G.: *The Acheulian Site of Gesher Benot Ya'Aqov, Israel: The Wood Assemblage*. Gesher Benot Ya'aqov Monograph Series. Oxford, Oxbow Books, 2002,
- [28] de Heinzelin et al.: *Environment and behavior of 2.5-million-year-old Bouri hominids*. Science **284**, 625-629, 1999,
- [29] McPherron, S.P. et al.: *Evidence for stone-tool-assisted consumption of animal tissues before 3.39 million years ago at Dikika, Ethiopia*. Nature **466**, 857-860, 2010,

[30] Villa, P. and d'Errico, F.: *Bone and ivory points in the Lower and Middle Paleolithic of Europe*.
Journal of Human Evolution **41**, 69-112, 2001,

[31] Čatić, I. et al.: *Systematization of polymers – from natural to artificial products*.
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GLOBALIZACIJA KAMENIH ALATKI I POČETAK MEHANIČKE OBRADE POLIMERA

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SAŽETAK

Na temelju istraživanja o utjecaju gume i plastike na globalizaciju nametnulo se pitanje o mogućnosti prepoznavanja prvog globalizacijskog puta materijalne kulture. Najstariji kameni alati potječu s nalazišta Gona u Etiopiji (starost 2,6 milijuna godina), a potom slijedi niz nalazišta uključujući Zapadnu Turkanu u Keniji (starost $2,34 \pm 0,4$ milijuna godina), Olduvai u Tanzaniji i Sterkfontein u Južnoafričkoj Republici (starost 2,0 - 1,6 milijuna godina.). Proizvodi s tih nalazišta su prva rezala, odnosno sjekači, sjeckala i odbojci. To širenje izradbe kamenih alata autori su nazvali putem kamenih alata.

Polazeći od zakonitosti sintezologije, koristeći znanja arheologije, proizvodne tehnike i polimerstva, postavlja se pitanje namjene tih alata. Oni su se dokazano rabili za postupke odvajanja prirodnih polimera životinjskog porijekla: rasijecanje kostiju da bi se došlo do srži i rezanje strvina.

KLJUČNE RIJEČI

globalizacija, put kamenih alatki, mehaničko procesiranje, prirodni polimeri