FLUVIAL-AEOLIAN SANDS IN CROATIA. ENVIRONMENTAL HISTORY CASE STUDY: DJURDJEVAC SANDS (ĐURĐEVAČKI PIJESCI)

FLUVIJALNO-EOLSKI PIJESCI U HRVATSKOJ. PRIMJER POVIJESTI OKOLIŠA: ĐURĐEVAČKI PIJESCI

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SUMMARY

This paper deals with sand dunes area of fluvial and aeolian origins in South-East Europe, the northwest of Croatia, nearby the small town of Djurdjevac, due northeast of Zagreb, the capital of Croatia, close to the Hungarian state border. These sands cover an area of approximately 1000km^2 owing to combined effects of fluvial and aeolian processes during the Quaternary Period. Based on research of aeolian sheet sands on a greater region of Pannonian Valley, we can establish three stages of fluvial and aeolian formation of sand accumulation in Croatia: Stage1: approx. twenty thousand years ago (Würm glacial, the last Ice Age); stage2: Older Holocene; stage3: triggered by man and prolonged well into the Early Modern Period. This paper will deal with this third stage. Based on contemporary level of research, medieval archives do not provide any notice of «open» sands in this area; they might have been covered by humus before the Middle Ages. Under the influence of man, in the Early Modern Period (17th and 18th centuries) connective stems of plants (roots) gradually disappeared. There was aeolian erosion, so the sands reappeared on the surface. This brought up the issue of viable, sustainable development or rather, unsustainable one: is reappearance of Croatian sands (that previously had been under the humus layers) an example of disturbed ecosystem? As we consider the previous 'coexistence' of local population here with the sands, it's logical to assume that early medieval 'reappearance' of sand dunes wasn't just due to anthropogenous factor, but also to climate changes as well? The author leaves a door open to assumptions, that anthropogenous factors here, in the manner that change in economies (and/or new techniques and agrarian methods, as well as introduction of new plants) here influenced creation of «bare» sands, its resurface and move. It took great efforts to reattach these «bare» sands; the efforts put in motion since the late 19th century onwards. The plants that were introduced in the sand zone were quickly adjusting to the new terrain and life on sands. These plants enabled creation of humus substrate in the soil here. Slowly the new fertile lands appeared on the layers of sand, which in the 20th century grew with forest and grass vegetation and various agricultural crops; the sands

here were covered various flora and fauna, quite atypical for other regions of Croatia. It's important to notice how stopping of aeolian sheet layers, that had begun in the 19th century, is now revived and undergoing process until present day, by planting pine trees and spreading pine forests.

Key words: environmental history, Croatia, early modern period, pijesci, povijesna geografija, Đurđevac

Ključne riječi: povijest okoliša, Hrvatska, rani novi vijek, sands, historical geography, Đurđevac

INTRODUCTION - EOLIAN SANDS IN CROATIA IN GENERAL

The surface of eolian sands in northwestern Croatia (southeastern Europe) is the area of approx. 1000km^2. Named after the closest town (Djurdjevac), the Djurdjevac Sands in the northwest of Croatia, bordering Hungary, consist of 15-40m thick layers of sand on the outer rims, and the deepest dunes go to 80m-deep sand layers. The sand layer is 10-0m higher than the neighboring wetland soil. Sand terrain is curly and waved (sand shelves changing into banks, swales and ditches). Under the main northwesterly and southwesterly winds, these wind-formed sand dunes are mainly shaped in meridian, longitudinally direction, usually exceeding sand swales by 4-5m. The highest point of the sands is a dune east of the town of Djurdjevac.

Djurdjevac dunes were deposited through combined effects of fluvial and eolian processes during Quaternary period and its two geologic epochs: the Pleistocene and the Holocene epochs. The dunes could be considered the ultimate southern extension of far greater sand desert in Hungary's southern province Somogy, thus their genesis should be considered as related and interlinked. Here we have numerous distinct characteristics of sand dune (up to 30m of relative elevation), a parabolic, crescent-elongated shape, with sand ditches and swales formed through sand blow-off of Drava river sediment.

Most of the surface sands are related to accumulating eolian activities during Holocene period. These sediments either sit on older Pleistocene sands or were brought as fluvial deposits, mostly consisting of Drava river pebble, gravel and sands. At certain spots, eolian sands are horizontally turned into wavy, sandy clay, particularly where sand dunes make contact with alluvial plain. Similar to Pleistocene deposits, here, too, we have wind-borne sands of fluvial «paleodrava». On the «cliffs» of sand dunes, there's a dominating coarse-granulated material, while swales and hollows between the dunes have accumulated sand clay, unless particularly distinct linear-deflated hollows. Slanted multilayers in these dunes undoubtedly show eolian activities from the west and northwest.

Sand deposits there are identical to those of the neighboring Hungarian provinces on the other side of Drava river- Somogy and Zala- south of Balaton Lake and Danube-Tisa interamnia, between the two rivers, as well as Hungarian Nyírség (upper Potisje). These are sediments made by wind (Eolian erosion), majority formed from the turn of Ice Age (Pleistocene) into our era (Holocene), or rather, in Neolithic Period.

Based on Eolian sands research in a greater Pannonian Valley, we can establish three phases of Drava river eolian sand accumulation. The first one is from some 20 thousand years ago (Würm Glaciations maximum), or the last glacial period. The second phase was older Holocene and the third phase is influenced by human civilization and going all the way to Early modern period.

In Pleistocene, the glacial frontier reached the eastern rims of the Alps. Glaciers here moved huge deposits of various glacially formed accumulation of unconsolidated glacial debris (final moraine of soil and rock). Turning to Holocene period, glaciers started to melt. Rivers formed from glaciers meltdown were carrying (in this case, Drava River) fluvial drift, eroding lots of material from the Alps into the Pannonian Valley. Due to temperature difference, strong winds eroded silt-like debris of soil and sand from these final moraines and river alluvial deposits and re-deposited them in various parts of the Pannonian Valley. This is how winds helped huge deposits of sands be formed. Soon after, a relatively humid climate of the area (approx. 850mm of annual precipitation) helped the sands to grow vegetation.

The most recent research has confirmed how the genesis of Podravina sands could be tied to the oldest Holocene period, or rather, to the intensive climate changes on the turn of Ice Age (Pleistocene) into the current geological epoch (Holocene).

These deposits of fossil dunes have obvious fluvial origin that were, at the end of Würm period and early Holocene shifted and re-deposited by winds - through eolian erosion - forming a shallow, wavy relief of low Djurdjevac dunes. Morphogenesis of these sands is firmly linked to great Pleistocene glacial-fluvial south of Bakonyi Petrified Forest in Hungary, which, at the end of Würm and early Holocene period, was subjected to strong eolian erosion and partially reached Podravina region here. Because of the climate change and glacier melting, vast amounts of melted ice and snow from the Alps in redundant streams flooded and carried huge piles of soil material toward the Pannonian Valley.

On the rims of the Alps, in today's western Hungary in particular, there had been huge flooding which later added up to final moraines from earlier Pleistocene glacial movement. Winds were picking up material from the flooded surface, small grains of sand and other stuff, bringing it to Pannonian Valley. In those times, year-round cold winds from the frozen Alps were bringing down thick, heavy and cold air, that warmed up and became thinner over the Pannonian Valley, lifting up to higher planes. The Alps winds were eastwardly, bringing from the final moraines and flooded areas (Eolian erosion) vast amounts of alluvial sediments. This is how younger loess eolian sediments and sands were formed across the Pannonian Valley and in Hungary in particular. A smaller relict of those is our Djurdjevac sands.

According to pollen analysis of plants that had grown in Holocene period, we can conclude that during the eolian sands sediment, the most represented widely spread were herbaceous plants (herbs). Prevailing vegetation was the one characteristic for prairies and marshes. Certain, smaller traces of acicular trees pollens (pine, fir tree) were found too. The most common northwesterly and westerly winds, ever-present to this day, influenced the direction of sand dunes and their re-shifting and reshaping.

We should bear in mind that in the first millennia these sands were moving, quick sands that wind drifted, carried and molded into true desert morphology - with dunes, even barhana. Due to geographical latitude-owed moderate climate that had formed here, relatively solid precipitation occurred. This affected the stabilization and taming of quick sands - the terrain got specific vegetation, adapting to sandy soil.

MIDDLE AGES - SANDS WERE COVERED WITH HUMUS SURFACE

Based on current research results, we conclude that medieval sources don't mention «open» sands in this region. The lack of mention does not mean sands weren't there at some point in the medieval period. It seems logical to back up the theory that «quick sands» weren't there even at

the end of the Middle Ages. The reliable sources mention the village of Molve (north of Djurdjevac), and it's possible that other settlements were there too. As Molve is a relatively old village mentioned back as early as mid 14th century, it's obvious the population of Molve in a way had developed a sort of a «coexistence with sands».

The similar situation is with today's village of Kalinovec (east of Djurdjevac). The archeologists have found grave sites, dating back to medieval times, on a today's sand dune. The very existence of the graves refers to a nearby church and a settlement in vicinity of the sands area. West of the found graves there was a swamp. The soil bed of this swamp terrain has a 4-8m thick layer of clay.

When it comes to Djurdjevac sands, one issue remains unanswered. Two medieval settlements had existed in the vicinity of Djurdjevac sands, however, both on non-sandy soil nearby Drava River. A document, dating to the late 14th century, mentions a theft of vine, stolen from Djurdjevac feudal manors. We can ask ourselves- where was the location of the vineyards, the wine was stolen from? As both villages had been nearby Drava River, it would not be logical to expect the vineyards on the hill slopes of distant Bilogora. The same reasoning can help us eliminate hill slopes in today's Hungary as potential vineyards location. The only place logical is the humus soil covering Djurdjevac sands.

It's obvious that further to abandoning these vineyards, located on the sand dunes near Djurdjevac in 16th century, the soil was slowly left to erode and later on, the winds that too could have opened up and «unearthed» the sands. In any case, to solve the mystery in the near future we would need comprehensive, systematic research of medieval localities and sites currently occupied by the sands.

»UNEARTHING« OF THE SANDS IN 17TH CENTURY

Here we have opened up an issue of so-called *sustainable development* or rather, is «unearthing» of Djurdjevac sands an example of irresponsible human behavior and so-called *unsustainable development*; or, is it a combination this and climate change, that has sped things up? It seems that at a certain point in the early modern times here we had dissonance and disturbance of equilibrium between man and his environment, resulting in «unearthing» the sands and its further uncontrolled spreading, restrained only on the turn of 19th to 20th century.

The situation is similar to the one in the sands of Deliblatska Pescara (Vojvodina region, in Serbia): as late as second-half of 18th century, it was a green area with forests and meadows, until a human secondary colonization destroyed vegetative cover layers, thus enabling formation of bare sands. There's little to read about this, even the 1552-1684 chronicles covering Ottoman invasions have no mention of quick sands, which leads to conclusion that there had not been any before.

Destructive anthropogenic processes had greatly influenced the latest genesis of Djurdjevac sands; extensive pasture, clearing of woods helped Eolian erosion, otherwise totally dormant and inactive in this post-glacial period (due to increase of humidity and spread of thick vegetation), to take effect. It's shown in lithostratigraphy profiles of individual dunes. All Pleistocene-created dunes have relatively thick layer of soil cover, and in younger dunes it's completely missing.

Additionally, we should take into account increased population numbers in settlements close to the sands, most probably in late 17th (surely during 18th century) influenced «unearthing» of sand dunes. After the vegetation linkage (roots) had disappeared, Eolian erosion took effect again and resurfacing of the sands.

17th century cartographic sources can help out re-create reconstruction of 17th century approximate appearance of the sands. Mid 17th century sources have provided 2 maps, both very descriptive of mid 17th century Djurdjevac greater area. It's interesting to notice absence of forest and woods around Djurdjevac, confirming the hypothesis that they had been cleared out in the sands area in early 17th century, most probably for defense purposes. Greater woods were covering the land alongside Drava River, terrain without military border strongholds. Start of colonization processes could be seen from sources telling of several settlements being formed. There is a mark on the map of desolate St. Mary church between Koprivnicka rijeka (Koprivnica stream) and Drava River, nearly halfway between Koprivnica and Djurdjevac; another one, marked as Rothernthurn, represents the area south of Djurdjevac that was beginning with settlement.

The 1673 map shows the area north of Djurdjevac an ait, an isle of a sort, a river sediment deposition between Drava flow and an eastward tributary stream. This depiction of Djurdjevac is identical to the situation some hundred years later, when secret maps showed sandy soil. This map has a marked area, between Djurdjevac and Molve, alongside western rim (that later were marshes), depicting sands.

After the Ottomans had left, the population from neighboring marshes and woods began returning to their «hearth», to their livestock and farming. However, through different activities on the land - wood clearing mostly, cutting down timber, cattle grazing - soil was bare and the sands became active, moving and turning from «alive» to «quick sands». Humans, again, caused repetition and reinforcement of eolian erosion and endangered survival again with unfavorable living conditions.

Once the sands terrain was repopulated and new settlements were formed, the «opening of sands» under anthropogenic influence occurred, probably helped by climate and hydrographic situation. Newly settled population engaged in intensive livestock raising, using the sands terrain for grazing. This is how the sands surfaced and the winds would shape dunes, and free the sands, creating ridges that could not be covered with vegetation, due to constant winds. Destroying and clearing of woods, cattle grazing and cart wheels leaving marks in the sand made it possible to keep it barren.

Local eolian and fluvial erosions were of importance in helping the sands to propagate and spread. The erosive processes significantly influenced today's micro morphology of Djurdjevac sands. More recent unearthing of the sands was strongly affected by destruction factors, too. This particularly applies to intensive settlement of the neighboring areas in Drava valley. Before the intensive grazing, wood clearing and scorching the land- the sands were completely tamed and stable.

It's pretty certain that human activities actuated eolian erosion; but- was it the human factor only? During the Middle Ages, people had lived here too, but historic documents have no mention of the surface sands. A thought, worth saying out loud- how come that medieval population never started eolian erosion? I doubt the medieval population was able to develop a special form of «coexistence» with the sands, significantly different from medieval way of life.

So, it's possible that some other factors enabled «resurface of the sands» in the Early modern times. To factors like human activities, we could probably add up the climate change, particularly so since the period of the Early modern times mostly overlap with so-called «Little Ice Age». This is why we should probably be looking for the reasons of «reopening of sands» in combined effects of the climate and man. However, future multidisciplinary research should definitely either confirm or reject this theory.

When we analyze the military maps of Djurdjevac regiment from the late 18th century, we can establish the existence and spreading of the sands in different areas around Djurdjevac. The big-

gest sand complex was north and east of Djurdjevac, as the maps strictly call these sand dunes. At the end of 18th century, the road travel from Djurdjevac to Molve, «across the sand dunes», was impossible whenever the weather was bad. Yet, heavy transport vehicles enabled the crossing of the sand dunes at any weather. All other roads, heading from the village and through the marshes (...) are passable with light carts only during hot, dry summers, when the marshes would be dried out; in wet weather, the roads were without firm ground and in heavy rains completely impassable». This is why people commuting between Molve and Djurdjevac were forced to use passage through the sands terrain, and folk tale even mentions occurrence of regular sand storms.

The next account with the sands was recorded by Djurdjevac teachers Anka and Milan Poljak in the year 1900, having recorded, among other things, the following: «Behind these meadows, that spread some 10 hours of walk to the north, there are the Sands, similar to African Sahara. The sands are spread from the northwest, with the village of Molve of an hour walking distance; to the southeast, with Kalinovac, also at one hour walking distance, that lies eastwardly; the sands surround Djurdjevac from the north and east and a fifth of Djurdjevac is within the sands already, as poor people settle down here, with their homes and gardens at small cost (...) yet, when the high winds blow, sand storms hurl and swirl the sands around, making ditches and hollows, piles and dunes and so on (...)»

Winds were easily lifting and moving around the particles of sand, so the relatively large sections of the sand terrains were slowly spreading and turning into «quicksand» sand desert. Similar cases of this development could be found in the sand desert Deliblatska pescara (Vojvodina province, Serbia), the most expressive example of continental «quick sands» in Europe.

Communication and commuting of peasants from big villages in southward terraces across the Podravina sands, that constantly moved around by eolian erosion, was difficult; particularly hard for them was to plow fields, use meadows and woods in northwardly laid alluvial soils by Drava river. Cart rigs had difficulty crossing the terrain from Novigrad, Virje, Djurdjevac or Kalinovac to Drava river, and then peasants formed caravan and cattle stopovers. These scattered stopover shelters, that first had been used for shepherds from spring to fall season, and thanks to breakup and division of family cooperatives later on (mainly by the end of 19th century), were turned into permanent hamlets. Even today there are still folk legends and tales of ´bloodied sands', as carts and people would disappear in sand storms.

REFORESTATION AND »CLOSING« OF THE SANDS

In recent times, the sands have mainly been covered with trees and bushes. The sands have developed specific flora and fauna, completely atypical and unlike other terrains of Varazdin Generalate and Krizevci county. Since 19th century, in fighting back the «quicksand», great systematic efforts have been undertaken to re-conquer the soil from the sands. In planting vegetation that can adapt easily to these sands, a great success has been achieved with acacia shrubs and trees (with large root surface that prevents migration of sand). These plants have enabled formation of humus substrate to feed the soil and make it fertile; in 20th century, the sands were planted with forest and grass vegetation, as well as various agricultural plants.

The first reforestation of the sands dates back to late 19th century, and relates to windscreen shielding (part of woods) from the sands, and starting grapes hybrids and vineyards. This first windscreen of wood was formed from planting black and silver pine trees, as well as acacia. During the calming down of sands and after the sands had settled, reforestation with black and silver pine and acacia trees continued. Settling down of the sands was done in a mechanical and a bio-

logical, or both ways at the same time. The mechanical ways prevented the sands from moving around by setting (digging in) boughs, and branches of common gorse, broom, alder shrubs etc.; biologically, it was done through sowing grasses (graminoids). The first seeds were acquired from the sand desert Deliblatska pescara, where it had been originally used to link quick sands to the firmer ground and later, own vegetation was used.

Out of many various types and technical methods of taming, linking and settling of the quick sands, the applied method was the one, successful in other European quicksand terrains; particularly successful was the one, applied in Deliblatska pescara desert. The experts used practical knowledge and experiences, as well as the basic principles of applied sciences, and started off the reforestation of the sands in four stages:

I. stage - scarping (terrain leveling of surface)

II. stage - sand settling

III. stage - planting of acacia shrubs

IV. stage - replacement of acacia with pine

These works that were undertaken in 20th century solved the problem of quick sands in the vicinity of Djurdjevac. A part of the sands, however, has been preserved and protected and in 1963 a part of unforested Djurdjevac sands was proclaimed the unique reserve and geographical-botanical park.

SAŽETAK

U radu se prikazuje pješčano područje fluvijalno-eolskog nastanka na sjeveru Hrvatske (u blizini grada Đurđevca, sjeveroistočno od Zagreba) na granici sa Mađarskom. Ovi pijesci se protežu na oko 1000 km^2. Ovi pijesci svoj nastanak zahvaljuju kombiniranom djelovanju fluvijalnih i eolskih procesa tijekom kvartara. Na temelju istraživanja eolskih pijesaka na širem prostoru Panonske nizine moguće je utvrditi tri faze formiranje fluvijalno-eolskih pješčanih akumulacija u Hrvatskoj: prva faza je iz vremena od prije 20-tak tisuća godina (maksimum würmskog glacijala tj. poslednjeg ledenog doba). Druga faza pripada starijem holocenu. Treća faza je uzorokovana djelovanjem čovjeka, a njen utjecaj seže rani novi vijek. U ovom radu ću obraditi tu treću fazu. Na temelju trenutnog stupnja istraženosti u srednjovjekovnim se izvorima ne spominju «otvoreni» pijesci na ovome području te ih je prije srednjega vijeka pokrio humus. Pod utjecajem čovjeka je u ranome novom vijeku (17. i 18. stoljeće) došlo do nestanka biljnog veznog materijala (korijenja). Javila se eolska erozija pa je došlo do ponovnog javljanja pijeska na površini. Time se otvara pitanje održivog odnosno neodrživog razvoja, odnosno nije li slučaj otvaranja hrvatskih pijesaka (koji su se nalazili ispod humusnog sloja) primjer poremećaja ekosustava. Uzevši u obzir primjer «suživota» stanovništva sa pijeskom u srednjem vijeku moguće je razmišljati na način da ranonovovjekovno «otvaranje» pješčanih površina vjerojatno nije imalo samo veze s antropogenim faktorom pa možemo pretpostaviti da su uz njega vjerojatno utjecaj imale i klimatske promjene. Autor ostavlja mogućnost djelovanja antropogenih faktora na način da je promjena gospodarenja (i/ili primjena novih tehnika i agrarnih kultura) na ovim prostorima imale utjecaj na stvaranje «golog» pijeska, odnosno na njegovo otvaranje i pokretanje. Za ponovno vezivanje «golog» pijeska je trebalo mnogo napora, koji su sustavno bili provođeni od kraja 19. stoljeća. Sađene su biljke koje su se brzo prilagođavale životu na pijesku. One su omogućile stvaranje humusnog supstrata u tlu. Time je postupno stvoreno plodno tlo na površini pijeska koje je u 20. stoljeću obraslo šumskom i travnom vegetacijom te različitim poljoprivrednim kulturama, a na pijescima se razvio osebujni biljni i životinjski svijet netipičan za druge prostore Hrvatske. Vrijedi istaknuti da po-

novno umrtvljivanje eolskog rada započeto tijekom 19. stoljeća traje sve do danas širenjem umjetnih nasada borovih šuma.

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