

Dragutin Gorjanović-Kramberger Geological Mapping Pioneer in Croatia

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Abstract: *Dedicated work of Dragutin Gorjanović-Kramberger is hereby presented on the occasion of celebration of one hundred and fifty years of his birth. His dedication in the development of first mapping sheets for geology map of "Croatia and Slavonia" and works in other areas of "practical geology" have led to the development of "Geological council" and independence of Croatian geology from foreign influence.*

Key words: *Gorjanović-Kramberger, Geological council, Croatian Geological Survey, geological maps, tectonics, thermal and mineral waters, karst geomorphology, loess*

It is well known that the territory of the Republic of Croatia until the end of the First World War was part of Austro-Hungarian Monarchy. Therefore the Hungarian geologists were investigating the areas of "Croatia and Slavonia" and the Austrian the areas of Dalmatia. By the end of the 19th century Austrian geologists in Austria and Slovenia have already been completing second version of geology map, while the Hungarian geologists in northern parts of Croatia have not even started the first draft. At the same time there were only few active Croatian geologists. They have been collecting and analyzing the items for display in geological museum; they were undertaking scientific work and teaching geology at University of Zagreb. The first person to teach geology was Professor Gjuro Pilar.

1 Summary of Scientific Contribution by Dragutin Gorjanović-Kramberger

The most important Croatian geologist Dragutin Gorjanović-Kramberger (1856-1936) has become internationally famous after the discovery of "diluvial man from Krapina". He is also known by the study of fossil fish, big mammals and molluscs, and less known by geological mapping and works in "practical geology". Although he achieved remarkable results in palaeontology and in palaeontology, for Croatian science and industry his work in other branches of geology is also very important. He fully immersed himself in all geology areas and has accomplished many important achievements. However some of these achievements did not receive such publicity outside of Croatia as did works in palaeontology and anthropology.

During that time "Croatia and Slavonia" were under Hungarian protectorate and under the "crown of St. Stjepan". In the major "high government institutions" it was thought that for all such countries one Geological Institute, the one in Budapest, is sufficient. Although Hungarian geologists were not undertaking geology mapping in the areas of "Croatia and Slavonia", they were trying hard to prevent Croatian geologist doing so (Poljak, 1926). Gorjanović-Kramberger succeeded in attempts to complete geological mapping on the Ptuj and Rogatec-Kozje sheets, initially started by Dreger (1898a, 1898b), by clever manoeuvring between the Hungarian and Austrian geological department. Then he continued on with geological mapping of Zlatar-Krapina and Zagreb sheets, by which he proved that Croatian geologists were able to undertake such important and "safe-guarded" project.

Dragutin Gorjanović-Kramberger inicijator geološkoga kartiranja u Hrvatskoj

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Sažetak: *Povodom sto pedesete obljetnice rođenja Dragutina Gorjanović-Krambergera, najvećega i najpoznatijega hrvatskoga geologa, prikazani su njegova angažiranost u izradbi prvih listova pregledne geološke karte na području "Hrvatske i Slavonije" te rad u drugim granama "praktične geologije" kojima je pridonio osnivanju "Geološkog povjerenstva" i osamostaljenju hrvatske geološke struke od stranih utjecaja.*

Ključne riječi: *Gorjanović-Kramberger, Geološko povjerenstvo, Hrvatski geološki institut, geološke karte, tektonika, termalne i mineralne vode, geomorfologija krša, prapor, les*

1. Ukupna znanstvena djelatnost Dragutina Gorjanović-Krambergera

Najveći hrvatski geolog Dragutin Gorjanović-Kramberger (1856-1936) postao je svjetski poznat po pronalasku i istraživanju *diluvijalnog čovjeka iz Krapine*, nešto manje bio je poznat po proučavanju fosilnih riba, velikih sisavaca i mekušaca, a najmanje je poznat po snimanju geoloških karata i po radovima u „praktičnoj geologiji“. Iako je u paleoantropologiji i u paleontologiji postigao svjetski priznate rezultate, za hrvatsku znanost i privredu nije manje značajan njegov rad u ostalim granama geologije u koji je uložio velik dio svog radnog elana i vremena. Rezultati tih istraživanja nisu manje vrijedni od njegovih dostignuća u paleontologiji i antropologiji, ali logično je da nisu imali takav publicitet izvan hrvatskih granica.

Poznato je da je teritorij današnje Republike Hrvatske do kraja I. svjetskog rata bio u sastavu Austro-Ugarske Monarhije, te da su mađarski geolozi istraživali područje "Hrvatske i Slavonije", a austrijski područje Dalmacije. Krajem 19. stoljeća austrijski geolozi su u Austriji i Sloveniji dovršavali već drugu verziju geološke karte, dok Mađari u hrvatskoj još nisu započeli ni prvu verziju. Istodobno su malobrojni hrvatski geolozi prikupljali i obrađivali eksponate za geološki muzej, bavili se znanstvenim radom i nastavom na Sveučilištu u Zagrebu, gdje je prvi profesor bio Gjuro Pilar.

S obzirom na to da je tadašnja "Hrvatska i Slavonija" bila pod mađarskim protektoratom, u svim "višim državnim institucijama" prevladavalo je mišljenje da je za zemlje "pod krunom Sv. Stjepana" dovoljan samo Geološki zavod u Budimpešti. Iako mađarski geolozi nisu provodili geološko kartiranje na području "Hrvatske i Slavonije", ipak su svim silama nastojali spriječiti da to rade hrvatski geolozi (Poljak, 1926). Gorjanović-Kramberger se je, vješt看 manevriranjem između budimpeštanskoga i bečkoga geološkoga zavoda, uspio izboriti za nastavak geološkoga kartiranja na listovima Ptuj i Rogatec-Kozje, koje je započeo austrijski geolog Dreger (1898. a, 1898. b). Potom je nastavio geološko kartiranje na listovima Zlatar-Krapina i Zagreb, te time dokazao da su i hrvatski geolozi sposobni izvoditi tako važne i "povjerljive" projekte.

Da bi ozakonio taj rad i stekao stalnu financijsku potporu nastojao je osnovati Hrvatski geološki zavod, ali je zbog velikih protivljenja "Državnoga geološkoga zavoda u Budimpešti", uspio ishoditi "samo" osnivanje "Geološkog povjerenstva". To mu je uspjelo tek kada je postao

Geolojska prijedlogna karta KRALJEVINE HRVATSKE-SLAVONIJE

izdaje
kr. i rv. slavon. dalmat. zemalj. vlada, odio za unutarnje poslove.
Snimio i obradio: Prof. Dr. Dragutin Gorjanović Kramberger.

KRAPINA

ZONE 21 COL. XIV.



6p
Oliv.-Serpentin

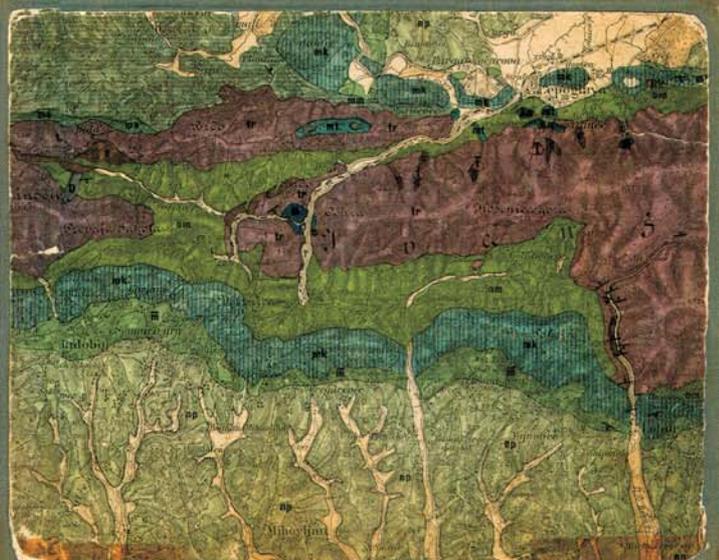


6g
Gornji, crni brašnoloci, sivi pješčenjaci i konglomerati. Obere Stufe; schwarze Ton-schiefer, graue Sandsteine und Konglomerate.

Dyas
7
Crveni grodenški pješčenjaci. Rote Grödener Sandsteine.

Trias
8
Ljštarni vapnenac (tm) i verfunski pješčenjak (f). Muschelkalk (tm) und Werfener Schiefer (f).

9
Gornji; svjetli vapnenac i dolomit. Obere Abteilung; helle Kalk und Dolomite.



Kreda i nje
Kreide und Flysch

kr kf
Stjepolovi vapnenac (kr), sivi pješčenjaci i sivi laporasti škriljci (kf). Helle Kalk (kr), graue Sandsteine und graue mergelige Schiefer (kf).

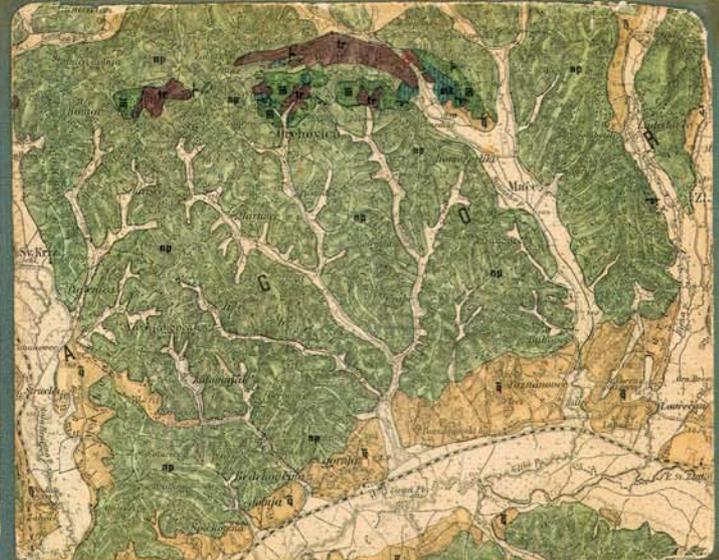
Oligocen

om
Soka slojevi, tređji primarni pješčenjaci i sivi pijesak. Sotaka-Schichten; härtere tuffige Sandsteine und gelbe Sande.

Princi andezita.
Andesit-Tuffe.

Alni i miocen
aus Miosän

mm
Morski lapori



Uj

i primari laporasti pješčenjaci. Marine Mergel und marie mergelige Sandsteine.

ms
Tređji pješčenjaci, Vapneni i primarni pješčenjaci. Härtere Sandsteine, Kalk- und Tuffsandsteine.



Mjersko
K. und k. militär.
Vermaßstab

Geologische Übersichtskarte
des
KÖNIGREICHES KROATIEN-SLAVONIEN

herausgegeben durch die
k. kroatisch-slavon.-dalmat. Landesregierung, Sektion für innere Angelegenheiten.
Aufgenommen und bearbeitet von: Prof. Dr. Dragutin Gorjanović Kramberger.

und ZLATAR



Speziell miozän
Miozän
Gorjuli
Obern

mk
Tirovine litaven.
Leithakalkbildungen.



Miozän

sp
Sarmatski slojevi.
Sarmatische Schichten.

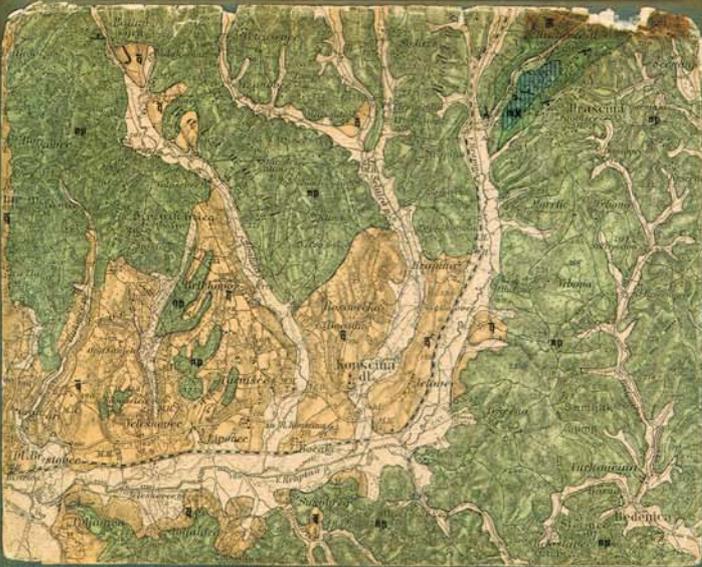
Pliozän

kp
Kongerijski slojevi.
Kongertensichten.

Quartär i recent.
Quartär und Recent

q
Diluvijalne štrnačne
lovisne.
Gehängelehm.

ra
Dolinski aluvij.
Talldenaalluvium.



Eruptiv

m
Melaphyr.

D
Diabas.

ag
Augit-Andesit.

lp
Elyolit (Liparit).



yl
Polotaj slojeva.
Streichen und Fallen
der Schichten.

o
Topla vrela.
Thermen.



Maßstab: 1:70.000

Geographisches Institut.
Wien.

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To protect and legalize this work and obtain further financial support, he tried to establish Croatian geological department. However due to a lot of objections from the "State geological survey in Budapest" he "only" managed to establish "Geological council". He accomplished this only after publishing four geology map sheets and their accompanying notes, after he became known all over Europe for his work and as a result of being named Royal advisor at the Viennese court. This real historical event is described by Poljak (1926), who states that Gorjanović-Kramberger "after sharp and serious discussion with "State Geological Survey in Budapest" managed to obtain permission to undertake geology mapping of those sheets and to later establish Geological Council.

By the order of the Royal Croatian-Slavonian-Dalmatian government, the Department of internal affairs, number 3, A, 2275 of 8th July 1909, a Geology Council was formed and established for the Kingdom of Croatia and Slavonia. This was an independent institution which comprised two sections: montangeological and agrogeological. D. Gorjanović-Kramberger, Royal Advisor and "occasional professor of geology and palaeontology" was made the chair of this council. This meant that now the right to produce and publish geology maps, scale 1:75 000 and 1:25 000, was in the hands of Croatian geologists, while until then the Geological Survey in Budapest was in charge. A year after, the work of the Geology Council was broadened and two new sections were formed: Geographical section and a Speleological section.

In the year 1911 Gorjanović-Kramberger managed to gain the support of Croatian-Slavonian government to publish the Geology Council Newsletter. He was also the first editor of this newspaper and until 1916 six issues were published. In the attempt to prevent the work of Hungarian geologists on the Croatian territory, he decided to start geology investigations in Slavonia and Srijem (although he already had many projects in northwest Croatia at the time). With this in mind he formed "Council for scientific investigation of Srijem". This council was financially supported by Croatian governor N. pl. Tomašić with annual contribution of 2000 krunas (Salopek, 1939-40).

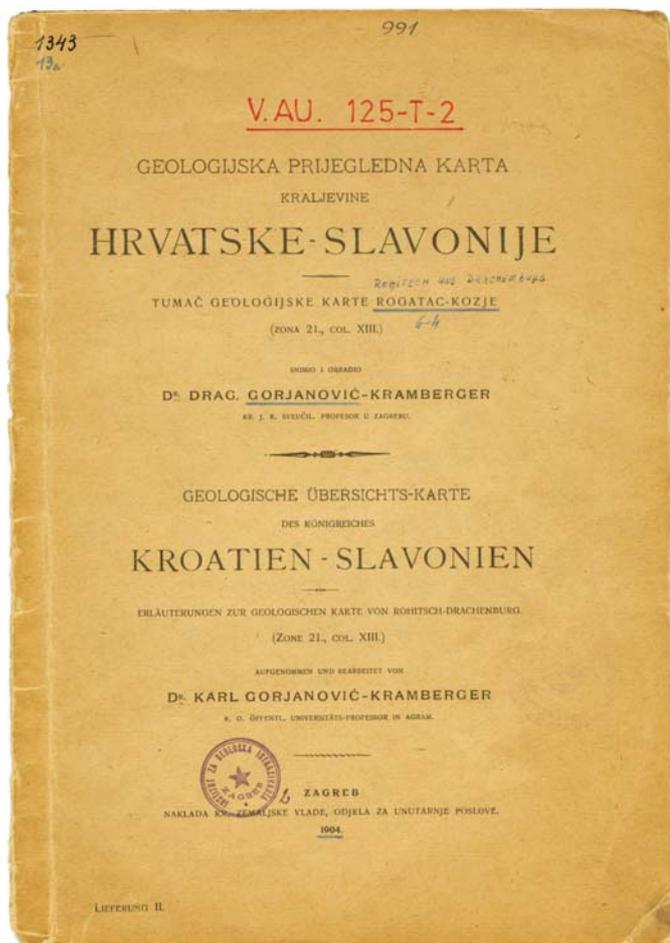
After 1909, Gorjanović-Kramberger gave over geological mapping to his younger assistant F. Koch. However he remained the chair of the Geological Council until 07/09/1922 when the Province government, the Department of Education and Religion relinquished this institution and established Geological Survey in Zagreb (today's Croatian Geological Survey).

Today, it seems unusual that Gorjanović-Kramberger had to put so much effort to obtain the permission to undertake mapping and publish geology maps on the territory of former Croatia and Slavonia.

It is well known that industrial and social development of an area or country depends on its geological base, and its knowledge can only be assessed based on geology maps. Geology influences the content and richness of soil, the existence of drinking water and mineral resources. Furthermore, the knowledge of geology is essential for development of transport, urbanization, and management of the occurrence of landslides. It enables good forward project planning and wise use of natural resources.

In times when Gorjanović-Kramberger was actively involved in geology, the information of the existence of a coal basin would have been as important as it is today the information on oil resources and as tomorrow it will be the drinking water. Even today we witness insufficient investigation of an area which then leads to expensive remediation of landslides and slips which still represents threat to safety. Hence, geology mapping has become more detailed, and currently new engineering-geology map for Zagreb region is being prepared (scale 1:5000).

Geology investigations have always been closely related to government administration due to control over natural resources and mineral exploration. Such an example is the case in 1347 when Croatian governor Nikola Banfić gave the charter to the inhabitants of Zagreb (then Grič) stating that salt deposits found in Slani Potok on Medvednica "can be kept and used for all times" (Marković, 2002). Therefore, first mineral explorers and later geologists were under the surveillance of police and army, and the results of their exploration were many times treated as either army, official or industry secret. For example, the geology maps mapped by Gorjanović-Kramberger were published by "government of the Kingdom of Croatia-Slavonia-Dalmatia, Department of internal affairs", while the sheets for Main Geology Map, scale



poznat diljem Europe i kada je stekao naslov kraljevskoga dvorskog savjetnika te kada je već objavio četiri lista geoloških karata i njihove tumače. Stvarnu situaciju opisao je Poljak (1926), koji navodi kako se je Gorjanović-Kramberger *nakon oštre i žučne borbe s "Državnim geološkim zavodom u Budimpešti"* uspio izboriti za snimanje navedenih listova, a poslije i za osnivanje Geološkog povjerenstva.

Naredbom Kraljevske hrvatsko-slavonske-dalmatinske zemaljske vlade, odjela za unutarnje poslove, broj III. A. 2275 od 8. srpnja 1909., osnovano je Geologijsko povjerenstvo za kraljevinu Hrvatsku i Slavoniju. To je bila autonomna institucija koja se sastojala od dviju sekcija: montangeologijske i agrogeologijske. Za predsjednika povjerenstva postavljen je *prigodni profesor geologije i paleontologije*, kr. dvorski savjetnik dr. Dragutin Gorjanović-Kramberger. Time je stečeno pravo na izradbu i objavljivanje geoloških karata mjerila 1:75 000 i 1:25 000, što je do tada bilo isključivo u nadležnosti Geološkog zavoda u Budimpešti. Godinu dana poslije na prijedlog predsjednika, proširena je djelatnost Geološkog povjerenstva te osnovana Geografska sekcija i Odbor za istraživanje spilja. Godine 1911. uspjelo mu je ishoditi potporu Hrvatsko-slavonske zemaljske vlade za izdavanje Vijesti Geološkog povjerenstva, kojima je on bio prvi urednik, te je do 1916. izdao šest svezaka. U nastojanju da spriječi djelovanje mađarskih geologa na teritoriju Hrvatske, Gorjanović-Kramberger odlučio se i za istraživanje Slavonije i Srijema, iako je tada u sjeverozapadnoj Hrvatskoj imao mnogo započetih projekata. U tu je svrhu osnovao *Komisiju za znanstveno izučavanje Srijema*, kojoj je hrvatski ban N. pl. Tomašić odobrio godišnju potporu od 2000 kruna (Salopek, 1939-40).

Nakon 1909. Gorjanović-Kramberger prepustio je geološko kartiranje svom mlađem suradniku F. Kochu, a predsjednikom Geološkog povjerenstva ostao je sve do 7. 9. 1922., kada je Pokrajinska vlada, Odjeljenje za Prosvjetu i Vjeru dokinula tu ustanovu i osnovala Geološki zavod u Zagrebu (današnji Hrvatski geološki institut).

Danas možda izgleda nevjerojatno što se Gorjanović-Kramberger morao toliko truditi da bi ishodio odobrenje za izradbu geoloških karata na teritoriju tadašnje Hrvatske i Slavonije. Poznato je da o geološkoj građi ovisi privredni, a time društveni razvoj nekoga kraja ili države, a njezino poznavanje moguće je samo na temelju geoloških karata. Geološka građa uvjetuje sastav i plodnost tla, postojanje pitke vode i svih vrsta mineralnih sirovina, a njezino poznavanje važno je za izgradnju kopnenih i plovnih putova, urbanizaciju i pri pojavi klizišta te omogućuje pravilno planiranje raznovrsnih projekata i korištenje prirodnih bogatstava. U Gorjanovićevu doba podatak da u nekom području ima ugljena bio je značajan isto kao što bi to danas bio podatak da ima nafte, a sutra će to biti pitka voda. I danas smo svjedoci da nedovoljna istraženost nekog područja dovodi do vrlo skupih sanacija klizišta i odrona koji unatoč tomu predstavljaju stalnu opasnost. Zbog toga se rade sve detaljnije verzije geoloških karata, a trenutačno se za područje grada Zagreba snima inženjersko-geološka karta mjerila 1:5000.

Zbog kontrole nad prirodnim bogatstvima istraživanja ruda, iz kojih su se poslije razvila geološka istraživanja, oduvijek su bila usko povezana s državnom administracijom. Tako je primjerice 1347. godine hrvatski ban Nikola Banfić u ime kralja (jer tada je samo kralj mogao to učiniti) izdao povelju građanima Zagreba (tada Griča) da pronađena nalazišta soli u Slanom potoku na Medvednici mogu "za vremena zadržati i njima se služiti" (Marković 2002). Zbog toga su prvi istraživači ruda, a poslije i geolozi sve do 1990. bili pod nadzorom policije ili vojske, a rezultati njihovih istraživanja mnogo puta su proglašavani vojnom, službenom ili privrednom tajnom. Tako je primjerice Gorjanović-Krambergerove geološke karte izdala "Kr. hrvatsko-slavon.-dalmat. zemaljska vlada, odio za unutarnje poslove", dok je listove Osnovne geološke karte M 1:100 000 SFRJ, koje su snimane 70 godina poslije, izdavao Savezni geološki zavod u Beogradu. Topografske podloge za te karte proglašene su "službenom tajnom", a kontrolirao ih je Vojnogeografski institut u Beogradu. Vjerojatno je i Gorjanović-Kramberger imao sličnih problema pri nabavi topografskih podloga za svoje karte.

Sve do 1990. godine nije bilo preporučljivo govoriti o značenju D. Gorjanović-Krambergera za kasnije osamostaljenje Hrvatske, stoga njegovi kroničari nigdje nisu isticali njegovo političko opredjeljenje i utjecaj. Iako kao sin postolara nije imao nikakvih društvenih prednosti, a promjenom prezimena odbacio je i potencijalne povlastice, ipak je na temelju rezultata svojih znanstvenih radova uspio steći titulu kraljevskog dvorskoga savjetnika. To je u ono doba bio najviši činovnički stupaj bez kojeg sigurno ne bi mogao osnovati Geološko povjerenstvo kao ni druge prateće ustanove. Budući da su sve tadašnje države u Europi imale takve institucije, mora se naglasiti da je osnivanje iste na teritoriju Hrvatske bio veliki doprinos hrvatskoj samostalnosti prilikom posljednjeg raspada Austro-Ugarske Monarhije. To se ubrzo potvrdilo, kada je osnutkom Kraljevine Jugoslavije Geološki zavod iz Zagreba sa svom svojom dokumentacijom preseljen u Beograd. Zanimljivo je da je prvi direktor te nove institucije, koja je poslije prerasla u Savezni geološki zavod, bio F. Koch.

Osim toga Gorjanović-Kramberger je bio inicijator raznovrsnih geoloških istraživanja koja su danas poznata pod nazivima: geotektonika, hidrogeologija, inženjerska geologija, geomorfologija krških i lesnih terena, "sekvencijska" stratigrafija i dr. U svakoj grani geologije kojom se bavio postizao je sjajne rezultate i pridonosio njezinu napretku.

Tijekom svog pedesetjednogodišnjeg znanstvenog djelovanja Gorjanović-Kramberger je objavio 244 rada. Od toga se na "pračovjeka iz Krapine" odnose 82 rada, na fosilne ribe 24, na fosilne školjkaše 16, na fosilne sisavce 14, na geologiju pojedinih područja 14, na geomorfologiju i krš 12, na les ili prapor 9, na tektoniku 5, na hidrogeologiju 5, na pregledne geološke karte 4, na tumače geoloških karata 4, na termalne i mineralne izvore 5, na zagrebački vodovod 3 i dr. (Magaš, Kochansky-Devidé, 1983). Osim toga postoje i njegovi raniji radovi, koji su

1:100 000 SFRJ, (mapped seventy years later) were published by State Geology Survey in Belgrade. It is possible that Gorjanović-Kramberger had similar problems when obtaining the topographic base maps.

Until 1990 it was not recommended to talk about the importance of Gorjanović-Kramberger's work for the independence of Croatia, therefore historians did not stress his political beliefs and influence. Socially, he had no advantage as he was the son of a cobbler, and changing the surname lessened the potential advantages, however based on the results of his scientific achievements he managed to gain the title of Royal Advisor. In those times this was the highest officer's level which allowed him to establish the Geology Council and other departments.

Since all other European countries at that time had such institutions, it must be noted that the establishment of Geology council on the Croatian territory was a big contribution to the independence of Croatia in particular due to break up of Austro-Hungarian Monarchy. This was soon confirmed when after the formation of Kingdom of Yugoslavia, Geological survey Zagreb was moved to Belgrade. It is interesting to note that the first managing director of this new institution, later State Geological Survey, was F. Koch.

In addition to his importance as scientific leader in social and political sense, Gorjanović-Kramberger was the initiator of different geological investigations which today are known as: geotechnics, hydrogeology, engineering geology, geomorphology of karst and eolian soils, sequence stratigraphy etc. In every area of geology that he was involved in, he was achieving remarkable results and has contributed to the progress of geology.

During his 50 years of scientific work Gorjanović-Kramberger has published 244 papers. Out of those, 82 papers are on "Early Man from Krapina", 24 papers are related to fossil fish, 16 to fossil shells, 14 to fossil mammals, 14 to geology of certain areas, 12 to geomorphology and karst, 9 to eolian sediments, 5 to tectonics, 5 to hydrogeology, 4 to geology maps, 4 to accompanying notes to geology maps, 5 to thermal and mineral springs, 3 to Zagreb water works etc. (Magaš and Kochanski-Devide, 1983). Apart from this there are other earlier works, published under Kramberger surname, as well as unpublished reports in various institutions (Gorjanović-Kramberger, 1896, 1902 and 1906).

Pure number of titles indicates how deep Gorjanović-Kramberger was involved in investigation of Krapina Early Man, and this is probably shown in the number of his cited papers. It must be noted that this involved his work in the second half of his scientific career. In the first half, his scientific work mostly involved accidental findings of new fossils; his first independent and thorough investigations were focused on collection of data, which he later used for preparation of geology maps and for other works. This part of his career was never well known and appreciated. Some historians think that he was forced in practical geology "just along the way" as there was a lack of "good geologists" (Radovčić, 1988). On the other hand, out of his work one can conclude quite the opposite.

In 1893 he was already publishing geological papers from the areas of northern Croatia, and collecting data for geology maps, sheet Ptuj and Rogatec-Kozje. Upon his friend's invitation, he visited Hušnjak hill, where at that time the sand was being dug to cover the town streets. As skilful palaeontologist he appreciated the importance of this location and he analyzed it with great detail and attention. Thereby, he saved Krapina archaeological findings from further destruction and ensured himself glory of discovery.

2 "Montangeological" Works by D. Gorjanović-Kramberger

Following the establishment of the Geological council, the "montangeological section" started its intensive work, while the activity of the "agogeological section" slowly died. Gorjanović-Kramberger was the most important contributor to the montangeological section, but the historians often overlook this activity as it was not as spectacular as palaeoanthropological or palaeontological. His statements and proofs that the remains of Neanderthal man from Krapina are not degenerated remains of today man, rather a new human kind, had made its way around the scientific world. It is interesting to note, that he also achieved remarkable results in investigations of fossil fish and was known for his work throughout Europe. Yet, his results in geological mapping and his work in practical geology were not a matter of luck, but a result of thorough and complex investigations. He could, even without the finding in Krapina, be called our best geologist.

His first field investigations from the north-western Croatia Gorjanović-Kramberger published in the papers: *Die Karsterscheinungen im westliche Teile des Agramer Gebirges* from 1881, then *Geologijski i hidrografski odnošaji Marija-Goričkih brda* from 1893, *Geologija gore Samoborske i Žumberačke* from 1894, *Strugača i njezin zapadni nastavak* published in 1897, and others. At the same time two geology maps were published in Austria; at the scale of 1:75 000 sheet *Pettau und Vinica* (Ptuj-Vinica) and *Rohitsch und Drachenburg* (Rogatec-Kozje). Both of these map sheets were mapped by Dreger (1898a and 1898b). On those maps all topographical names, geological data and legend, as well as notes that accompany the map are printed in German language. If the Hungarian geologists had mapped the area of *Croatia and Slavonia*, then all notes would have been in Hungarian language.

Hungarian geologists that have been investigating coal deposits and train tracks in Croatia used every occasion to change our topographical names into Hungarian ones. This was the reason why Gorjanović-Kramberger (1904) disputes several Hungarian geologists "usurpation" of our brown coal and lignite mines and their inclusion "under the Hungarian crown". Gorjanović-Kramberger also comments: "And the names of counties and towns are changed so much that not even we Croats know them!". He was very displeased by the fact that

objavljeni pod prezimenom Kramberger, kao i neobjavljena izvješća u fondovima raznih ustanova (Gorjanović-Kramberger, 1896, 1902 i 1906).

Već sam broj naslova pokazuje koliko se Gorjanović-Kramberger posvetio istraživanju krapinskog pračovjeka, a to vjerojatno pokazuje i broj njegovih citiranih radova, ali valja naglasiti da se on time najviše bavio u drugoj polovici svoje znanstvene karijere. U prvom je razdoblju njegov znanstveni rad najvećim dijelom ovisio o slučajnim nalazima fosila, a prva su mu samostalna i sustavna istraživanja bila usmjerena na prikupljanje podataka koje je poslije koristio za izradu geoloških karata i drugih radova. Taj dio njegove znanstveno-istraživačke djelatnosti nikada nije bio dovoljno rasvijetljen ni valoriziran. Neki njegovi kroničari čak smatraju da je on zbog pomanjkanja "stručnih geologa" bio prisiljen samo "uz put" baviti se praktičnom geologijom (Radovčić, 1988). No iz njegovih se objavljenih radova može zaključiti da je u stvari bilo obratno. On je već 1893. objavljivao geološke radove s područja sjeverne Hrvatske, te prikupljao podatke za izradu geološke karte listova Ptuj i Rogatec-Kozje. Na poziv znanaca iz Krapine, posjetio je Hušnjakovo brdo gdje se tada iskopavao pijesak za nasipavanje gradskih ulica. Kao iskusan paleontolog shvatio je značenje tog nalazišta te ga detaljno i savjesno obradio. Time je spasio krapinsko nalazište od daljnje devastacije, a sebi osigurao vječnu slavu.

2. "Montangeološka" djelatnost D. Gorjanovića-Krambergera

Osnutkom Geološkog povjerenstva "montangeološka sekcija" započela je intenzivan rad, dok je djelatnost "agrogeološke sekcije" postupno zamrla. U radu montangeološke sekcije bio je najistaknutiji D. Gorjanović-Kramberger, ali njegovi kroničari uglavnom zanemaruju tu djelatnost, jer ona nije tako spektakularna kao paleoantropološka ili paleontološka. Njegovi dokazi da ostaci neandertalca iz Krapine nisu degenerirani ostaci današnjeg čovjeka već nova ljudska vrsta, odjeknuli su u cijelom znanstvenom svijetu. Zanimljivo je da je on i u istraživanju fosilnih riba postigao odlične rezultate te bio poznat diljem Europe. Ipak njegovi rezultati u geološkom kartiranju kao i radovi iz praktične geologije nisu bili slučajni, već plodovi dugotrajnih i sustavnih istraživanja, te bi ga se i bez nalaza u Krapini moglo smatrati našim najvećim geologom.

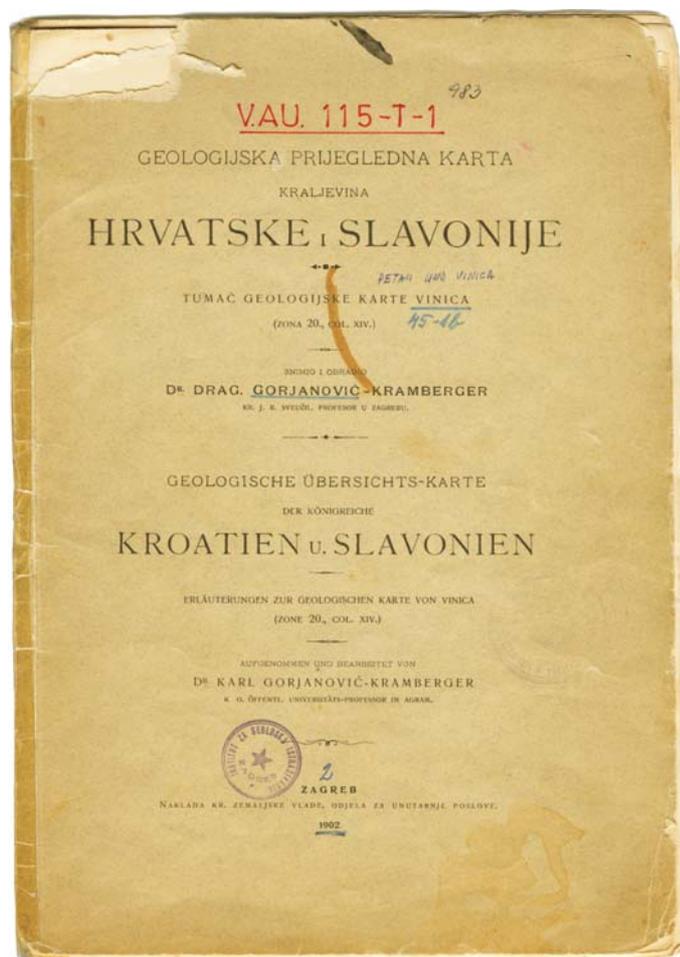
Svoja prva terenska istraživanja s područja sjeverozapadne Hrvatske Gorjanović-Kramberger je objavio u radovima: *Die Karsterscheinungen im westliche Teile des Agramer Gebirges* iz 1881., zatim *Geologijski i hidrografijski odnošaji Marija-Goričkih brda* iz 1893., *Geologija gore Samoborske i Žumberačke* iz 1894. te *Strugača i njezin zapadni nastavak* koji je tiskan 1897. i dr. Istodobno su u Austriji objavljene pregledne geološke karte, M 1:75 000 listova *Pettau und Vinica* (Ptuj-Vinica) i *Rohitsch und Drachenburg* (Rogatec-Kozje), koje je snimio austrijski geolog Dreger (1898.a, 1898.b). Na tim su kartama svi toponimi te geološkoj podaci i legenda, kao i tumač geološke karte tiskani na njemačkom jeziku. Da su tada

mađarski geolozi kartirali teritorij "Hrvatske i Slavonije", sigurno bi sve oznake bile tiskane na mađarskom jeziku. Mađarski geolozi koji su istraživali ležišta ugljena i trase željezničkih pruga u Hrvatskoj, svakom su prilikom "mađarizirali" hrvatske toponime. Zbog toga Gorjanović-Kramberger (1904) osporava nekolicini mađarskih geologa "prisvajanje" hrvatskih rudnika smeđeg ugljena i lignita te njihovo uvrštavanje "pod ugarsku krunu". Također navodi: "Nadalje su imena županija i mjesta tako raznolično izopačena da ih ni mi Hrvati ne poznamo!". Najviše ga ljuti što mađarski geolog Kalcsinszky naše: "hrvatske županije Viroviticu i Srijem zove Vöröcze i Szrerem, Varaždin – Varasd, Koprivnicu – Kaproncza" i sl. Iz toga je vidljivo da se Gorjanović-Kramberger, bez obzira na njemačko podrijetlo svog prezimena, smatrao Hrvatom.

Prilikom geološkog kartiranja Dreger nije "prelazio" tadašnju granicu Austrije i Hrvatske, tako da ti listovi nisu bili popunjeni. U to doba je Gorjanović-Kramberger u Beču objavio nekoliko radova i održao nekoliko predavanja, što je vjerojatno bio povod da mu se dopusti nastavak geološkog kartiranja na hrvatskom teritoriju. Zbog toga su legende i tumači svih tih geoloških karata morali biti pisani dvojezično, na hrvatskom i njemačkom jeziku.

Hrvatski dio "Geologijske prijedledne karte" lista Ptuj-Vinica tiskan je 1902., a dvije godine poslije (1904) tiskani su listovi Rogatec-Kozje i Zlatar-Krapina, dok je list Zagreb objavljen 1908. godine. Legende i tumači geoloških

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Geološki prikazna karta KRALJEVINE HRVATSKE-SLAVONIJE

izdaje
kr. hrv. slavn. dalmat. zemalj. vlada, odio za unutarnje poslove.
Saimio i obradbo: Prof. Dr. Dragutin Gorjanović Kramberger.

ROGATEC-
ROHITSCH und



ZONE 21 COL XIII.

Carbon



Orni brastolci, sivi
pješčenjaci i konglomerati.
Schwarze Tonschiefer,
graue Sandsteine und
Konglomerate.

Dyas



Crveni grodenski pješčenjaci.
Rote Grödener Sandsteine.

Trias



Ljsturni vapnenac (tm)
i verfenski škrlj (t).
Muschelkalk (tm)
und Werfener Schiefer (t).



Gornji:
svjetli vapnenac i dolomit.
Obere Abteilung:
helle Kalko und Dolomite.

Oligocen



Socka slojevi,
tvrdi pješčenjaci
i žuti pjesci.
Sotka-Schichten;
härtere tuffige Sandsteine
und gelbe Sande.



Pršinci andezita.
Andesit-Tuffe.

locen,
dlocen.



Tvrđi pješčenjaci, vapneni
i pošastli pješčenjaci.
Härtere Sandsteine,
Kalk- und Tuffsandsteine.



Tvorevine litavca u opće.
Leithalkbildungen
im allgemeinen.



Mjerilo — Ma



K. und k. militär-ge
Verisfällige

Geologische Übersichtskarte des KÖNIGREICHES KROATIEN-SLAVONIEN

V.AU. 125-a

Kozje

herausgegeben durch die
k. kroatisch-slavon.-dalmat. Landesregierung, Sektion für innere Angelegenheiten.
Aufgenommen und bearbeitet von: Prof. Dr. Dragutin Gorjanović Kramberger.

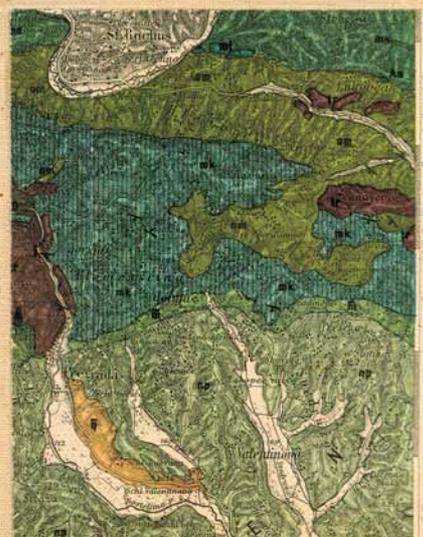
991

DRACHENBURG



Gorjui mioceen
Ober-Mioceen

 Sarmatski slojevi.
Sarmatische Schichten.



Pliocen

 Kongerjski slojevi.
Kongerjensichten.

Quartär | recent.

Quartär und Recent.

 Diluvijalne obronačne
ilovine.
Gehängelehm.

 Dolinski aluvij,
Talbodenalluvium.



 M
Melaphyr.

 D
Diabas.

Eruptiv



 Augit-Andesit.

 Polotaj slojeva.
Streichen und Fallen
der Schichten.

Stab 1:70.000

graphisches Institut.
Verfahren.

 Topla vrela.
Thermen.

Hungarian geologist Kalcsinszky calls our "Croatian county of Virovitica and Srijem, Vöröcze and Szererem, Varaždin he calls Varasd, and Koprivnica – Kaproncza" and so on. From this one can see that Gorjanović-Kramberger, in spite of German origin of his surname, considered himself to be a Croat.

During geological mapping Dreger did not "cross" the boundary of the former Austria and Croatia; therefore his geology map sheets were incomplete. At that time Gorjanović-Kramberger has published several papers and held several talks, which was probably the reason why he was allowed to complete geological mapping in the Croatian territory. Consequently the map legend and accompanying notes for all geology maps had to be written bilingually, in Croatian and German.

The Croatian part of the Geology map, sheet Ptuj-Vinica was published in 1902, and two years later (1904) sheets Rogatec-Kozje and Zlatar-Krapina were published as well. The sheet Zagreb was published later in 1908. The legends and the accompanying notes for the geology maps were written according to chronostratigraphic subdivision, and the lower units are shown as lithostratigraphic, sometimes with local names (such as Macej sandstone). On the geology map Ptuj-Vinica eleven chronostratigraphic units are defined, on the map Rogatec-Kozje 15 units are defined, on map Zlatar-Krapina 21, and on the map Zagreb 18 units. All mapped units are described in detail in accompanying notes, along with

the separate "Tectonics", "Igneous Rock", "Hot springs", and "Useful stone and ore" sections. For comparison, one needs to know that Geology map sheet Zagreb (scale 1:100 000), published 70 years later, and has 36 chronostratigraphic units (Šikić et al., 1979a and 1979b). The new geology map which is still in the working stage will have over 60 lithostratigraphic units.

Gorjanović-Kramberger determined stratigraphy of mapped units on the basis of "fossil microfauna" which he personally analyzed, whereas the rocks without fossils he compared to similar rocks in the Alps. Petrographic determination of igneous and metamorphic rocks was undertaken by F. Koch.

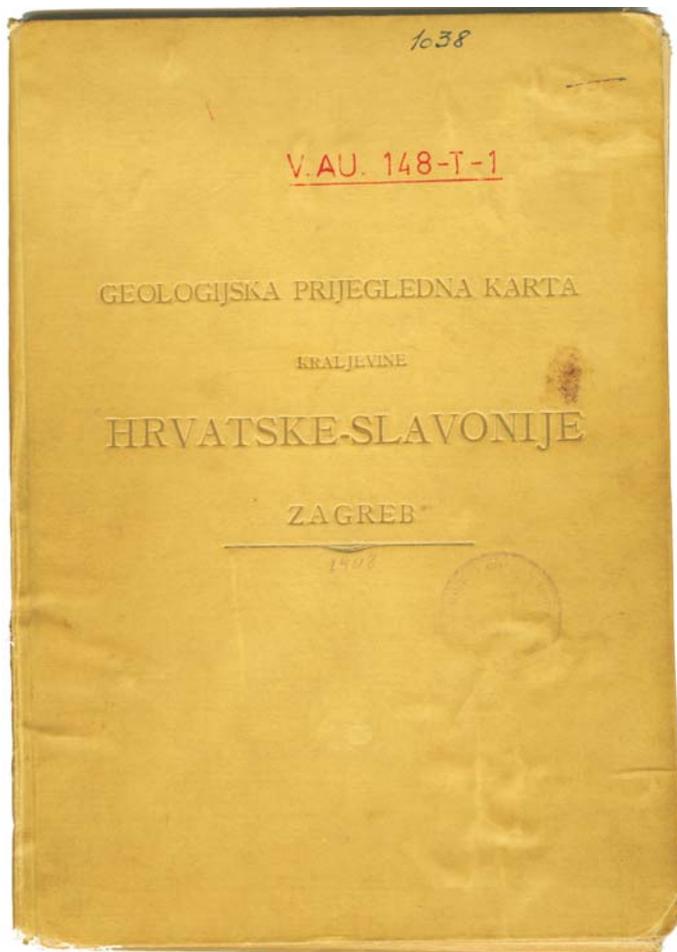
The area of Croatia on the Ptuj-Vinica sheet is 336 km², on the Rogatec-Kozje sheet 474 km², while on sheets Zlatar-Krapina and Zagreb it is 1052 km², respectively. The total area of all sheets is 2914 km², thus, it is hard to understand how Gorjanović-Kramberger with only one assistant (F. Koch) managed to map this whole area, determine microfauna, write accompanying notes to geology maps, and prepare all of the above for publishing. At the same time it is important to mention that he was involved in investigation of Krapina anthropology finding, analysis of the collected material and writing his best papers on Krapina Early Man.

As a comparison, according to the regulations of the former State geology survey in Belgrade, to map an area of that size around 2900 "field days were required". Certainly, Gorjanović-Kramberger and Koch did not need to have 16 to 24 "location points" per every square kilometre, as one would need for geology map scale 1: 100 000. In addition, the transport in those days was slower; therefore more time was required for field work. It is known that Gorjanović-Kramberger drove around in carriage and Koch was riding a horse, they stayed overnight in rectory and aristocrat lodges while undertaking the field work. Nevertheless, comparing their "*Geologjske prijegledne karte*" and today's geology maps, one can see that they completed their work thoroughly. It surprises how they managed to map small occurrences of "socka layers" (characteristic for the occurrence of brown coal) in deep trenches in the area of Ivanščica and Strahinščica.

Also interesting is the discussion between Gorjanović-Kramberger and Kišpatić on tuff found near Margečan in Hrvatsko Zagorje. Gorjanović-Kramberger linked the occurrence of tuff with lower Miocene volcanics, while Kišpatić thought that those were not tuffs rather fine-grained quartz rock (Gorjanović-Kramberger, 1904a, 1904b, Kišpatić, 1909). The most recent investigations found that Gorjanović-Kramberger was indeed right, but the tuffs are not of Miocene but Triassic age (Šimunić et al., 1981, 1982).

The biggest difference between the early and recent geology maps is that the early ones were produced on the old "fuzzy" topographic base, they had very little information on dip and dip direction, the geology boundary "type" is not defined and there are no data on faults. Therefore, from the relationship between the "isolines

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karata pisani su prema kronostratigrafskoj podjeli, a niže su jedinice prikazane kao litostratigrafske, katkad i s lokalnim nazivima (primjerice Maceljski pješčenjaci). Na geološkoj karti Ptuj-Vinica izdvojeno je 11 kronostratigrafskih jedinica, na karti Rogatec-Kozje 15, na karti Zlatar-Krapina 21, na karti Zagreb 18 tih jedinica. Sve kartirane jedinice, detaljno su opisane u tumačima geoloških karata, a uz njih su u posebnim poglavljima opisani *Tektonika, Eruptivne stijene, Topla vrela te Korisne kami i rude*. Radi usporedbe valja spomenuti da Osnovna geološka karta, list Zagreb M 1:100 000, koja je objavljena sedamdeset godina poslije, ima 36 kronostratigrafskih jedinica (Šikić i dr., 1979. a i b), dok će najnovija karta, M 1:50 000, koja je u pripremi, imati više od 60 litostratigrafskih jedinica.

Stratigrafsku pripadnost kartiranih jedinica Gorjanović-Kramberger je određivao na temelju "fosilne makrofaune" koju je osobno analizirao, dok je stijene bez fosilnog sadržaja uspoređivao sa sličnim stijenama u Alpama. Petrografske odredbe eruptivnih i metamorfnih stijena obavio je F. Koch.

Hrvatski dio terena na listu Ptuj-Vinica ima površinu 336 km², na listu Rogatec-Kozje površina je 474 km², dok listovi Zlatar-Krapina i Zagreb imaju po 1052 km². Ukupna površina svih listova iznosi 2914 km² i teško je shvatiti kako je Gorjanović-Kramberger, uz samo jednog suradnika (F. Kocha), uspio obići i snimiti taj teren, odrediti makrofaunu, napisati tumače geoloških karata i sve to pripremiti za tisak. Pritom je potrebno naglasiti da se istodobno bavio istraživanjem krapinskog nalazišta, obradom prikupljenog materijala i pisanjem svojih najpoznatijih radova o krapinskom pračovjeku.

Za ilustraciju valja spomenuti da bi, prema normama nekadašnjeg Saveznoga geološkog zavoda u Beogradu, za tu površinu terena bilo potrebno oko 2900 "terenskih dana". Naravno da Gorjanović-Kramberger i Koch nisu morali na 1 km² imati 16-24 "točke opažanja", kao što je to bilo potrebno pri izradbi Osnovne geološke karte mjerila 1:100 000. Osim toga tadašnja su prijevozna sredstva bila mnogo sporija od današnjih, pa im je za obilazak terena bilo potrebno znatno više vremena. Poznato je da se Gorjanović-Kramberger, po terenu vozio u kočiji dok je Koch jašio na konju, a stanovali su po župnim dvorovima i plemićkim kurijama. Ipak, uspoređujući njihove "Geologijske prijezledne karte" i listove Osnovne geološke karte, vidljivo je da su oni solidno obavili svoj zadatak. Ponekad začuđuje kako su u dubokim jarcima na području Ivanščice i Strahinščice uspjeli izdvojiti male pojave "socka slojeva", koji su karakteristični za pojavu smeđeg ugljena. Zanimljiva je i rasprava o tufovima kraj Margečana u Hrvatskom zagorju koja se vodila između Gorjanović-Krambergera i Kišpatića. Prvi ih je povezivao s donjomiocenskim vulkanizmom, a drugi je smatrao da to nisu tufovi već sitnozrnata kvarcna stijena (Gorjanović-Kramberger 1904. a i b; Kišpatić 1909). Novija su istraživanja pokazala da je Gorjanović-Kramberger bio u pravu, ali da tufovi nisu miocenski već trijaski (Šimunić i dr., 1981, 1982).

Najveće su razlike između starih i današnjih geoloških karata u tome što su prve karte rađene na zastarjeloj "šrafiranoj" topografskoj podlozi, imaju vrlo malo oznaka za položaj slojeva, nije ustanovljen "karakter" geoloških granica te nema oznaka za rasjede. Zbog toga se iz odnosa "izohipsa i geoloških granica" ne može odrediti strukturna građa terena, kao ni superpozicijski slijed naslaga. Čini se da tada nije bilo uvriježeno da se na geološke karte unose oznake ustanovljenih ili pretpostavljenih tektonskih elemenata, iako se u tumačima tih karata o njima naveliko raspravljalo. Ni na jednoj geološkoj karti nisu ucrtani rasjedi, osi bora i slični tektonski elementi bez kojih se danas ne može zamisliti ni jedna geološka karta.

Prema Gorjanović-Krambergerovu navodu, list Zagreb sniman je uz suradnju Gj. Pilara, ali kako je "rukopisna" karta bila izgubljena, on je sam napravio novu verziju, koja je objavljena 1908. godine. Iz polemika koje su ta dvojica vodili o oledbi Zagrebačke gore i o postanku zagrebačke terase, vidljivo je da se nisu mogli složiti oko nekih postavki, te da je to najvjerojatnije prouzročilo prekid njihove suradnje (Pilar, 1877, Gorjanović-Kramberger, 1907).

Tumače geoloških karata je Gorjanović-Kramberger koristio i za prikaz tektonskih odnosa, te je (1902) izradio shematsku tektonsku kartu iz koje se vidi raspored paleozojsko-mezozojskih jezgri na području Hrvatskog zagorja. Jezgre su poredane u pet paralelnih nizova koji se protežu u smjeru istok-zapad i sjeveroistok-jugozapad. On je smatrao da su to: "Rastrgani, dakle labilni istočnoalpski ogranci". Ujedno je osporavao geografsku podjelu planina u Hrvatskom zagorju koju su napravili geografi Hranilović i Hirc. Oni su među ostalim, smatrali da Strugača pripada planinskom nizu Ivanščica-Strahinščica, dok je Gorjanović-Kramberger ustanovio da se između tih gora nalazi uska i duboka sinklinala, ispunjena neogenskim sedimentima. Zbog toga navodi da njihov prikaz "geografskog razdjeljena Hrvatskog zagorja ne odgovara modernom znanstvenom shvaćanju".

U Tumaču lista Zlatar-Krapina iz 1904. opisuje *Balatonski rasjed* koji se proteže od Toplice kraj Sv. Jane, preko Stubičkih i Varaždinskih toplica do Balatona. Iako postojanje tog rasjeda poslije nije dokazano, ipak se njegovo ime još i danas koristi u geološkoj literaturi, samo što ga različiti autori "pomiču" od južnih padina Medvednice do doline rijeke Dravinje u Sloveniji.

U radu *Die Geotektonischen Verhältnisse des Agramer Gebirge...* iz 1907. godine i Tumaču geološke karte lista Zagreb (1908) obrađuje se ista tektonska problematika. U njima se spominju četiri tektonske faze, od kojih je prva bila u paleozoiku, druga početkom oligocena, treća u pliocenu i četvrta u kvartaru. S današnjeg stanovišta je vidljivo da je Gorjanović-Kramberger dobro rasporedio "svoje" tektonske faze i njima obilježio najmarkantnija tektonska zbivanja na Medvednici. Ipak je to pojednostavnjeno shvaćanje jer "njegova" paleozojska faza odgovara cijeloj hercinskoj orogenezi koja je trajala

and geological boundaries” one can not define the structural characteristics of the terrain, or superposition sequence of units.

It seems that, at that time it was not common to place the symbol for known and assumed tectonic elements on the geology map, although they were discussed in the accompanying notes. No geology map from that time had indicated faults, fold axis and similar tectonic elements, without which we can't imagine geology map today.

According to Gorjanović-Kramberger testimonial, map sheet Zagreb was completed in association with Gj. Pilar, but since the map was “hand drawn” it got lost. Gorjanović-Kramberger made a new version, which was published in 1908. A controversy between Gorjanović-Kramberger and Gj. Pilar regarding the melting of ice from Zagreb ranges and the formation of Zagreb terrace indicates that they could not agree about the hypothesis. This was most likely the reason behind the break in the partnership (Pilar, 1877, Gorjanović-Kramberger, 1907).

64 Gorjanović-Kramberger used the accompanying notes to the geology maps to show the tectonic relationships and in 1902 he completed schematic tectonic map. On this map one can see the layout of the Palaeozoic-Mesozoic entities in the area of Hrvatsko Zagorje. These entities are located in five parallel rows which extend in the east-west and northeast-southwest direction. He contemplated that these were: “Broken up, unstable offshoots from eastern Alps”. At the same time he opposed geographical division of ranges in Hrvatsko Zagorje initially done by geographers Hranilović and Hirc. They considered that Strugača belongs to the Ivanščica – Strahinščica ranges, while Gorjanović-Kramberger established that between those ranges there is a narrow and deep syncline, filled with Neocene sediments. Therefore he states that their hypothesis of “geographical separation of Hrvatsko Zagorje does not fit into the modern theories and understandings”.

In the accompanying notes to Zlatar-Krapina sheet from 1904 he explains the *Balaton fault* which extends from Toplice near St. Jana, through Stubičke and Varaždin Toplice to Balaton. Although the existence of this fault has not been proven, his name is still used in the geological literature; however some authors “move” the fault from southern flanks of Medvednica to Dravinja river valley in Slovenia.

In his paper *Die Geotektonischen Verhältnisse des Agramer Gebirge* from 1907 and the accompanying notes to geological map sheet Zagreb (1908) he deals with the same tectonic issues. In there he mentions four tectonic phases, of which first was in Palaeozoic, the second at the beginning of Oligocene, third in Pliocene and the fourth in Quaternary. From today's point of view one can see that Gorjanović-Kramberger placed “his” tectonic phases well and then used them to mark the most important tectonic events on Medvednica.

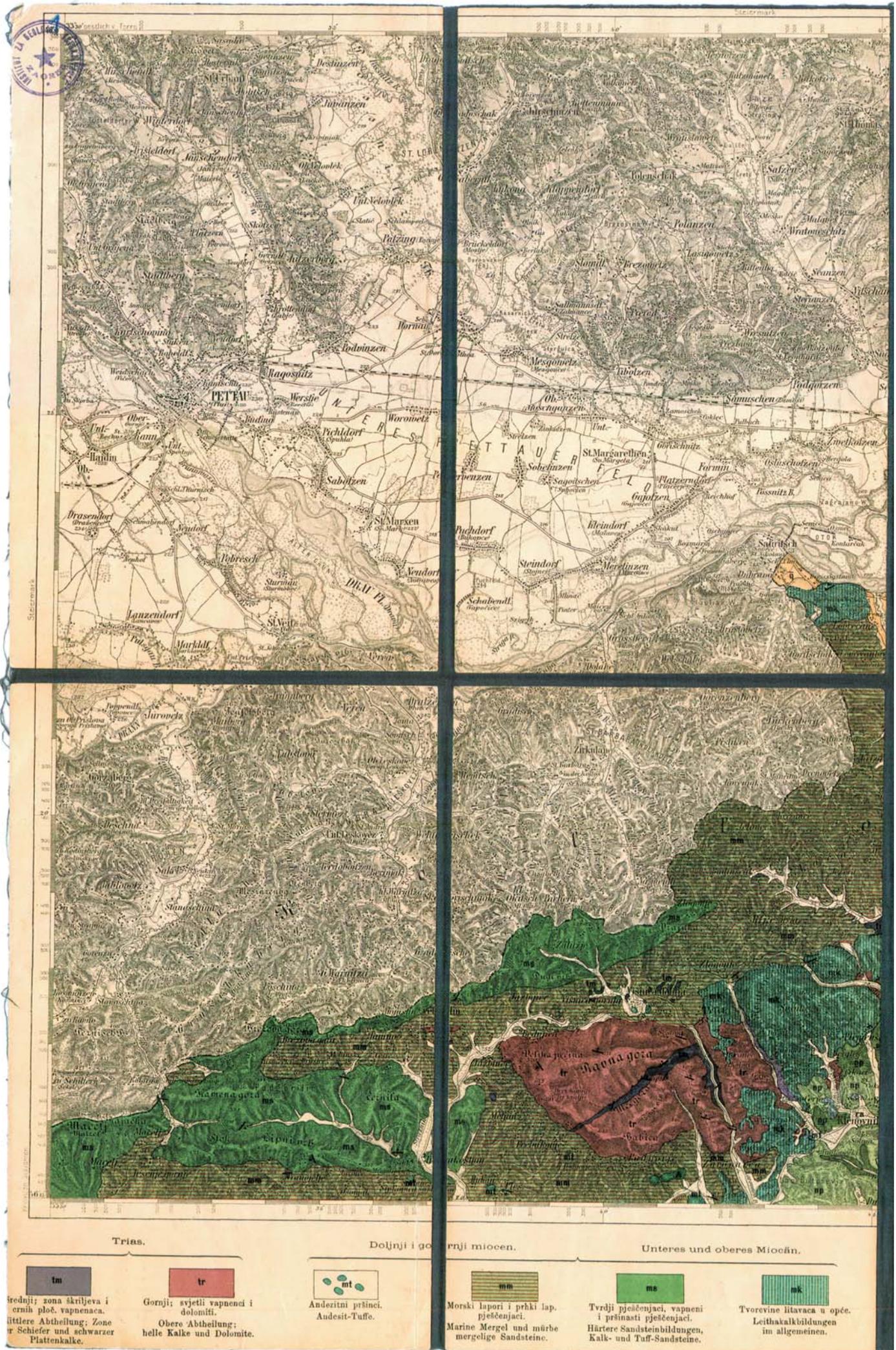
Yet, this is simplified understanding and representation since “his” Palaeozoic phase relates to the whole Hercyn orogenesis which lasted about 100 million years, while in whole Mesozoic (110 million years) he did not notice any tectonic phases. During the whole Tertiary (approximately 65 million years) he assumed only two tectonic phases, although between those there are several less pronounced phases.

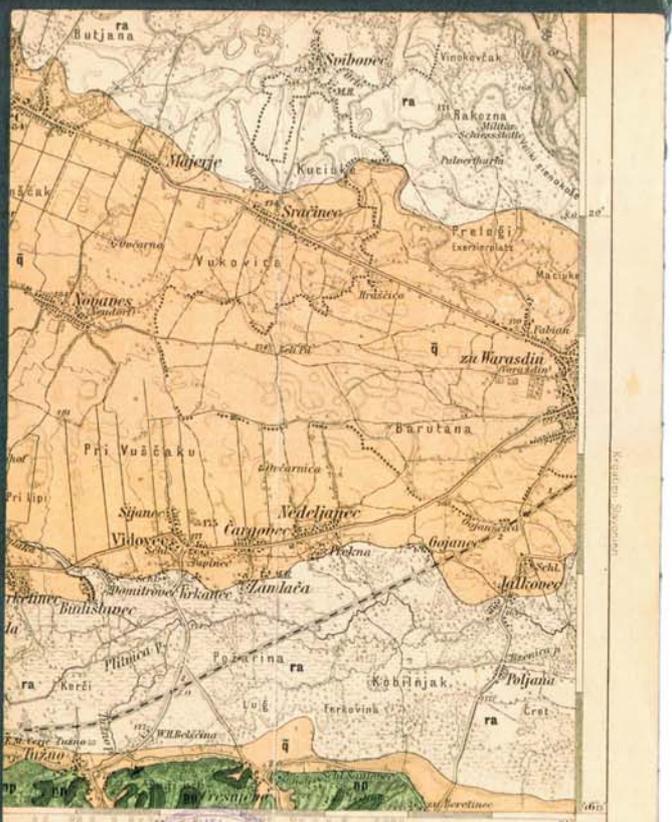
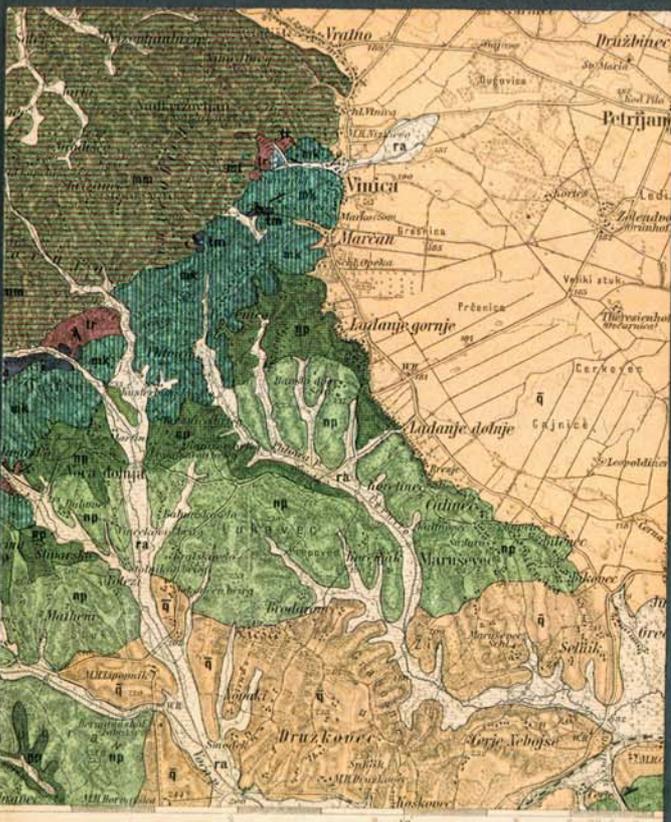
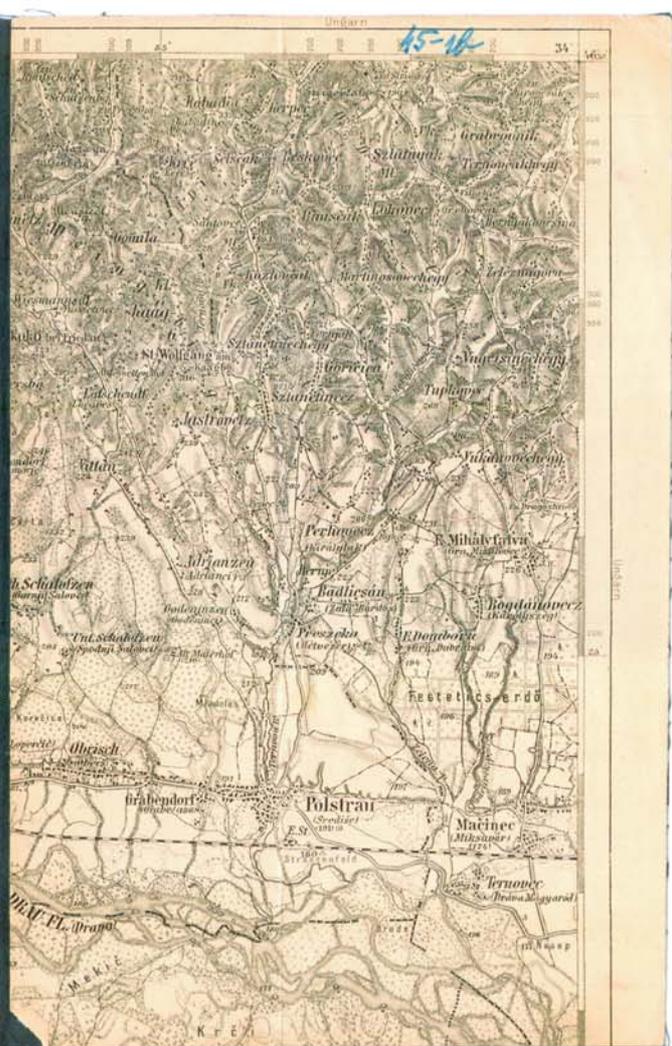
Gorjanović-Kramberger was the first geologist to mention the faults located on the edge of Medvednica horst, cross cutting fault near Kašina and tectonic link between Zagrebačka and Samoborska gora. He included the biggest part of Medvednica and middle part of Kalnička ranges into “Mojsisovicsevo Oriental land”, while the western part of Medvednica he attached to the flanks of the eastern Alps.

It is interesting how in spite of the opposition he explained the evolution of Zagreb terrace and assumed the existence of Ilički fault which separates Zagreb into two parts: the lower and the upper. Gorjanović-Kramberger proved that this fault was formed in diluvium which gives him a status of the pioneer of today's neotectonic, something his followers were fearful of. He also explains the big fault that separates Medvednica and Kalnik from the area which was later called Moslavačko – Vrbovečki step (Basch, 1983a and b). This fault has now been proven by deep exploration holes, and many “tectonics experts” label it Zagreb-Kulč or Zagreb-Zemplin (Pamić and Horvatović, 2003).

From the accompanying notes to geology maps sheet Zlatar-Krapina and Zagreb, one can see how much importance was given to volcanic activity in Croatia. He even included earthquakes (which were relatively frequent in the second half of 19th century) into volcanic activity in the broad sense of word. Different depth of epicentre he explained by different depths of igneous reservoirs. Gorjanović-Kramberger held several talks and wrote articles for newspapers in which he explained the genesis of earthquake. He investigated the propagation of seismic waves, and concluded that they are formed where longitudinal and cross-cutting faults meet. Such an example is earthquake in Zagreb (1880), earthquake in Gornje Jesenje (1898) and Ivanec earthquake (1903), where the earthquake propagates along the mountain ranges.

Of interest are his observations on the influence of earthquake on thermal springs. In one of his earlier works from 1897b, Gorjanović-Kramberger mentions two earthquakes which in year 1776 and 1880 cooled and mixed thermal water in Sutinske toplice. This shows that hypothesis (not scientifically proven) on occurrence of strong earthquakes being around every 100 years is not negligible. The information on reoccurrence of earthquake in Sutinske toplice in 1776 and again in 1880 is the first written document in Croatia which points out to this issue. Nonetheless, since there were no strong earthquakes in Croatia since 1880, one can assume that this hypothesis does not stand.





Pliocæn.	Quarter recent.	Eruptiv.
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<p>Kongerjske naslage. Congerianschichten.</p>	<p>Aluvij dolina. Aluvien der Thalböden.</p>	<p>Položni slojeva. Streichen und Fallen der Schichten.</p>



D. Trajković

One can say that Gorjanović-Kramberger was for his time the most significant geologist for “hot and mineral springs”, which he explained in the accompanying notes to geology maps, with more detailed work undertaken in several papers (1902, 1905, 1906, 1910, and 1917). He was also involved with defining protection zones around thermal springs in Sutinske toplice and Topusko, mineral water spring in Apatovac (1902c), Jamnica and Lasinja (1905b).

Based on his knowledge of geology of Pannonian part of Croatia, Gorjanović-Kramberger tried to resolve the source of thermal and mineral water in this area. During geology mapping he identified many volcanic rock outcrops, and since he was linking earthquakes with melted magma in different depths of lithosphere, he concluded that volcanic activity was not over.

According to him, juvenile water sourced at thermal wells occurs following condensation of volcanic gases and vapours in the final phase of volcanic activity. Gorjanović-Kramberger introduced term “thermal lines”, as a representation of deep faults, to link “volcanic sources” at depths with thermal springs at the surface. By introducing this term he tried to explain the linear layout of thermal springs and high yield of individual springs.

In the area of Hrvatsko Zagorje he assumed four thermal lines on which he “placed” most thermal springs. These are: Balaton, Krapina and Zagorje thermal line, and andesite and volcanoclastics zone which he also considered a thermal line. He linked Varaždin Toplice and Toplica at Dobrna in Slovenia with andesite and volcanoclastic zone, and assumed that Varaždin and Stubičke toplice along with Toplica near Sv. Jana are found on the Balaton thermal line i.e. fault. Sutinske and Stubičke Toplice he “linked” with Zagorje thermal line, and Tuhelj, Krapina, Semnik and Sutinske Toplice he “linked” with Krapina thermal line. He assumed that high yield of individual thermal springs can be explained by the fact that at some thermal springs two thermal lines cross. In Varaždin Toplice, Balaton thermal line and Zone of andesite and volcanoclastics cross, in Stubičke Toplice, Balaton and Zagorska thermal lines cross, while in Sutinske Toplice, Krapina and Zagorje thermal lines cross.

It is interesting to note that Gorjanović-Kramberger (1902, 1905) classified mineral waters in Apatovac, Jamnica and Lasinja as meteoric waters and not juvenile; although he knew that they are sourced from igneous rocks.

Considering huge authority that Gorjanović-Kramberger had, his theory about the source of thermal water and thermal lines was supported by his colleagues and his followers, and even today it is still accepted by some. After more than half a century Miholić (1940 and 1952) refuted the theory by Gorjanović-Kramberger, based on numerous chemical analysis he has proven that thermal waters in all thermal springs in northern Croatia are renewable. He “kept” the concept of thermal lines, however he somewhat changed their name and location. Later investigations in Hrvatsko Zagorje it was found that there are no

thermal lines, but thermal springs occur on the hinge of elongated anticlines (Šimunović and Hećimović, 1999).

Apart from thermal and mineral waters Gorjanović-Kramberger was involved with drinking water from Zagreb water supply (from “geological and hydrographic point of view”), and he published several papers (1888 and 1889). His skills were acknowledged, and “Royal mining unit” made him a consultant in 1902 for the construction of water well for drinking water in Varaždinske Toplice. The aim was to construct this well within the wellhead protection zone of the main thermal spring. It must be noted that after his intervention this well was not constructed, however 100 years after this event a highway was constructed within the protection zone of minor thermal springs in Varaždinske Toplice.

Gorjanović-Kramberger was concerned about the contamination of wells and in 1905 he wrote about the contamination of water well in Topusko which was threatening thermal water springs and pointed that it should be decommissioned.

During the construction of the hospital on Šalata in Zagreb (1911a) he pointed out the unsuitable location of the hospital, which as generally happens in geology, was not taken on board. Today it would be very useful to know what was the issue that Gorjanović-Kramberger was concerned about.

In addition to all other jobs that he had, Gorjanović-Kramberger also studied eolian deposits in Slavonia. In the year 1911 (1911b), and after this time he published several papers where he explains the formation and composition of eolian plains, their morphology and hydrogeology. He noticed that three aquifer zones exist in eolian sediments, and he linked their formation with thin clayey layers. On the steep cut banks of Danube near Vukovar, he made a geological section which he used to subdivide quaternary sediment based on the sequential changes of eolian sediments and clayey zones. Although this does not represent the whole quaternary period (only its upper part), which is what he thought, this work represents the beginning of today’s “sequential” geology in Croatia and is today applied to older stratigraphy.

Most of his working life Gorjanović-Kramberger was investigating the karst features and he published nine papers with this thematic (from 1881 to 1916). First he wrote about the Zagrebačka gora karst (1881) and then he discussed on several occasions “Shallow karst in the area of Generalski Stol in Croatia”, and karst and hydrogeology of Velebit and other areas. It is interesting to mention that he was the first geologist (1912) to write about thrust in the Dinarides area. He thought that in the area of Generalski Stol the thin thrust of Cretaceous sediments is underlain by completely different structures which generate thermal waters.

Apart from all works in “practical geology” mentioned above, Gorjanović-Kramberger has published many more papers and reports which due to insufficient space could not be presented in this paper.

Zanimljivo je da Gorjanović-Kramberger (1902, 1905) nije mineralne vode u Apatovcu, Jamnici i Lasinji smatrao juvenilnima, iako je znao da izviri iz eruptivnih stijena, već ih je svrstao u "meteorske" vode.

S obzirom na veliki autoritet Gorjanović-Krambergera, njegovu teoriju o podrijetlu termalne vode i o termalnim linijama podupirali su njegovi suvremenici kao i neki njegovi nasljednici, a mjestimice se održala i do danas. Nakon više od pola stoljeća Miholić (1940, 1952) je oborio Gorjanović-Krambergerovu teoriju, te na temelju mnogobrojnih kemijskih analiza dokazao da su termalne vode u svim topicama sjeverne Hrvatske obnovljive. On je ipak "zadržao" termalne linije samo ih je razmjestio malo drugačije i dao im druge nazive. Kasnijim istraživanjima u Hrvatskom zagorju ustanovljeno je da u tom području ne postoje termalne linije, već da se termalna vrela pojavljuju u tjemenu izduženih antiklinala (Šimunić, Hećimović 1999).

Osim termalnih i mineralnih voda Gorjanović-Kramberger se "sa gledišta geološkoga i hidrografijskoga" bavio i pitkom vodom zagrebačkog vodovoda, te o tome objavio nekoliko članaka (1888, 1889). Njegova stručnost bila je priznata i time što ga je "Kr. rudarsko satništvo" 1902. odredilo za konzultanta pri izgradnji zdenca pitke vode u Varaždinskim topicama koji su htjeli kopati u "unutarnjoj zaštitnoj zoni" glavnoga termalnog izvora. Valja spomenuti da nakon njegove intervencije taj zdenac nije izgrađen, ali je ipak 100 godina poslije preko zaštitne zone sporednih termalnih izvora u Varaždinskim topicama izgrađena autocesta. On je već 1905. pisao o velikoj onečišćenosti zdenaca pitke vode u Topuskom koji su ugrožavali izvore termalne vode te upozoravao da bi ih se moralo zatvoriti.

Prilikom izgradnje bolnice na Šalati u Zagrebu (1911. a), iznio je nepovoljno mišljenje o njezinoj lokaciji koje, kao što to najčešće biva u geološkoj struci, nije bilo uvaženo. Danas bi bilo vrlo zanimljivo ustanoviti što je Gorjanović-Kramberger zamjerao tadašnjim graditeljima.

Uza sve poslove koje je obavljao Gorjanović-Kramberger, dao se i na proučavanje lesa ili prapora u Slavoniji. Godine 1911., ali i poslije o tome je objavio nekoliko radova u kojima objašnjava postanak i građu lesnih zaravni, njihovu morfologiju i hidrogeologiju (1911. b). Tako je primjerice zapazio da u lesu postoje tri vodonosna horizonta postanak kojih je povezivao sa zaglinjenim proslojcima. Na strmo odsječenoj obali Dunava kraj Vukovara, snimio je geološki profil na kojem je, prema ritmičkoj izmjeni lesa i zaglinjenih zona, načinio stratigrafsku podjelu kvartara. Iako nije riječ o cijelom kvartarnom

razdoblju, kao što je on mislio, već samo o njegovu gornjem dijelu, taj bi se rad mogao smatrati početkom današnje *sekvencijske* geologije u Hrvatskoj koja se danas primjenjuje i u starijim naslagama.

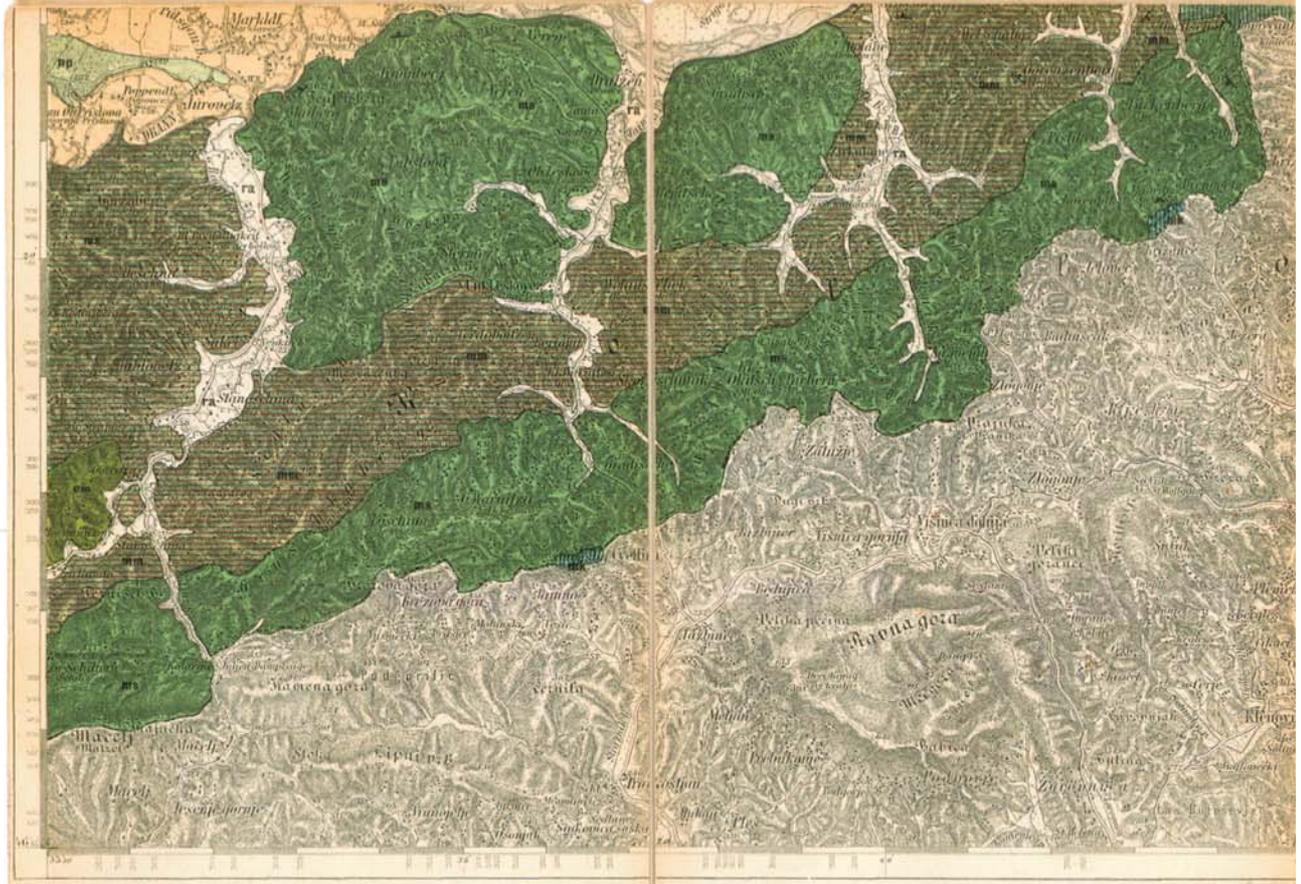
Velik dio svog radnog vijeka Gorjanović-Kramberger bavio se i istraživanjem krških fenomena i o tome od 1881. do 1916. objavio devet radova. Prvo je pisao o kršu Zagrebačke gore (1881), a potom se u nekoliko navrata osvrnuo na "Plitki krš okolice Generalskog Stola u Hrvatskoj" te na krš i hidrologiju Velebita i dr. Zanimljivo je da je on prvi pisao (1912) o navlaci u području Dinarida. Smatrao je da je na području Generalskoga Stola tanka navlaka krednih naslaga ispod koje su potpuno drugačije strukture koje generiraju termalnu vodu.

Osim navedenih Gorjanović-Krambergerovih radova iz tzv. praktične geologije, postoji još velik broj objavljenih radova i izvještaja koji zbog ograničenog prostora nisu mogli biti obuhvaćeni ovim člankom.

3. Zaključak

Rezultati rada D. Gorjanović-Krambergera u geološkom kartiranju i u drugim oblicima geološke djelatnosti nisu manje vrijedni od njegovih dostignuća u paleontologiji i antropologiji, ali nisu tako poznati široj javnosti. Iako je u paleontologiji i antropologiji postigao svjetski priznate rezultate, ipak je za hrvatsku znanost i privredu veoma značajan njegov doprinos i u ostalim granama geologije. Navedeni radovi pokazuju veoma širok raspon njegova znanstvenoistraživačkog djelovanja koji nikad poslije nije dosegnut u geološkoj struci. U svakoj grani geologije kojom se bavio postizao je sjajne rezultate i pridonosio njezinu napretku. Sve to upućuje na njegov veliki radni elan, izvanredne umne sposobnosti, veliki talent za geološku struku i smisao za organizaciju rada. Stoga se može zaključiti da je Gorjanović-Kramberger ostavio neizbrisiv trag u hrvatskoj i svjetskoj paleontologiji i antropologiji, ali i u praktičnoj geologiji koji nije izbljedio ni 70 godina nakon njegove smrti.

Ni Gorjanović-Kramberger ni njegovi kroničari nigdje nisu isticali njegov politički utjecaj ni zasluge bez kojih ne bi bilo osnovano Geološko povjerenstvo te druge prateće ustanove, a hrvatski geolozi bi se još desetke godina bavili usko specijaliziranim znanstvenim radom. S obzirom na to da su sve tadašnje države u Europi imale takve institucije, mora se naglasiti da je njezino osnivanje na teritoriju Hrvatske bio veliki doprinos hrvatskoj samostalnosti prilikom raspada Austro-Ugarske Monarhije.

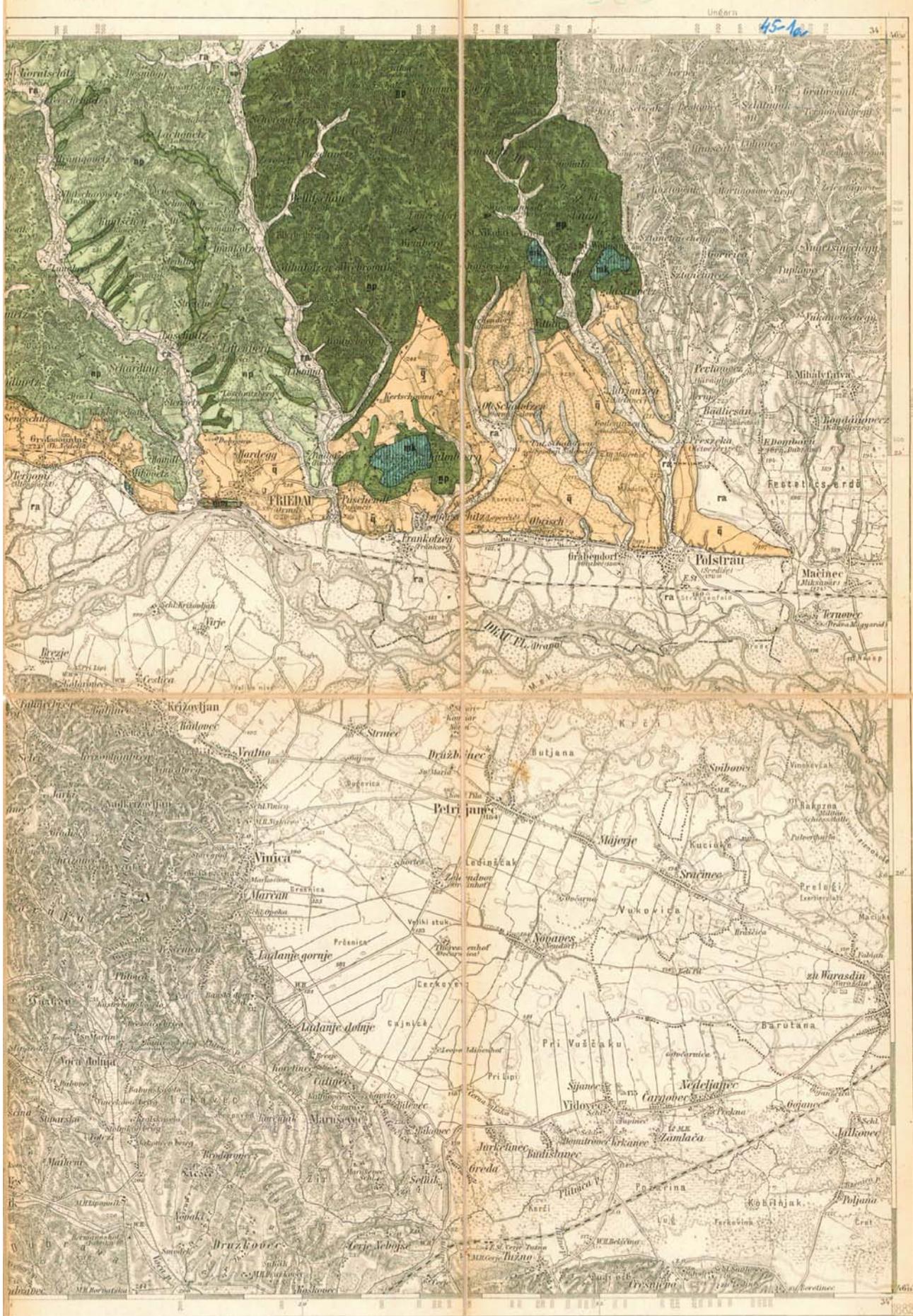


In topograph. Hinsicht bis zum Jahre 1897 evidentgestellt

Oligoän		Miooän		
				
Sandstein und Mergel der Sotska-Schichten	Marine Mergel und mä- delige Sandsteine	Härtere Sandsteinbildungen, Kalk- und Tuff-Sandsteine	Leithakalkbildungen im Allgemeinen	Congerien

Maßstab





Pliocän

Quartär und Recent



1:75.000

0 1 2 3 4 5 6 7 8 9 km

0 100 200 300 400 500 Schritte

3 Conclusion

The results of Gorjanović-Kramberger's work in geological mapping and other areas of geological activity are not less valuable than his achievements in palaeontology and anthropology, but are not as well known to public. Although he achieved worldwide recognized results in palaeontology and anthropology, for Croatian science and industry his importance in other areas of geology is significant.

All mentioned works indicate wide range of his scientific and research work which has not been achieved after him in geology. In every area of geology that he was involved in, he achieved outstanding results and he contributed to the progress of geology. All of this indicated his great determination, strength, excellent thinking

skills, recognized talent for geology and a sense for work and time management. Therefore, one can conclude that Gorjanović-Kramberger left a significant mark in Croatian and world palaeontology and anthropology, but also practical geology, and this mark remains 70 years after his death.

Neither Gorjanović-Kramberger nor his historians ever mentioned his political influence or performance. Yet, without those there would be no *Geological council* and other institutions, and Croatian geologists would have for the several tens of years been involved with highly specialized scientific work. Considering that all European countries at that time had such institutions, one must mention that its establishment on the territory of Croatia was a great contribution to Croatian independence during the break up of Austro-Hungarian Monarchy.

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