ATMOSFERSKI UTJECAJ ERUPCIJE VULKANA LAKIJA NA HRVATSKU 1783. GODINE

ATMOSPHERIC EFFECTS OF THE LAKI ERUPTION A.D. 1783 IN CROATIA

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Na osnovu podataka prikupljenih u samostanskim kronikama autor opisuje učinke erupcije vulkana Lakija 1783. godine. Rad potvrđuje da sumporasta magla na prostoru Hrvatske nije imala nikakvih direktnih posljedica, ali je aerosol tijekom tri sljedeće godine uzrokovao klimatske anomalije.
Ključne riječi: kronika, erupcija vulkana Laki, magla, Hrvatska, klimatske anomalije

Based on data gathered from the monastery chronicles the author points out the effects of the Laki eruption in 1783. This study proves that the sulphurous fog in Croatia had no direct consequences, but the aerosol caused weather anomalies during the next three years.
Key words: chronicle, Laki eruption, fog, Croatia, climate anomalies

Uvod

Stare hrvatske kronike bilježe da je 18. stoljeće bili razdoblje ratova, gladi, kuge i klimatskih anomalija. Uistinu, 1700-e bile su godine obilježene teškoćama, ne samo s obzirom na osnovne uvjeta ljudskog zdravlja i preživljavanja. Što se tiče ratova, nije postojalo desetljeće bez manje ili više katastrofalnih vojnih sukoba. Duge snježne zime slijedile su jedna drugu kratko prekinute samo malo blažim vremenskim razdobljima. I poljoprivreda i stočarstvo bili su pod negativnim utjecajem ne samo hladnih zima već i kišovitih ili sušnih ljeta. Posljedice takvih loših vremenskih uvjeta bile su loša žetva, oskudica hrane i nerijetko glad. Uz to nekoliko je puta kuga, usprkos strogim kontrolama, prešla granicu s Bosnom (u to vrijeme dio Otomanskog Carstva) te opustošila sela i gradove (Kužić, 1999; Koplaki i dr., 2001). Niz katastrofa obično je trajao tri godine, međutim, ponavljanjem tih trogodišnjih nizova katastrofa situacija je bila nepodnošljiva. Najgore je bilo u razdoblju od 1779. do 1780. te 1784./85. Između ta dva razdoblja došlo je do erupcije islandskog vulkana Lakija.

Introduction

The old Croatian chronicles noted that the eighteenth century was a period of wars, famines, plagues and climatic anomalies. Actually, the 1700s were disturbed years, not only in relation to basic human health and survival. As regards the wars, there was no decade without more-or-less disastrous military conflicts. Long snowy winters followed one another shortly intermitted only by milder seasons. Both agriculture and cattle-breeding were affected not only by severe winters, but also by rainy or rainless summers. The consequences of such a rough weather were bad harvests, food shortages and not rarely widespread starvations. Furthermore, in spite of rigorous control, appalling plague epidemics, crossed the frontier with Bosnia (at that time part of the Ottoman Empire) and wiped out the countryside and cities (Kužić, 1999; Koplaki et al., 2001). Usually a single chain of disasterous reactions lasted for three years, but the repetition of these trienniums made conditions insufferable. The worst one was the period from 1779/80 until 1784/85, and the eruption of Icelandic Laki interpolated between these two bad periods.

Ciklus nevolja započeo je propašću žetve uzrokovanom sušom 1779. godine. Sljedeće dvije godine nisu bile nimalo bolje te je situacija postala očajnom, a glad je postala općom pojavom. Iako nije zabilježen točan broj sudeći prema sačuvanim spisima, procijenjeno je da je od gladi umrlo 20 000 osoba. Pravi razmjer katastrofe postaje jasan ukoliko znamo da je 1781. ukupan broj stanovnika Dalmacije prelazio brojku od 264 000 (PERIČIĆ, 1980).

Meteorološka objašnjenja loše žetve osnovni su pristup kojim se može utvrditi utjecaj maloga ledenog doba na ljudsku povijest. Analiza međuodnosa vremenskih prilika, žetve i gladi korisna je znanstveno-istraživačka metoda čijim je korištenjem moguće objasniti nedostatak hrane te otkriti učinkovitost države. Dobro je poznato da su nakon početka 18. st. takve krize u zapadnoj Europi postale sve rjeđe i bezopasnije. Uvođenjem novih kultura, posebno krumpira, poljoprivreda postaje sve manje osjetljiva na meteorološke prilike (MICHAELOWA, 2001; XOPLAKI I DR., 2001). Ali mletačka uprava u Dalmaciji nije bila zainteresirana za ništa drugo osim za prikupljanje poreza i sinekura. Poput odnosa Danske prema Islandu i *Serenissima* (Mletačka Republika) se prema svojoj *terri oltremare* (prekomorskim posjedima) ponašala kao prema koloniji. Primjerice, krumpir su u Dalmaciju donijeli Francuzi tijekom svoje kratkotrajne vladavine u 19. stoljeću.

U svibnju 1782. kuga se proširila otomanskom Bosnom, u Zenici, Sarajevu i Travniku. Uzbunjivanjem pograničnih snaga država je pokušala zaustaviti njezino daljnje širenje, ali su pojedinci koji su se više bojali smrti od gladi nego same bolesti, probili blokadu i prenijeli kugu prema unutrašnjosti. Prvi slučaj kuge zabilježen je u lipnju 1783. u Omišu, a ta se bolest ubrzo proširila cijelim krajem (MAKARSKI LJETOPIS, 1993). Konačno širenje kuge uz tragične posljedice zbilo se 1784. u Splitu. Usmrtila je preko 1500 osoba. Da bi se u potpunosti shvatio razmjer katastrofe, potrebno je znati da je grad Split zajedno s predgrađima u to vrijeme imao oko 9000 stanovnika (BOŽIĆ-BUŽANIĆ, 1989). Vjerojatno je da bi se ovaj ciklus nesreća završio 1785. izbijanjem rata s Turcima da država nije poduzela brze obrambene akcije koje su obeshrabrile susjedne ratoborne vođe (MAKARSKI LJETOPIS, 1993; PERIČIĆ, 1980).

Laki nije vulkan u pravom smislu te riječi. On je samo jedna u nizu uzvisina smještenih duž 25 km duge pukotine na središnjem dijelu južnog Islanda. Pukotina je dio sustava Grímsvötn te se erupcija

The cycle of miseries started with a failure of crops caused by drought in 1779. The next two years were no better, marked by desperate conditions, and the hunger became general phenomenon. Although there is no exact data, based on preserved registers, it was estimated that famine caused 20,000 fatalities. The right proportion of the consequences should be understandable, if we know that the entire population of Dalmatia in 1781 outnumbered 264,000 inhabitants (PERIČIĆ, 1980).

The meteorological explanation of bad crops is the basic approach used to determine the impact of the Little Ice Age on human history. The emphasis on weather-crop-hunger relationship provides a useful tool for analysing food shortages and reveals government efficiency. It is well known that these crises became less frequent and less violent in Western Europe after the early eighteenth century. In this period agriculture became less vulnerable in relation to meteorlogical conditions due to the introduction of new plants, particularly potato. (MICHAELOWA, 2001, XOPLAKI ET AL., 2001). But Venetian administration in Dalmatia was interested in nothing else but the tax collection and sinecures. As well as Denmark in Iceland, the *Serenissima* treated its *terra oltremare* as a colony. For instance, in Dalmatia potato was introduced by the French during their shortlived rule in the 19th century.

The plague began to rage in the Ottoman Bosnia, in Zenica, Sarajevo and Travnik in May 1782. Having raised the frontier control forces the government tried to prevent its spreading, but blockade-runners, terrified more by the starvation than by the disease, carried it over. The first case of plague appeared in June 1783 in Omiš and soon afterwards it was spread all over the province (MAKARSKI LJETOPIS, 1993). The final onslaught with tragical consequences took place in Split in 1784. The pestilence killed more than 1500 persons. To grasp the complete picture of the chatastrophe, it is necessary to know that the city of Split, including suburbs, had about 9000 inhabitants at that time (BOŽIĆ-BUŽANČIĆ, 1989). It is quite probable that this cycle of miseries would have ended after the beginning of war with Ottomans in 1785, if the government hadn't taken prompt defensive actions which discouraged neighboring warlords (MAKARSKI LJETOPIS, 1993, PERIČIĆ, 1980).

Laki is not a volcano in a traditional sense. It is only one among hills lined up along more than 25 kilometers long fissure in central part of southern Iceland. The fissure is a part of Grímsvötn system,

ponekad krivo naziva erupcijom Grímsvötn. Pored toga na Islandu erupciju nazivaju *Skaftáreldar* ili Vatre Skaftára prema istoimenoj rijeci. Konačan naziv erupcije prihvaćen je na osnovu prijedloga A. Hellanda, i to radi lakšeg izgovora (THORODDSEN, 1925).

Najpouzdaniji svjedok, župni svećenik, Jón Steingrímsson zabilježio je da je katastrofa počela u 9 sati na Duhovsku nedjelju 9. lipnja 1783. (THORODDSEN, 1925). Nakon početne faze "subplinijske" erupcije tijekom sljedećih osam mjeseci izljevna erupcija stvorila je drugu najveću količinu bazaltne lave u novije vrijeme – oko 14,7 km^3. Izljev lave "havajskog" tipa najmanje je opasan, ali ovaj je oslobodio golemu količinu plina – oko osam milijuna tona fluora te oko 122 mil. t sumpornih plinova (pretežno $S0_2$ i H_2S), koji su zajedno stvorili 200 mil. t H_2SO_4. (Budući da to nije tema ovoga rada, ne će se raspravljati o točnosti navedenih podataka dobivenih provedenim simulacijama). Raspon količine plinova procjenjuje se od 71 do 374 mil. t (OMAN I DR., 2005). Dok su se učinci vrlo otrovnog fluora osjećali na Islandu, sumporna kiselina pretvorena u aerosol proširila se diljem Europe stvarajući čudnu gustu maglu. U nekim mjestima uzrokovala je iritaciju očiju ili neugodan sumporni smrad, negdje je negativno je utjecala na biljke, metali su korodirali, dok je u Veneciji zabilježeno taloženje prašine s primjesama sumpora i željeza (THORODDSEN, 1925; LAMB, 1970). Ali vidljivi atmosferski učinci diljem Europe bili su neupitni – gdje se god magla pojavila, bila je plave ili plavkaste boje.

Mnogobrojne su rasprave o klimatskim poremećajima koji se mogu pripisati erupciji Lakija. Za početak može se spomenuti zabilješka Benjamina Franklina (FRANKLIN, 1789) u kojoj navodi da su ekstremni vremenski uvjeti možda vezani uz posljedice erupciju vulkana Hekla. U svojoj knjizi *Über die strengen Winter der letzten zwanzig Jahre des Jahrhunderts* Christoph Heinrich Pfaff pretpostavlja da je maglu uzrokovala "strašna vulkanska erupcija na Islandu, gdje je 8. lipnja novi vulkan počeo rigati vatru". Osim toga postoji još mudrih zabilješki i puno netočnih objašnjenja kao npr. u Švedskoj, gdje su ljudi mislili da je maglu uzrokovao niz uzastopnih potresa na jugu Italije u Calabriji (THORODDSEN, 1925; PFAFF, 1810).

and the eruption was sometimes misnamed as Grímsvötn Eruption. Besides, on Iceland, they call it *Skaftáreldar*, or Skaftár Fires, after local river Skaftá. Finally the name Laki Eruption was generally accepted based on suggestion made by A. Helland due to easier pronounciation (THORODDSEN, 1925).

The most reliable witness, the parish priest, Reverend Jón Steingrímsson noted that the Disaster began at nine o'clock on Whit Sunday, 8th June 1783 (THORODDSEN, 1925). After the initial phase of "sub-Plinian" eruption in the course of the next eight months the effusive eruption produced the second largest volume of molten basalt lava in modern times – about 14,7 km^3. An effusive or "Hawaiian" eruption type is the least dangerous, but this one released enormous amount of gas – about 8 million tonnes of fluorine, and about 122 million tonnes of sulphureous (mostly SO_2, and H_2S) gases, that together created 200 million tonnes of H_2SO_4. It is beyond the scope of this article to discuss critically and comprehensively the variety of available simulations. The range of estimated gas quantity is from 71 to 374 million tonnes (OMAN ET AL., 2005). While the effects of highly poisonous fluorine were noticeable in Iceland, the sulphuric acid converted to aerosol spread all over Europe forming curious undispersable fog. Locally it caused eye irritations or unpleasant sulphurous smell. At some places it damaged plants, corroded metal and in Venice sedimented dust with sulphuric and iron compounds was noticed (THORODDSEN, 1925; LAMB, 1970). But, the visible atmospheric effects of the fog represented its unquestionable characteristic – all over Europe, wherever the fog was seen it was blue of bluish.

There has been a lot of disputes on the climatic disturbances attributable to this eruption. To begin with the famous Benjamin Franklin's note (FRANKLIN, 1789) in which he suggested that the weather extremes may have been connected to the consequences of the Hekla volcano eruption. Christoph Heinrich Pfaff in his book *Über die strengen Winter der letzten zwanzig Jahre des 18. Jahrhunderts* presupposed that the fog was caused "by the terrible volcano eruption in Iceland, where on 8th June a new volcano had begun belching fire". Besides that we can find more sagacious notes, and much more erroneous explanations, such as that in Sweden where people thought that the fog was caused by the series of successive earthquakes in Calabria (South Italy) (THORODDSEN, 1925; PFAFF, 1810).

Kroničari i njihove zabilješke

Postoji nekoliko zapisa koji opisuju dva posljednja desetljeća 18. stoljeća u Hrvatskoj, a najbolji se mogu pronaći u kronikama franjevačkih samostana. Franjevci su najvećim dijelom potjecali iz lokalnog stanovništva i od njega se nisu otuđili. Stoga je vidljiv njihov utjecaj na polju naobrazbe, koja se značajnije počinje razvijati tijekom 18. st. U Dalmaciji škole su vodili crkveni redovi, a ne država. Nije čudno da je dvadeset godina kasnije Napoleonov maršal Auguste Marmont iznimno cijenio njihov utjecaj i rječitost, za razliku od pojedinih prosvjetitelja koji su se divili sami sebi te podcjenjivali franjevce (Marmont, 1856-7). U osnovi imali su istu ulogu kao i njihov islandski kolega, pjesnik Jónas Hallgrímson (Thoroddsen, 1925; Ringler, 1996-8). Štoviše, poput njega i franjevce su zanimali prirodni fenomeni. Dakako, budući da ne postoje mjerenja količine oborina, posebice usporedna mjerenja, neophodno je iskoristiti podatke o vremenu zapisane u njihovim kronikama. Takav tip dokaza učestao je i bliži načinu razmišljanja povjesničara nego znanstvenim mjerenjima. Pitanje je može li se onda iz njihovih promatranja dobiti dosljedan niz informacija koje bi bile vjerodostojne? Budući da njihova djela

Chroniclers and their notes

There is a number of entries describing the last two decades of the 18th century in Croatia, and the best ones can be found in the Franciscan monastery chronicles. The Franciscans mainly originated from the local population and didn't drift apart. Therefore, their influence was noticeable in education, a matter by which the eighteenth century acquired a deserved reputation. In Dalmatia, it was not the government but the church orders who kept schools. It is not surprising that, twenty years later, Napoleon's marshall Auguste Marmont highly respected their influence and erudition, unlike some self-admiring Enlighteners who undervalued the Franciscans (Marmont, 1856-7). Basically, they played the same role as their Icelandic colleague, poet Jónas Hallgrímson (Thoroddsen, 1925; Ringler, 1996-8). Moreover, just like him, they also possesed wide and growing interest in natural phenomena. Honestly speaking, we cannot expect to find rainfall measurements, let alone their parallel series. Therefore, we must try to make use of the weather data found in their chronicles. This type of evidence is pretty frequent and more common for historian than for scientific measurements. Therefore can we, by using their observations, accquire a consistent set

Slika 1 Geografski smještaj Makarske i Živogošća
Figure 1 Position of Makarska and Živogošće

nisu u dovoljnoj mjeri dostupna – posebice izvan Hrvatske – autor je preveo važne zabilješke kako bi bile razumljive i podložne raspravi ostalim znanstvenicima.

1. *Makarski ljetopis* djelo je triju franjevaca iz lokalnog samostana. Makarska je lučki grad smješten u podnožju strme planine Biokova, druge po visini (1762 m) na sjeveroistočnoj obali Jadrana (φ = 43°17'38'', odnosno 43,2969° N; λ = 17° 01'15'', odnosno 17,0178° E). Makarska se nalazi u središnjem dijelu uskoga priobalnog plodnog pojasa (Sl. 1.). U trajanju od 13 godina, u razdoblju od 1781. do 1794. zapise je unosio redovnik Andrija Ivičević (1740.-1799.), profesor filozofije i teologije u franjevačkim školama (MAKARSKI LJETOPIS, 1993).

Zapise koji slijede napisao je Ivičević i odnose se na meteorološke opise u razdoblju od 1779. do 1785.:

...
Na 1779.
Kako poče ovo godište, onako poče i suša ter velika, tako da za pet miseci nije kapi dažda palo, to jest, đenara, febrara, marča, aprila i mađa, ter žita sva usanuše ...

1780.
Prošastoga godišta bio je velik glad, ter još slidi ove godine; doklen će pak durat, Bog sam znade.
...

1781.
Ovoga lita bih velika suša, osuši se sve grožđe i bih vrlo malo vina, ... Bih maslina dosta u svemu Primorju, premda od velike suše mnoge opadoše prija zrilosti. U Principovu bih malo žita svakoga;
...

Na 11. febrara 1782.
Pade velik snig na suvu zemlju i bih studen mnogo velika za 14 dana po svoj Dalmaciji, i posanuše masline, smokve, bajami, naranče i ostala voća, živine male i velike pokrepaše, žito izebe, a i loze na mnogi misti. Mnogi starci rekoše da ovako leda nisu zapantili u svoj život. ...

Prošasti miseci, toh jest marča (aprila), a još i ovoga mađa jest bijo mnogo velik glad u svoj Dalmaciji; ovde bi se prid manastir skupilo po 380 siromah u subotu za primiti lemozinu od manastira, i svakomu se je davalo ne samo u subotu, nego svaki dan ko bi doša pitat. ... Od početka ove godine i priko svega mađa jesu puali šiloci mnogo veliki, a

of information relevant both to us and the period in question? Due to the fact that their works are not as commonly and easily available as one might wish – especially outside Croatia – I have decided to translate relevant notes in order to provide world-wide intelligibility and evaluation.

1. *Makarski ljetopis* (Makarska chronicle) is a work done by three Franciscans from the local monastery. Makarska is a sea-port town situated at the foot of the sheer rocky Biokovo Mountain, the second highest mountain (1762 m) on the northeast Adriatic coast (N43° 17' 38'' – 43,2969, E17° 01' 15'' – 17,0178). It is placed in the center of the narrow fertile belt called Primorje, i.e. Littoral Croatia (Fig. 1). For 13 years, from 1781 to 1794 the records were entered by friar Andrija Ivičević (1740-1799), professor of philosophy and theology in the Franciscan orders schools (MAKARSKI LJETOPIS, 1993).

The following are Ivičević's entries related to the meteorological events from 1779 to 1785:

…
In 1779
As this year began, so it began a great drought, so that for five months it didn't fall any drop of rain – i.e. in January, February, March, April and May. Therefore, all cereals withered ...

1780
Last year it was great famine which has continued in this year. How long will it last, God does know only. ...

1781
This summer it was great drought. The grape shrivelled away, so there was very scantily wine … All over the Coastland there was pretty much olives …, although a great deal of them fell off before ripeness because of great drought. In the Doge's lands there was dearth of cereals. ...

On the 11th February 1782
It fell great snow on the dried ground, so it was severe cold for 14 days all over Dalmatia. It withered olive-trees, fig-trees, almond-trees, orange-trees and other fruit, bovine and sheep cattle perished miserably. Cereals was frost-bitten and vine suffered in many places, too. Many old men said that they have not remembered such an iciness in their lifetime. ...

... Throughout past months, that is to say in March (April) and May as well, it was very severe

navlastito u aprilu, i mnogo zla i škode jesu učinili u vinogradijim. ... Nadalo se je da će biti dosta žita novoga biloga, ali ne će zašto je bila velika suša, i evo do Petrova dneva ne bi kiše.

Na 11. septembra 1782.
Jematva ove godine dospi u Primorje u malo dana, zašto bih mnogo rđava intrada od vina, a bila je i od žita tako da ljudi nisu ni simena ufatili, nego pobiže sve u Posavinu za ranom, ali ji ne će da primaju, zašto je i onamo gladno. Ovoga svega lita nije bilo kiše u ovim našim stranam. ...

Decembar 1782./Febrajo 1783.
...
Ove godine kako sam gori reka, malo je žita rodilo .../... i u ovo vrime pomriše mnogi siromasi od glada i studeni. ...

Giugno 1783.
Prvi dan đunja bih lipo i ugodno vrime; ... Na 16. ... učini šiloko veliko i dura tri dni, i učini štetu u vinogradi i u maslinam.
Na 19. pade lipa kišica i veoma ugodna; ***ali sutradan na 20. učiniše se tmine i posli tmina*** *učini šiloko, ter jest na 21., ali mnogo veliko bijaše.*
...
Od 20. ovoga miseca počele su tmine mnogo velike, da se od nji sunce ne viđaše, i evo još slide do prvog jula.
...

Luglio 1783.
Ovi misec od jula *počeo je s lipim vrimenom,* ***ali slide tmine mnogo velike, ali nisu škodljive.***
Na 20. počeše kalavat iste tmine i na 23. pristaše; *a na 27. pade lipa kišica i ugodna brez nikave grmljavine. Ovoga miseca bilo je mnogo skakavaca, da su letili na jata i učiniše štete dosta po vinogradi i po vrtli.*
...

Agosto 1783.
Ovoga svega miseca bila su lipa vrimena, i na 23. pade lipa kiša, ...

Settembre 1783.
I ovi misec setembar lip bijaše, i pade kiša lipa na 7. istoga i natopi lipo, i učini vrime i ljudi otrgaše svoje vinograde po lipu vrimenu. Bih dosta žita svakoga i vina. ...

Ottobre 1783.
Misec otobar bih ugodan od lipi vrimena ...

hunger all over Dalmatia. In this place, in front of the monastery about 380 wretched men used to gather on Saturday in order to receive alms from the monastery. Everybody, who came asking for, was bestowed not only on Saturday, but also every day. ... Since the beginning of this year and during entire May, especially in April it has blown high southeast wind so that it has been done much evil and damage in vineyards. ... People has expected that it will be enough wheat, but it will not, because there was great drought. So, see, till the St. Peter's Day (i.e. the 29th June) *there was no rain.*

On the 11th September 1782
This year grape harvest in Coastland was finished in a few days, because it was the bad vine yield, and the cereals one was poor as well, so that people didn't get enough seed for sowing. Therefore one and all fled from starvation to the Sava Valley looking for victuals. But they weren't welcomed, because it was famine there, too. All this summer it didn't rain in these our provinces. ...

December 1782 / February 1783
...
This year, as I said above, the cereals crop was poor, and ... / ... in this time many wretched men starved and died from cold. ...

June 1783
On the first day of June it was fair and pleasant weather; ... on the 16th ... the high southeast wind rose and lasted for three days, and made damages in vineyards and olive-trees.
On the 19th it drizzled very pleasantly; ***but on the following day, on the 20th, the gloominess set in*** *and thereafter southeast wind rose, precisely on the 21st, and was very high.*
...
From the 20th of this month it has begun such a dense gloom that the Sun couldn't be seen, and the gloom has continued till the first of July yet.
...

July 1783
This month of July *began with the nice weather,* ***but it has continued a very thick gloom which hasn't been harmful.***
On the 20th the aforesaid gloom had begun to get thinner and on the 23rd it disappeared. *On the 27th it drizzled pleasantly without any thunder. This month there were so many locusts, that they flew in flights and made much damages in vineyards and kitchen gardens.*
...

9. novembra 1783.
Ovoga miseca vrlo lipa su vrimena i ugodna bila, reka bi da je lito; ...

Decembre 1783.
Misec decembar počeo je s lipim vrimenom; ali na 8. istoga učinilo je zlo vrime i mećava. Posli toga slidila je kiša do 16.; pak lipo vrime do sv. Tome, a na sv. Tomu opet učini kiša i slidila je svega ovoga miseca do 5. đenara.

Gennaro 1784.
Na 6. đenara učini mnogo velika bura i mećava. Na 20. opet učini bura, i učini škodu u vrtlim. ...

Fabraro 1784.
Ovi misec febrar poče s velikom studeni i na prvi učini velika bura, izlomi mnoge masline, raskri mnoge kuće, razbije mnoge brode ...
Ova bura učini mnogo štete po svemu Primorju, učini u ništo zelje, i sve ozebe. Na 4. istoga učini šiloko s kišom, i slidili je svaki dan, kad veće, kad manje do dvadeset.. I onda budući mina, učini lipo vrime. ...

Marzo 1784.
Ovoga su miseca slidila zla vrimena, a navlastito bura i šiloci do danas 19. i kiše je bilo dosta. ...

Decembre 1784.
Misec decembar vas bio je kišovit i zla vrimena bila su u njemu; u ovomu misecu ništa se nije čulo iznova.

Gennaro 1785.
Na prvi ovoga miseca učinilo je lipo vrime, i tako je slidilo do 26. istoga, ne bi reka da je misec januar, nego da je jul ili agost. ...
Na 26. istoga januara učinila je velika bura, snig i krupica, i zlo vrime slidilo je do 14. febrara. ...

Febraro 1785.
I ovi misec počeo je zlim vrimenom i slidio je do 14.; pak učini lipo, ali za malo dura, jer opet poče snig i slidi velika studen, i pozebe na mnogo mista žito i voća. ...

Marzo 1785.
Marač misec bio je studen kako i prošasti i studen je dosta štete učinila. ...

Maggio / Luglio / Settembre 1785.
Ovoga miseca ... pak je zasušilo; i žito nije dobro ufatilo ... / I ovi misec vas je bijo suv i od vrućine

August 1783
This month was nice weather, and on the 23rd it rained pleasantly, ...

September 1783
This month September was nice, too, and it rained on the 7th pleasantly and watered well. Thereafter it has begun nice weather and men gathered grapes. There was enough wine and cereals of all sorts. ...

October 1783
This month October was pleasant owing to the nice weather ...

9th November
This month it has been very nice and pleasant weather, one would say it was summer ...

December 1783
The month December had begun with nice weather, but on the 8th the evil weather with blizzard set in. Thereafter it followed rain till the 16th, and then nice weather till St. Thomas Day (i.e. the 21st December), *and on the St. Thomas Day it rained and has continued in this month till the 5th January.*

January 1784
On the 6th January very high northeast wind rose and blizzard began. On the 20th the northeast wind set in and made damages in kitchen gardens. ...

February 1784
This month began with the severe cold and on the first day the high northeast wind set in, broke up many olive-trees, unroofed many houses, smashed many ships ...
This northeast wind made much damage all over the Coastland, turning the vegetable into nothing, and all was frost-bitten. On the 4th the southeast wind with rain set in and has continued every day – sometimes higher, sometimes weaker, till the twentieth. And then, as it had blown over, the fair weather began. ...

March 1784
During this month bad weather has continued, particularly the northeast and southeast wind, to this day the 19th, and there was much rain. ...

December 1784
Entire month of December was rainy and the evil weather was in it. In this month was nothing new to hear.

January 1785
On the first day of this month fair weather came

sve izgori po Primorju ... / Na 7. setembra nađe plemenita kiša, veoma korisna ... (MAKARSKI LJETOPIS, 1993)

2. Drugi svjedok također je bio franjevac. Njegovo ime je Frane Radman (1722.-1789.), a rođen je u Donjem Muću. U to vrijeme bio je župnik u župi Živogošće (φ = 43°11'16'', odnosno 43,1789° N; λ = 17°10'00'', odnosno 17,1728° E) oko 67 km jugoistočno od Splita, tj. 12 km jugoistočno od Makarske (Sl. 1). Za razliku od svog subrata Radman svoj doživljaj prije spomenutog razdoblja izražava pjesmom *Pisma od pokaranja koja dojdoše svrhu Dalmacije 1778*. Služeći se desetercem, živopisno i s puno emocija, slično kao i njegovi zemljaci Ivičević ukratko je iznio sve nevolje koje su zadesile stanovništvo. Prema Radmanovu mišljenju prirodne su sile predstavnici i izvršioci Božje volje te pjesma završava zazivom da prestanu griješiti (BUJAS, 1971). Konačno, iako u njegovim stihovima ne nalazimo precizne informacije, ne može se zanijekati njihova intrigantnost, posebno opis klimatskih anomalija i sumporaste magle:

...
Zatim sičnja slideće godine *(1779.)*
Daž natopi polja i planine.
...
Prođoše nam dnevi još i Sveci,
Ne natopi za 9 miseci:
Niti rosi niti daždić pada
Do početka sjajnog listopada.
...
Do godišta miseca veljače *(1781.)*
Led udari nikad od toga jače,
Nit je prija čula živa glava:
Sve izebe, i gora i trava.
...
Paka pade straovita tmina ***(1783.)***
Svrhu zemlje, mora i planina.
Od po lipnja do polak rujna
I ta bič sta tri miseca puna.

Međuto je kuga udarila,
... (BUJAS, 1971)

3. Redovnik Marijan Lanosović (1742.-1812.) profesor folozofije koji je služio u sjeveroistočnoj Hrvatskoj te uredno, iz dana u dan, bilježio sve važnije događaje. Pročitavši svega nekoliko stranica prepisanih iz njegova dnevnika, autor je došao do zaključka da je Lanosović bio dobar poznavatelj meteorologije. Original njegova dnevnika iz franjevačkog samostana u Osijeku je izgubljen, ali je Josip Bösendorf, na sreću, napravio jasnu kopiju

and continued till the 26th – one couldn't say it was January, but July or August. ... On the 26th very high northeast wind with snow and hail had set in, and evil weather continued till the 14th February...

February 1785
This month, too, began with evil weather and it continued till the 14th. Then there was fair weather, but it was short-lived, as it began to snow and continued so severe cold that the cereals and fruit-trees were frostbitten. ...

March 1785
The month of March was as icy as the last one, and the cold made much damage. ...

May / July / September 1785
This month ... drought began, so the grain didn't take root ... / This entire month was so dry that everything in Coastland was parched by heat ... / On the 7th September the noble, very beneficial rain came... (MAKARSKI LJETOPIS, 1993)

2. Another witness was also a Franciscan. He was Frane Radman (1722-1789), born in Donji Muć. At the time he was parish priest in Živogošće (N43° 11' 16'' – 43,1789, E17° 10' 00'' – 17,1728) – about 67 km SE from Split, i.e. 12 km SE from Makarska (Fig. 1). In distinction from his confrater Ivičević, Radman expressed his impressions of the afore mentioned period by a poem named "*About the castigations which befell Dalmatia in 1778*". Using the ten-syllabic verse similar like his countrymen he summed up, vividly and emotionally all of calamities which had been striking the people. According to Radman, the nature forces represent and perform God's will, and the poem ends by his appeal to people to stop sinning (BUJAS, 1971). Finally, although this lyric provides no detail data, its peculiarity cannot be denied, above all the description of the climatic anomalies and the sulphurous fog:

...
January of next year was mild *(1779)*
Rain watered mountain and field.
...
By day and by night it was the same
For nine months it did not rain,
Neither sprinkled nor did shower
Until the beginning of October.
...
Till the month February of that year *(1781)*
Biting ice was ruling everywhere,
No one living has never heard,
That all grass and wood became dead.

*te objavio najveći dio dnevnika (Bösendorf, 1910; Bösendorf, 1916). U razdoblju od 1774. do 1783. Lanosović je živio u Osijeku, gradu smještenom na desnoj obali rijeke Drave, u blizini Dunava (*φ = 45°33'40'', odnosno 45,5511° N, λ = 18°41'50'', odnosno 18,6939° E). Grad okružuju ravnice – na jugu su plodne, a na sjeveru močvarne. Zabilježio je sljedeće događaje:

Godina 1782.
22. svibnja
Ove godine su ovdje, kao i u mnogim krajevima Slavonije, bili slabi urodi … Ovoga su mjeseca na području Srijemske, Virovitičke, Baranjske i Bačke županije uništeni skakavci … (Bösendorf, 1910)

1783.
20. lipnja
Pojavila se i traje gusta magla, kakvu ljudi ne pamte da bi je vidjeli u to doba.
... (Bösendorf, 1910)

Još je jedna zabilješka redovnika Jake Baltića (1813.-1887.) iz franjevačkog samostana Guča Gora u središnjoj Bosni. Budući da nije bio očevidac služio se nekim starijim izvorima te se njegove zabilješke ne će razmatrati detaljno. U svakom slučaju bilo bi vrijedno spomenuti:

Godina 1782. (pogrješno)
… Vrime je sveđer slidilo mutno, čadina sveudiljna po svoj Bosni. …(Baltić, 1991.)

Koliko je poznato, s iznimkom dvaju ili triju slučajeva, prirodoslovcima nisu poznate hrvatske kronike koje sadrže klimatske zabilješke, ne samo one neobjavljene već i objavljene. S druge strane, hrvatski povjesničari rijetko su objavljivali radove na engleskom. Međutim, ni jedna ni druga strana ne bi smjele koristiti jezičnu barijeru kao izliku. I ova priča o Lakiju potvrđuje jezične probleme. Kako su, naravno, najvažniji izvori napisani na islandskom jeziku, sve donedavno znanstvena zajednica s njima nije bila upoznata (Scarth, 1999)

Rasprava

U Hrvatskoj postoje mnogi pisani izvori o debeloj suhoj maglici nastaloj nakon erupcije islandske pukotine. U svakom pogledu Ivičevićeve kronike predstavljaju najbolji izvor. Pružaju opsežan uvid u razmatrano razdoblje ne naglašavajući samo

Then it fell a dreadful darkness (1783)
on sea, land and mountain highness.
Since mid June till the fifteenth September
This scourge for three months stayed over.

Meanwhile the plague broke out
... (Bujas, 1971)

3. Friar Marijan Lanosović (1742-1812), professor of philosophy, serving in monasteries in the northeastern Croatia, was recording systematically all worth mentioning, from day to day. Having read only a few transcribed pages from his diaries, it becomes obvious that he was meteorologically-minded. The original of his diary from Franciscan monastery in Osijek is lost, but, fortunately Josip Bösendorfer made a clean copy, and published a large portion of it. (Bösendorfer, 1910; Bösendorfer, 1916). Since 1774 until 1783 Lanosović lived in Osijek, the town situated on the right bank of the Drava River not far from the Danube River (N45° 33' 40'' – 45,5511, E18° 41' 50'' – 18,6939). The city is surrounded by plains – to the south they are fertile and to the north swampy. He noted the following events:

Year 1782
22nd May
Here and in many regions of Slavonia it was bad crops this year … This month locusts were exterminated in counties of Srijem, Virovitica, Baranja and Bač. ... (Bösendorfer, 1916)

Year 1783
20th June
It arose and has lasted a thick fog. It was not remembered by people that the fog of such kind was ever seen at this time.
... (Bösendorfer, 1910)

There is another note made by friar Jako Baltić (1813-1887) from Franciscan monastery Guča Gora in the Central Bosnia. Since he was not an eyewitness, he used some older sources, and his entry will not be disscused in detail. Nevertheless it might be worth mentioning:

Year 1782 (mistaken)

... It continued the overcast weather incessantly – the gloominess without intermission all over Bosnia. ... (Baltić, 1991)

ekstremne uvjete. Lansovićev izvor na žalost nije cjelovit, dok je Radmanova pjesma, iako više poput anegdote, mnogo korisnija. Postoji još nekoliko neriješenih pitanja o kojima je potrebno raspravljati.

Vidljivo je da su plinovi (tj. sumporni aerosol), dvanaest dana nakon što su izbačeni u atmosferu došli do središnjeg dijela sjeveroistočnog Jadrana i istočne Slavonije uz tok rijeke Dunava. Udaljenost među tim prostorima je oko 290 km te su više od 3000 km udaljeni od Islanda.

Posebnu pozornost privlači Lanosovićev datum dolaska magle, 20. lipnja 1783., jer ne odgovara informaciji da je fenomen 23. lipnja 1783. zabilježen u glavnom gradu Mađarske – u Budimu (starom upravnom dijelu Budimpešte, prije ujedinjenja s Peštom), 215 km sjevernije od Osijeka. Iz toga proizlazi da je magla došla do Hrvatske poput široke fronte iz smjera istoka-sjeveroistoka. To me dovelo do zaključka da je aerosol prenesen atmosferskom cirkulacijom koja je poprimila oblik slova "J" ili obrnutog slova "C". U početnoj fazi aerosol se kretao u smjeru istoka ili sjeveroistoka, zaobišao istočni dio središnje Europe, te došavši do južnog Balkana, zaokrenuo u smjeru

Slika 2 Smjer širenja magle. Kružići označavaju smještaj Makarske i Osijeka.
Figure 2 Scheme of fog spreading direction. The circles mark positions of Makarska and Osijek

As far as I know, except for two or three cases, natural scientists haven't been aware of any Croatian chronicle containing climatic notes, not only the unpublished, but also the published ones. On the other hand, Croatian historians rarely published works in English. Who is to be blamed for? In my opinion the blame has been on both sides, and the language barrier as an excuse does not pardon neither one nor the other. The story of Laki also confirms the difficulties caused by language barrier. Since the most important source was written, of course, in Icelandic, it was not known to the scientific community until recently (SCARTH, 1999).

Discussion

In Croatia there are many contemporary narrative sources describing the thick dry haze originated from the eruption of the Icelandic fissure. In every respect, the Ivičević's chronicle is the best one. It provides an extensive insight into the period in question, since it does not emphasize only extreme conditions. The Lanosović one is, unfortunately, fragmentary, and Radman's poem, although more anecdotal, is however more useful. There are some unsettled questions that need to be dealt with here.

We can see that within twelve days after having been injected into the atmosphere, the gases, i.e. sulphatic aerosol reached the central part of the northeast Adriatic coast and the east Slavonia near the river Danube. The distance between these areas is about 290 km, and both of them are more than 3000 km away from Iceland.

The Lanosović's date of the fog arrival, June 20, draws special attention, since it doesn't correspond to the information that the phenomenon was seen in Hungarian capital – in Buda (the old administrative part of Budapest, before its uniting with Pest), on July 23th, 215 km norther from Osijek. Hence, it follows that the fog reached Croatia like a broad front coming from east-southeast. It brought me to the conclusion that the aerosol was transported by atmospheric circulation which took a shape of letter "**J**" or reversed "**C**". Moving in initial phase eastwardly or northeastwardly it rounded the East Central Europe, and then, reaching the south Balkans it turned round more northwestwardly (see Ivičević's note of the wind direction on the days in question) (Fig. 2). It should be related to a high pressure system which stayed over central Europe, i.e. west Hungary. Moreover, the mentioned dates generally correspond to all reports from

sjeverozapada (vidi Ivičevićevu zabilješku o smjeru vjetra na dane koji su u pitanju (Sl. 2.). Situaciju je potrebno povezati sa sustavom visokog tlaka koji se zadržao nad središnjom Europom, tj. zapadnom Mađarskom. Štoviše, spomenuti datumi općenito se poklapaju sa svim izvješćima od Skandinavije do Sicilije (THORODDSEN, 1925; LAMB, 1970).

Na žalost, i Ivičević i Radman nisu izvijestili o boji izmaglice, ali postoje brojni razlozi koji upućuju na činjenicu da je bila plave ili plavkaste boje, kao što je zabilježeno u svim ostalim izvorima. Nadalje, izgleda da magla niti je bila opasna niti je smetala, niti imala miris, ali je zabilježeno da to nije bila uobičajena magla. Radmanov izraz *pokora* više je poetično poimanje nego stvarno posljedično obilježje fenomena. Upravo suprotno, za trajanja magle nije bilo ni grmljavine ni oluja.

Nadalje, u Osijeku kao i u Makarskoj, kroničari nisu napisali ništa o prašini ili pepelu koji su padali iz oblaka aerosola. Podatak da su fine sitne čestice zamijećene u Veneciji, koja je smještena oko 340 km sjeverozapadno od Makarske, može se iskoristiti za procjenu raširenosti prašine iz Lakija.

Podatak o trajanju tmine vidno se razlikuje kod Ivičevića i Radmana je. Čije je svjedočenje vjerodostojnije? Budući da Lanosović ne navodi nikakav podatak, odluku nije lako donijeti. Prije spomenut nestanak izmaglice tijekom zadnjeg tjedna srpnja može se objasniti prestankom prve erupcije 25. srpnja 1783. Sljedeće razdoblje magle trebalo bi povezati s novim količinama plinova koji su izbijali iz još jedne skupine pukotina nakon njihova otvaranja 29. srpnja 1783. (THORODDSEN, 1925; OMAN I DR., 2005). S obzirom na točnost, Ivičević je pouzdaniji, osobito ukoliko u obzir uzmemo Radmanovu pretpostavljenu pjesničku slobodu (posebno zaokružena vremenska razdoblja), iako se u drugim izvorima nalazi podatak da se izmaglica doslovno zadržala do kraja godine (THORODDSEN, 1925; LAMB, 1970).

Uz to postoji neslaganje među znanstvenicima o distribuciji plinova; drugim riječima, nije sasvim jasno je li se magla nalazila u višim slojevima (stratosfera 10-30 km) ili u najnižim slojevima (troposfera < 10 km) atmosfere (HIGHWOOD, STEVENSON, 2003). Sudeći prema zabilješkama franjevaca, posebno rečenici *Paka pade straovita tmina / Svrhu zemlje, mora i planina,* možemo zaključiti da magla nije bila samo vidljiva nego doslovno opipljiva.

Scandinavia to Sicily (THORODDSEN, 1925; LAMB, 1970).

Unfortunately, both Ivičević and Radman did not report the haze color, but there is every reason to believe that it was blue or bluish, like it was noted everywhere else. Furthermore, it seems the fog was neither perilous nor annoying nor smelled, but they noticed that it was not a normal fog. The Radman's term "*scourge*" is more likely a poetical affectation than the real consecutive characteristic of the phenomenon. Just to the contrary, there was no thunderstorm, nor any other tempest during the fog.

Further, in Osijek as well as in Makarska the chroniclers did not mention anything about dust or ash falling from aerosol cloud. Since the fine firm particles were registered in Venice which is situated about 340 km north-westerly from Makarska, it can be used to estimate the extent of the Laki dust.

The striking difference between Ivičević and Radman is the duration of the gloom. Whose testimony is more credible? Since we have no evidence from Lanosović, it is not easy to make a decision. The mentioned dissappearance of the haze in the last week of July may be explained by stopping of the first eruption run on the 25th July. The next period of the fog should be connected with new amount of gases which were gushing from another fissure section when it opened on the 29th July (THORODDSEN, 1925; OMAN ET AL., 2005). Considering all, the exactness of Ivičević gives more reliance than the presumable poetical licence (especially the rounded period) of Radman, although in other sources it was noticed that the haze persisted virtually until the end of the year (THORODDSEN, 1925; LAMB, 1970).

Besides, there is a disagreement among scientists about the gas injection range, in other words, it is unclear whether the fog should be placed in the higher layers (stratosphere 10-30 km) or the lowest layers (troposphere <10 km) of atmosphere (HIGHWOOD, STEVENSON, 2003). Based on the franciscans' notes, especially the sentence *Then it fell a dreadful darkness / on sea, land and mountain highness*, we can conclude that the fog was not only visible but also, and literally, palpable.

Zaključak

Razmotrivši iznesene okolnosti, možemo zaključiti da je došlo do nesretnih poklapanja događaja. Vulkanska aktivnost pukotine Laki neočekivano se dogodila nakon trogodišnjeg razdoblja suše, oštre hladnoće i gladi, te kao posljedica nije uslijedilo očekivano razdoblje blagih godina. Očito je da usjevi 1783. godine nisu oštećeni – naprotiv, naši izvori govore o dobroj žetvi, ali dvije sljedeće zime i suša tijekom ljeta trebale bi biti povezane s klimatskim poremećajima koje je uzrokovao Laki. To također potvrđuje zaključak o neposrednim i zakašnjelim učincima aerosola. Međutim, potrebno je istaknuti da je doseg utjecaja erupcije u značajnoj mjeri ovisio o prirodno-geografskim obilježjima. Konačno, neupitno je da kugu nije uzrokovao Laki, ni direktno ni indirektno.

Prema mišljenju mnogih koji su tijekom 18 st. živjeli u Hrvatskoj, kao i brojnim povjesničarima od tada, 18. st. bilo je opasno, burno i dekadentno – opasno i burno običnim ljudima te dekadentno vladajućoj aristokraciji. Ali zasigurno nitko nije ništa znao o islandskoj katastrofi, tako da je nitko nije ni mogao povezati s opisanim stanjem u Hrvatskoj, niti uočiti učinke erupcije Lakija. Konačno, dok se godina 1783. na Islandu pamti kao *moðu harðindi* (tj. glad od izmaglice), u Hrvatskoj je ona bila duboko urezana u pamćenje ljudi, ne zbog magle nego zbog kuge, koja je opustošila mnoga naselja.

Conclusion

Taking into account circumstances in Croatia, we may conclude that there occurred an unfortunate concurrence of events. The volcanic activity of the Laki fissure supervened after the triennium of drought, biting ice and starvation, postponing the expected period of mild years. It is obvious that the crops in 1783 were not damaged – on the contrary, our sources report on good harvest, but the next two harsh winters and the drought during the summer should be connected to the climatic disturbances caused by Laki eruption. Herewith it also confirms the conclusion of the immediate and lagged effects of the aerosol. However it is necessary to note, that the geographical pattern as an important factor of the eruption impact should not be ignored. In conclusion, it is clear that the plague was not caused by Laki, neither directly nor indirectly.

To those living in Croatia at the time, and to many historians since, the eighteenth century seemed, with good reason, a dangerous, turbulent, and decadent age – dangerous and turbulent to the common people, and decadent to the rulling aristocracy. But, it is certain that nobody knew anything about Icelandic disaster so that nobody could connect it to previously described situation in Croatia, neither perceive the effects of the Laki eruption. Finally, while the year 1783 on Iceland was remembered as *moðu harðindi* (i.e. famine caused by the haze), in Croatia it was deeply rooted in people's mind not because of the fog, but the plague which devastated many settlements.

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