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# HGI

JUBILARNO IZVJEŠĆE | ANNIVERSARY REPORT

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# Uvod Introduction

Gornja slojna povrsina gornjokrednih vapnenaca u Nacionalnom parku Kornati (foto V. Brčić) /  
Upper bedding planes of the upper Cretaceous limestones in Kornati National Park (photo by V. Brčić)



Borani vapnenci na otoku Levrnaki (NP Kornati) (foto V. Brčić)  
Folded limestones on the island of Levrnaka (NP Kornati) (photo by V. Brčić)

# Predgovor

# Foreword

Dr. sc. **Dragan KRASIĆ**, predsjednik Upravnog vijeća / *PhD, president of the Governing Board*

Dr. sc. **Josipa VELIĆ**, prof. emerita, vanjski član Upravnog vijeća / *PhD, prof. emerita, external member of the Governing Board*

Akademik **Goran DURN**, vanjski član Upravnog vijeća / *Academician, external member of the Governing Board*

Poštovani čitatelji,

Upravno vijeće upravlja Hrvatskim geološkim institutom (HGI-CGS) s ciljem izgradnje što prepoznatljivije, aktivnije i kvalitetnije institucije koja provodi znanstvena i stručna istraživanja u geologiji i geološkom inženjerstvu. Jedna od bitnih komponenti iz nadležnosti Upravnog vijeća je ona razvojna. U zadnjih deset godina u odnosu na prethodno razdoblje razvidan je pozitivan trend u znanstvenoj i istraživačkoj aktivnosti HGI-CGS-a koji se očituje u obranjenim disertacijama, znanstvenim radovima, međunarodnim i domaćim projektima. Posljedica toga je da se HGI-CGS sve više strateški pozicionira kao prepoznatljiva sastavnica istraživačkog prostora u Republici Hrvatskoj te kao međunarodno priznata i partnerska znanstvena institucija. Tome su pridonijeli svi zaposlenici HGI-CGS-a koji trebaju napraviti još više kvalitativnih koraka naprijed da do kažu značaj i važnost geološke struke u mnogim segmentima društva. Uz znanost, koju treba trajno unaprijeđivati i staviti u funkciju gospodarstva, nužno je ojačati svijest o pripadnosti instituciji i odgovornosti prema poslu koji se obavlja. Prepoznatljivost i kvaliteta dolazi iznutra, zato je na svim zaposlenicima odgovornost da HGI-CGS učine još boljim. Upravno vijeće dat će vjetar u jedra broda na kojem plovite kako biste ostvarili zacrtanu viziju. Sadržaj ovog posebnog izdanja godišnjaka HGI-CGS-a povodom sto deset godina kontinuiranog djelovanja jasno pokazuje da ste na dobrom putu.

Dear readers,

The Governing Board manages the Croatian Geological Survey (HGI-CGS) with the aim of building as recognisable, active, and high-quality institution as possible, which conducts scientific and professional research in the fields of geology and geological engineering. One of the important components of the Governing Board's competences is the developmental one. Within the last ten years a positive trend in the scientific and research activity of the HGI-CGS is visible in comparison to the previous period, manifesting itself in defended PhD dissertations, scientific papers, international and national projects. The consequence of this is that the HGI-CGS is evermore strategically positioned as a recognisable component of the research landscape in the Republic of Croatia, and as an internationally acclaimed scientific partner institution. All of the employees of HGI-CGS have contributed to this, and they should make even more qualitative steps forward to prove the significance and importance of the geological profession in many segments of the society. Along with science, which needs to be permanently improved and put into the function of the economy, it is necessary to strengthen the awareness of belonging to the institution and assume responsibility for the work being performed. Recognisability and quality come from within, and therefore the responsibility is on all employees to further improve HGI-CGS. The Governing Board shall give wind to the sails of the ship on which you sail in order to achieve the set out vision. The contents of this special edition of the HGI-CGS's Annual Report on the occasion of 110 years of continuous activity clearly shows that you are on the right path.

# Uvodnik ravnatelja

## Introduction by the Director

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Poštovane kolegice i kolege, drage čitateljice i čitatelji,

sto deset godina kontinuiranog djelovanja u području geoloških istraživanja Hrvatskog geološkog instituta (HGI-CGS-a), razlog je objavljivanja ovog posebnog izdanja godišnjeg izvješća. Hrvatski geološki institut je osnovan 1909. godine, a njegovih je prihvati godina opisano u monografiji „Hrvatski geološki institut 1909. – 2009.: Sto godina u službi domovine“, dok je ovdje prikazana znanstvena i istraživačka aktivnost HGI-CGS-a nakon 2009. godine. Znanstvena produktivnost istraživača HGI-CGS-a rezultat je interdisciplinarnog pristupa i suradnje s uglednim domaćim i svjetskim znanstvenicima i ustanovama, što se očituje u sve većem broju projekata ugovorenih u međunarodnoj suradnji. Naša se uspjehost tijekom posljednjih deset godina temelji na stogodišnjem znanstvenom djelovanju HGI-CGS-a te na širokoj međunarodnoj umreženosti kao osnovi svih ozbiljnih i kvalitetnih istraživačkih djelatnosti, što se u konačnici očituje priznatim domaćim i međunarodnim projektima koji su opisani u ovoj publikaciji te u brojnim znanstvenim radovima. Također, možete naći priloge koji predstavljaju rad pojedinih zavoda te priloge koji govore o znanstvenoj produktivnosti. Znanstvenici i stručnjaci HGI-CGS-a ostvarili su tijekom posljednjeg desetljeća niz uspjeha u provođenju brojnih znanstvenih projekata i izradi studija i elaborata. Posebnost geologije je njezina multidisciplinarnost i interdisciplinarnost koja prožima cjelokupni rad HGI-CGS-a, a koja je zorno prikazana u ovom posebnom broju godišnjaka.

Dolaskom brojnih mladih istraživača koji su izradili svoje disertacije u HGI-CGS-u došlo je do znanstvenog pomlađivanja. Vjerujem da će se pozitivni trendovi, kojima je obilovalo ovo desetogodišnje razdoblje, nastaviti, i da će HGI-CGS i dalje provoditi istraživanja i djelatnost definiranu strateškim znanstvenim ciljevima.

Dear colleagues, dear readers,

The reason for the publication of this special issue of the Annual Report of the Croatian Geological Survey (HGI-CGS) is 110 years of its continuous activity in the field of geological research. The HGI-CGS was founded in 1909 and its first hundred years were described in the monograph "Croatian Geological Survey from 1909 to 2009: Hundred years in the service of the homeland", while its scientific and research activity since 2009 is described in this publication.

The scientific productivity of researchers in the HGI-CGS is a result of an interdisciplinary approach and cooperation with eminent national and international scientists and institutions, which is reflected in the increasing number of projects contracted through international collaboration. Our success over the last ten years was based on the centennial scientific work of the HGI-CGS and on a wide international network as the basis of all important and quality research activities. Success is ultimately manifested through recognised national and international projects described in this publication, and in numerous scientific papers. In addition, this report contains sections presenting the work of individual departments, and sections on scientific productivity. Over the past decade, scientists and professionals of the HGI-CGS have achieved great success in the implementation of numerous scientific projects and the preparation of studies and reports. The particularity of geology is its multidisciplinarity and interdisciplinarity, which pervades the overall work of the HGI-CGS and is shown in detail in this special issue of the Annual Report.

The arrival of numerous young researchers who completed their dissertations at the HGI-CGS rejuvenated the institute in scientific sense. I believe that the positive trends achieved in this ten-year period will continue, and the HGI-CGS will go ahead with research and activities defined by strategic scientific goals.

Važno je istaknuti da se geološka znanost povezuje s gospodarstvom i radom lokalnih zajednica te djeluje u interesu konkretnih državnih strategija i ciljeva. Takva je uloga HGI-CGS-a prepoznata u zaštiti voda, u istraživanju nestabilnosti na padinama, u izgradnji infrastrukture, istraživanju i eksploataciji mineralnih sirovina i geotermalne energije, te u suradnji s javnim ustanovama za zaštitu prirode i okoliša. Za uspješno funkciranje HGI-CGS-a zaslužne su i njegove stručne službe i tehničko osoblje, bez kojih provođenje velikog broja istraživanja ne bi bilo moguće. Neupitna je i uloga HGI-CGS-a kao čuvara geoloških informacija i dokumentacije važnih za Republiku Hrvatsku (RH) koja, nažalost, ni tijekom ovog desetljeća nije formalizirana u suvremenom zakonskom okviru.

Gledamo u budućnost u želji za novim geološkim znanjima, kako bismo upoznali i predstavili geološku građu RH akademskoj zajednici i svim zainteresiranim dionicima te time dali doprinos cjelokupnom razvoju naše domovine.

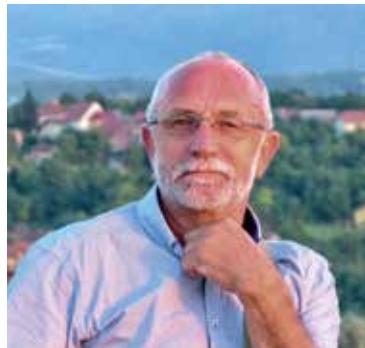
It is important to point out that geological science is associated with the economy and the work of local communities and acts in the interest of supporting national strategies and goals. Such role of the HGI-CGS is recognised in the water protection, slope instability analyses, infrastructure construction, exploration and exploitation of mineral resources and geothermal energy, and in cooperation with public institutions for the protection of nature and the environment. Administrative and technical staff is also commendable for the successful operation of the HGI-CGS. Without them, many research projects would not be possible. The role of the HGI-CGS as a custodian of geological information and documentation important for the Republic of Croatia is also indisputable, but has unfortunately not been formalised into the contemporary legal framework neither during this past decade.

We look into the future with the desire for new geological knowledge, in order to study and present the geological structure of the Republic of Croatia to the academic community and all interested stakeholders, thereby contributing to the overall development of our homeland.

# Uvodnik bivšeg ravnatelja

## Introduction by the Former Director

Prof. dr. sc. **Josip HALAMIĆ**



Geološke karte su za državu od posebnog gospodarstvenog značaja jer čine podlogu za održivo gospodarenje prirodnim resursima (energetske i neenergetske mineralne sirovine, pitka voda, zaštita okoliša). Hrvatski geološki institut (HGI-CGS) utemeljen je 1909. godine kao *Geologisko povjerenstvo za kraljevine Hrvatsku i Slavoniju* i njegova misija bila je proučavanje montangeoloških i agrogeoloških prilika u Hrvatskoj i Slavoniji kroz geološko i agrogeološko kartiranje te tiskanje geoloških karata s odgovarajućim tekstrom različitih namjena i mjerila. Tijekom skoro stogodišnje tradicije geoloških istraživanja na području Republike Hrvatske (RH) i svladavanja svih mijena proteklih vremena te višekratnih promjena imena, uz sustavno financiranje nekoliko različitih država, ispunjavana je tako definirana temeljna zadaća HGI-CGS-a. Međutim, od strane Ministarstva znanosti, obrazovanja i sporta (MZOS-a) 2007. godine ukida se direktno financiranje te temeljne djelatnosti, *Programa izrade geoloških karata*, te su se projekti geoloških karata za finansijska sredstva morali natjecati sa svim ostalim znanstvenim projektima (zProjekti). Takav način financiranja bio je nedostatan za ispunjenje zadane misije. Nažalost, i ti se projekti 2013. godine ukidaju i prelazi se na namjensko višegodišnje institucijsko financiranje i time praktički prestaje financiranje izrade bilo kakvih geoloških karata u RH, tj. financiranje temeljne djelatnosti HGI-CGS-a, što je od nenadoknadive štete, ne toliko za HGI-CGS, koliko za državu. Čak ni odluka Nacionalnog vijeća za znanost da se listovi geoloških karata i njihovi tumači vrijednuju kao originalna znanstvena djela neće pomoći u osiguravanju financiranja njihove izrade.

Još jedna zapreka provođenju temeljne djelatnosti HGI-CGS-a je i nepostojanje Zakona o geološkim istraživanjima i geološkoj dokumentaciji koji, usprkos svim nastojanjima od 1990. godine, zbog političkog nerazumijevanja nije usvojen. Time se čini neprocjenjiva šteta geološkoj djelatnosti, budući da ogroman

Geological maps are of particular economic importance for countries, as they form the basis for sustainable management of natural resources (energy and mineral resources, drinking water, environmental protection). The Croatian Geological Survey (HGI-CGS) was founded in 1909 as the *Geological Commission of the Kingdoms of Croatia and Slavonia*. Its mission was to study geological features of mountainous and agricultural land in Croatia and Slavonia by geological and agrogeological mapping, and to provide geological maps with corresponding explanations for various purposes and in different scales. During the almost centennial tradition of geological research on the territory of the Republic of Croatia (RH), overcoming the challenges of past times as well as numerous changes of its name, along with systematic funding by several different states, the fundamental tasks of the HGI-CGS have been consistently fulfilled. However, the direct funding of this fundamental activity, provided by the *Program for production of geological maps*, was terminated by the Ministry of Science, Education, and Sports (MZOS) in 2007. Hence, the geological mapping projects had to compete for funds with all other scientific projects (zProjects). This funding approach was insufficient for fulfilment of the defined mission. Unfortunately, the zProjects were also terminated in 2013, with a shift to dedicated multiannual institutional funding. Thereby, the funding of production of any kind of geological maps in the RH, i.e., the financing of the HGI-CGS fundamental activity, had stopped in practice. This presented a devastating loss for the entire country, more so than for the HGI-CGS. The decision of the National Council for Science to evaluate sheets of geological maps and their explanatory notes as original scientific work will be of no help in securing funds for their production.

Another obstacle of the fundamental activity of the HGI-CGS is the absence of a law on geological research and documentation, which, despite all endeavours since 1990, still has not been

broj geoloških podataka i materijalne dokumentacije biva izgubljen i bit će nedostupan za buduća istraživanja.

Odlukom HGI-CGS-a da postane javni znanstveni institut, te promjenom ranije navedenog načina financiranja njegove temeljne djelatnosti, HGI-CGS je bio prisiljen na prebacivanje težišta financiranja svojih istraživanja na kompetitivne domaće i inozemne znanstveno-istraživačke projekte koji se od strane MZO-a vrjednuju pri evaluaciji uspješnosti institucije. U tom je smislu u zadnjem desetljeću napravljen veliki napredak u obrazovanju znanstvenika: u HGI-CGS-u te je doktoriralo 25 djelatnika. Unatoč tome, i znatnom ulaganju u laboratorijsku opremu, znanstvena izvršnost HGI-CGS-a je, radi inertnosti pojedinih znanstvenika u objavljivanju znanstvenih radova, nedovoljna, što se ne odražava samo na rezultate vrjednovanja, nego i na prolaznost prijavljenih znanstvenih projekata.

Na međunarodnom planu HGI-CGS je prepoznatljiv kao kvalitetan i pouzdan partner u provođenju znanstvenoistraživačkih i drugih projekata, a tome uvelike doprinosi i njegovo članstvo u europskoj organizaciji geoloških institucija, EuroGeoSurveys (EGS), posredstvom kojeg HGI-CGS sudjeluje i u opsežnom H2020 programu GeoERA, koji je prijelazna faza utemeljenju ERA NET-a za geoznanosti u Europskoj uniji.

Osobno želim, i čvrsto vjerujem, da će HGI-CGS u sljedećem razdoblju biti u stanju prevladati sve navedene prepreke i nastaviti ispunjavati misiju koja mu je zadana pri njegovom utemeljenju prije 110 godina.



passed due to political misunderstandings. This furthermore causes irreparable damage to the geological research, as an immense quantity of geological data and material documentation is lost and will hence be unavailable for future research.

Due to the decision of the HGI-CGS to become a public scientific institute, and due to the change in the above-mentioned method of funding, the HGI-CGS has been forced to look for funding of its research in competitive domestic and foreign scientific-research projects, which are evaluated by the MZOS in the scope of assessment of the institution's success. In that sense, great progress has been made during the last decade with regard to substantial investment in laboratory equipment and the education of scientists in the HGI-CGS, with 25 students having defended their PhD theses. Nevertheless, the level of HGI-CGS scientific excellence is insufficient due to the inertia of certain scientists with respect to publishing scientific papers. This is reflected not only in evaluation results, but also in the success rate of scientific project applications.

At an international level, the HGI-CGS is recognized as an excellent and reliable partner in collaborations regarding scientific-research and other kinds of projects. This attribute is owed to its membership in the European organisation of geological surveys, EuroGeoSurveys. Through this network, the HGI-CGS also participates in the comprehensive H2020 programme GeoERA, which is a transitional phase in the foundation of ERA NET for geosciences in the European Union.

I personally wish, and strongly believe, that in the near future the HGI-CGS will be able to overcome all of the mentioned obstacles and continue fulfilling the mission assigned to it at its foundation 110 years ago.





Erozijska granica u kvartarnim naslagama kod Karlovca (foto R. Avanić) /  
Erosional boundary in Quaternary deposits near Karlovac (photo by R. Avanić)

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*About the institute*



# Povijesni pregled

## Historical Overview

Autor teksta / Author of the text: dr. sc. **Slobodan MIKO**

Povijest hrvatske geologije i uloge Hrvatskog geološkog instituta u njezinom razvoju tijekom prvih sto godina detaljno je opisana u monografiji HGI 100. (HALAMIĆ i PIKIJA, 2009), te je ovdje prikazan sažetak razvoja HGI-CGS-a od 1909. do 2019. godine. Povijest HGI-CGS-a započinje utemeljenjem Geološkog povjerenstva 1909. godine. Dragutin GORJANOVIĆ-KRAMBERGER i Gjuro PILAR smatraju se začetnicima ustroja hrvatske geologije na kojem su radili u okrilju Državnog geološkog instituta u Beču. Na prijedlog GORJANOVIĆ-KRAMBERGERA Kraljevskoj zemaljskoj vladi osnovano je GEOLOGIJSKO POVJERENSTVO ZA KRALJEVINE HRVATSKU I SLAVONIJU 3. srpnja 1909. godine, što je potpisao tadašnji ban Pavao RAUCH. GORJANOVIĆ-KRAMBERGER je imenovan predsjednikom povjerenstva te su ustrojena dva odsjeka: (1) montangeološka sekcija (voditelj Ferdo KOCH) i (2) agrogeološka sekcija (voditelj Franjo ŠANDOR). U



Bista Dragutina Gorjanovića – Krambergera  
Bust of Dragutin Gorjanović – Kramberger

The history of Croatian geology and the role of the Croatian Geological Survey (HGI-CGS) in its development during the first hundred years were described in detail in the monograph "HGI 100" (HALAMIĆ & PIKIJA, 2009). Here, a summary is presented of the HGI-CGS development from 1909 to 2019. The history of the HGI-CGS started with the establishment of the Geological Commission in 1909. Dragutin GORJANOVIĆ-KRAMBERGER and Gjuro PILAR are considered founders of Croatian geology. They studied under the auspices of the State Geological Institute in Vienna. At the suggestion of GORJANOVIĆ-KRAMBERGER to the Land's Royal Government, the Commission for the Kingdoms of Croatia and Slavonia was founded on the 3 July 1909, and the founding documents were signed by governor Pavao RAUCH. GORJANOVIĆ-KRAMBERGER was appointed president of the commission and two departments were established: (1) the Department of Mountain Geology (headed by Ferdo KOCH) and (2) the Department of Agrogeology (headed by Franjo ŠANDOR). In the period from 1909 to 1923, while the institution was led by its founder D. GORJANOVIĆ-KRAMBERGER, the majority of field activities took place in the area of Velebit Mt. and Lika and Gorski kotar regions. The most prominent geologist, primarily in the area of geological mapping, was F. KOCH. He was the author of the printed geological maps of Knin-Ervenik, Pag, and Gračac-Ermaj (Rmanj), along with the corresponding explanatory notes. The commission formally operated until 1922, when the **Geological Institute – Royal Geological Institute** was established in Zagreb. GORJANOVIĆ-KRAMBERGER was appointed as the director of the Institute. He organised the Institute, and in 1923 F. KOCH was appointed director. He remained in this position until 1928. This entire period was characterised by a reduced volume of geological research due to insufficient financial support. Geological maps essentially stopped being printed. KOCH, the director of the Institute, published the map Karlobag-Jablanac at a scale of 1:75,000 in 1929. The law establishing the Geological Institute of the Kingdom of Yugoslavia (29 December 1930) announced the abolition of the independence of the Geological Institute in Za-

razdoblju od 1909. do 1923., kada je čelnik ustanove njen ute-meljitelj D. GORJANOVIĆ-KRAMBERGER, glavnina terenskih ak-tivnosti odvijala se na području Velebita, Like i Gorskog kotara. Najangažiraniji geolog, prvenstveno na geološkom kartiraju, bio je F. KOCH, autor tiskanih listova geoloških karata Knin-Er-venik, Pag i Gračac-Ermain (Rmanj) te pripadajućih tumača. Povje-renstvo je formalno djelovalo do 1922. god., kada je uspostavljen Geološki zavod – **Kraljevski geološki zavod u Zagrebu**. Direktorom zavoda imenovan je GORJANOVIĆ-KRAMBERGER. On je izvršio ustroj zavoda, a već 1923. direktorom je imenovan F. KOCH, koji ostaje na toj funkciji do 1928. Cijelo razdoblje ka-rakterizira smanjeni obim geoloških istraživanja kao posljedica nedostatne finansijske potpore, te je praktično prestalo tiskanje geoloških karata. Direktor zavoda KOCH objavljuje 1929. god. kartu Karlobag-Jablanac u mjerilu 1:75.000. Zakon o Geološ-kom institutu Kraljevine Jugoslavije (29. prosinca 1930. god.) najavljuje prekid samostalnosti Geološkog zavoda u Zagrebu. Nakon formiranja Banovine Hrvatske u Zagrebu je ponovno osnovan Geološki zavod. ŠUKLJE 1939. godine ponovno osni-va **Geološki zavod Banovine Hrvatske** sa sjedištem u Zagrebu. ŠUKLJE vodi Zavod tijekom II svjetskog rata pod imenom **Hrvatski državni geoložki zavod** (1941-1945.) sve do 1947. god. Nakon završetka II svjetskog rata zavod je preimenovan u **Državni geološki zavod**, a sredinom 1946. god. tadašnja hr-vatska vlada donosi uredbu kojom se osniva **Geološko-rudar-ski institut Hrvatske** sa sjedištem u Zagrebu. 1947. god. je na čelo Geološko-rudarskog instituta došao I. JURKOVIĆ. Tada je institutu pripojen i Zavod za rude, goriva i metalurgiju, čime je znatno ojačan kemijski odjel, odnosno laboratorij i rudarski odjel. Glavnina stručnog rada institutskih geologa u spome-nutim godinama i neposredno nakon toga je bila vezana na istraživanje mineralnih sirovina u Hrvatskoj. Rješenjem Vlade Narodne Republike Hrvatske 21. listopada 1950. god. Geološko-rudarski institut mijenja ime u **Zavod za geološka istraživanja NR Hrvatske**, te je idućih nešto više od četiri godine financiran kao Republička geološka služba. Ustanova mijenja ime u **Zavod za geološka istraživanja** godine 1955. Iste je godine direktor imenovan J. OGULINEC. Godina 1958. iznimno je značaj-na za Zavod za geološka istraživanja, ali i sveukupnu geologiju u Hrvatskoj. Naime, te godine započela je izrada Osnovne geološke karte, tada pod nazivom Kompleksna geološka karta ili A karta. Naziv Osnovna geološka karta službeno se rabio od 1960. god., pa do završetka projekta. To je, bez sumnje, kapi-talni geološki projekt za hrvatsku geologiju, a izvodio se na te-ritoriju čitave tadašnje države. Teritorij Hrvatske obuhvaćen je sa 74 lista M 1:100.000. Zavod za geološka istraživanja mijenja naziv u **Institut za geološka istraživanja (IGI)** 1960. godine.

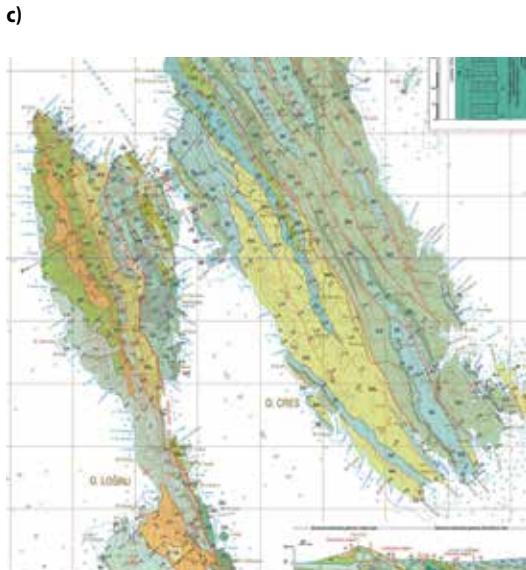
greb. After the formation of the Banovina of Croatia, the Geolog-ical Institute was re-established in Zagreb. In 1939, ŠUKLJE again founded **the Geological Institute of the Banovina of Croatia**, with its headquarters in Zagreb. ŠUKLJE was the director of the **Croatian State Geological Institute** (1941-1945) during World War II up until 1947. After the end of World War II, the Institute was renamed to the **State Geological Institute**, and in mid-1946, actual Croatian government adopted a decree establishing the **Croatian Geological-Mining Institute** with headquarters in Zagreb. In 1947, I. JURKOVIĆ became head of the Geological-Mining Institute. At that time, the Institute was joined by the Depart-ment of Ores, Fuels and Metallurgy, which significantly strength-ened the chemical department, i.e. the laboratory, and the mining department. During these years and shortly thereafter, most of the expert work of the Institute's geologists was related to the exploration of mineral resources in Croatia. On the 21 Oc-tober 1950, by the decision of the Government of the People's Republic (PR) of Croatia, the Geological-Mining Institute changed its name to the **Institute for Geological Research of the PR of Croatia**. During the next few years, it was financed as the Repub-lic Geological Survey. In 1955, the institution changed its name to the **Department of Geological Research**. In the same year, J. OGULINEC was appointed director. The year 1958 is exception-ally important for the Department of Geological Research, but also for geology in Croatia in general. Namely, the construction of the "Basic geological map" was initiated, under the name of the "Complex Geological Map" or the "A" map. The title Basic geolog-ical map has officially been used since 1960 until the end of the project. This represented without a doubt a capital geological project for Croatian geology, and it was carried out on the entire territory of the former Yugoslavia. The territory of Croatia was cov-ered by 74 sheets at a scale of 1:100,000. In 1960, the Department of Geological Research changed its name to the **Institute for Geological Research** (IGR). The Institute then acquired scientific status, and its co-founders were faculties, INA Naftaplin, the As-sociation of Electrical Companies, and the Chamber. Within the IGR, three departments were established: the geological, miner-al-petrographic, and hydrogeological department. The structure of this Institute, which was established in 1966, has been retained to date, owing to the efforts of director L. NIKLER. In 1977, the IGR changed its name to the **Geological Department**, but it did not change its internal structure until 1988, when it changed its name back to the **Institute for Geological Research**. In the 1980s, ac-tivities were carried out to enact the Law on Geological Research, under coordination of the IGR director D. BOŠKOVIĆ. The law was enacted in 1986 and foresaw the functioning of the IGR as a **geo-logical survey**. The Institute's scientific and professional activity

Institut tada stjeće znanstveni status, a suosnivači su fakulteti, INA Naftaplin, Zajednica elektroprivrednih poduzeća i Komora. U IGI-ju su formirani odjeli, i to: geološki, mineraloško-petrografske i hidrogeološki. Obrisi strukture instituta koji su nastali su 1966. god. zadržani su do danas, a za to je zaslužan direktor L. NIKLER. Godine 1977. IGI mijenja ime u **Geološki zavod**, ali bez promjene unutarnje organizacije sve do 1988 godine, kada se vraća naziv **Institut za geološka istraživanja**. Osamdesetih godina odvijale su se i aktivnosti za donošenje Zakona o geološkim istraživanjima, a koordinator tih aktivnosti je bio direktor IGI-ja D. BOŠKOVIĆ. Zakon je donesen 1986. godine, a predviđao je funkciranje IGI-ja kao **geološke službe**. Znanstvena i stručna aktivnost Zavoda odvijala se u kontinuitetu uz usvajanje niza novih metodologija. U razdoblju od 1960. do 1991. godine obranjeno je dvadesetak disertacija iz područja prirodnih znanosti i geološkog inženjerstva. Tijekom izrade Osnovne geološke karte uočena je potreba izrade standardiziranih karata vezanih uz primjenjena geološka istraživanja. Tijekom ovog razdoblja dopunjeno je standard i nastavljena izrada Osnovne inženjerskogeološke karte M 1:100.000, te izrada Osnovne hidrogeološke karte istog mjerila. Obavljene su pripreme i izrađen program za izradu Karte mineralnih sировина M 1:100.000, koja je uključivala i prognoznu kartu. Terenski dio projekta Osnovne geološke karte M 1:100.000 je službeno završen 1985. god., a u idućim godinama završavane su karte i tumači. Istovremeno su sredinom osamdesetih godina započete pripreme za izradu geološke karte po principu litostратigrafske račlambe naslaga u mjerilu 1:50.000, koja je radno nazvana Kompleksna geološka karta, a upotrebljavan je i naziv Osnovna geološka karta II (OGK II). Umjesto dotadašnjeg direktora instituta Ž. BABIĆA, 1991. god. direktorom je imenovan Đ. BENČEK koji je dužnost obnašao do kraja 1996. god. Na temelju Zakona o znanstvenoistraživačkoj djelatnosti, HGI-CGS je 1992. upisan u Registar znanstvenoistraživačkih organizacija i jedinica kao radna znanstvenoistraživačka organizacija – **Institut za geološka istraživanja** (IGI) a 1997. godine prestao njegov status državnog instituta koji je trajao 88 godina te postaje jedan od 25 javnih znanstvenih instituta u RH. Ravnatelji Instituta nisu više imenovani, već se biraju javnim natječajem (B. BIONDIĆ, 1997.-2001.; D. MATIČEC, 2001.-2005.; J. HALAMIĆ, 2005.-2017.; S. MIKO 2017.-2021.). Nakon 1997. godine finansiranje programa izrade geoloških karata nastavlja se putem znanstvenoistraživačkih projekata sve do 2014. godine, nakon čega se finansiranje istraživanja vezanih za program geološkog kartiranja nastavlja uglavnom iz vlastitih prihoda HGI-CGS-a. Kao javni znanstveni institut, veliki dio istraživanja je fokusiran na izobrazbu istraživačkih kapaciteta (u razdoblju od 1997. do

continued, along with the adoption of a number of new methodologies. In the period from 1960 to 1991, twenty dissertations were defended in the field of natural sciences and geological engineering. During the construction of the basic geological map, the need for standardised maps related to the applied geological surveys was recognised. During this period the standard was completed, and construction of the Basic engineering geological map and the Basic hydrological map continued, both at the scale of 1:100,000. Preparations were made, and a programme was developed for the construction of a map of mineral resources at the scale of 1:100,000, which also included an assessment map. The field work within the basic geological map projected at the scale of 1:100,000 was officially completed in 1985, and the maps and explanatory notes were completed in the following years. At the same time, in the mid-1980s, preparations began for the construction of the geological map based on the lithostratigraphic classification of deposits at the scale of 1:50,000, which was called the Complex geological map, but the title Basic geological map II (BGM II) was also used. In 1991, the former director of the Institute Ž. BABIĆ was succeeded by Đ. BENČEK, who was in charge until the end of 1996. In 1992, based on the Law on scientific research activities, the IGR was inscribed into the register of scientific research organisations and units as a working scientific research organization, the **Institute for Geological Research** (IGR). In 1997, its status as a state institute, which lasted for 88 years, came to an end. IGR became one of the 25 public scientific institutes of the Republic of Croatia. The Institute's directors were no longer appointed, but selected through public calls (B. BIONDIĆ, 1997-2001; D. MATIČEC, 2001-2005; J. HALAMIĆ, 2005-2017; S. MIKO, 2017-2021). From 1997 to 2014, funding of the geological mapping programme continued through scientific research projects, after which financing continued mainly from the institute's own revenues. Being a public research institute, a large part of the research in IGR is focused on the development of research capacities (54 doctoral dissertations were completed in the period from 1997 to 2018). Moreover, the number of employed scientists increased from 12 (1997) to 42 (2018). This increment in the number of scientists was facilitated through significant investments in laboratory, fieldwork and IT equipment, especially since 2005. In 2005, the Institute for Geological Research changed its name to the **Croatian Geological Survey** (Hrvatski Geološki Institut in Croatian), and in the next year it became a member of the European association of geological services, EuroGeoSurveys. In order to overcome the change in funding and the generally reduced funding of research by the Ministry of Science (2014), applications to EU projects (20 projects) and to projects of the Croatian Science Foundation (5 successful projects) intensified.

2018. izrađene su 54 doktorske disertacije) te je broj znanstvenika povećan s 12 (1997.) na 42 (2018.). Povećanju broja znanstvenika doprinijela su i znatna ulaganja u laboratorijsku, teoretsku i informatičku opremu, osobito od 2005. god. Institut za geološka istraživanja 2005. god. mijenja ime u **Hrvatski geološki institut**, i naredne godine postaje član europskog udruženja geoloških službi, EGS-a. Kako bi se premostila promjena u načinu financiranja te generalno smanjeno financiranje istraživanja od strane Ministarstva znanosti (2014.), intenzivira se prijavljivanje projekata na fondove EU (20-ak projekata) te na natječaje HRZZ-a (5 uspješno prijavljenih projekata). Budućnost znanstvenoistraživačkog rada osigurana je putem projekata i više od deset doktoranata koji trenutno izrađuju svoje disertacije. Program geoloških karta i njegovo izvođenje u velikoj mjeri počiva na izgledu budućeg finansijskog razdoblja kroz programske ugovore.

The future of scientific research work is secured through these projects, and more than ten PhD candidates who are currently completing their dissertations. The geological mapping programme and its implementation largely depend on the layout of the future financial period provided through programme contracts.



Razvoj Osnovne geološke karte na primjeru otoka Cresa i Lošinja: (a) 1908. List Mali Lošinj i Lun, mjerilo 1:75.00(Waagen); (b) 1968. List Cres (Magaš) i List Lošinj (Mamužić), mjerilo 1:100.000; (c) 2015. List Cres i Lošinj, mjerilo 1:50.000, (Fuček et al.)

Development of Basic geological map – example of Cres and Lošinj islands: (a) 1908. Sheet Mali Lošinj and Lun, scale 1:75,00(Waagen); (b) 1968. Sheet Cres (Magaš) and Sheet Lošinj (Mamužić), scale 1:100,000; (c) 2015. Sheet Cres and Lošinj, scale 1:50,000, (Fuček et al.)

# Organizacijska struktura, zaposlenici i proračun

## Organizational Scheme, Employees and Budget

**RAVNATELJ | DIRECTOR:**

Dr. sc. Slobodan MIKO  
tel: (+385 1) 6160-749  
fax: (+385 1) 6144-718  
e-mail: slobodan.miko@hgi-cgs.hr

**Tajnica HGI | Secretary of the CGS:**

Mladenka JURČIĆ, dipl. iur.

**UPRAVNO VIJEĆE | GOVERNING BOARD**

Dr. sc. Dragan KRASIĆ (MINGO\*), predsjednik – *Chair*  
Dr. sc. Željko DEDIĆ (HGI-CGS)  
Prof. dr. sc. Goran DURN (RGNF\*)  
Dr. sc. Anita GRIZELJ (HGI-CGS)  
Prof. dr. sc. Josipa VELIĆ (RGNF\*)

**ZNANSTVENO VIJEĆE | SCIENTIFIC COUNCIL**

Dr. sc. Željka BRKIĆ, predsjednica – <i>Chair</i>	Dr. sc. Josip HALAMIĆ
Dr. sc. Tamara MARKOVIĆ, zamjenica predsjednice – <i>Chair deputy</i>	Dr. sc. Ozren HASAN
Dr. sc. Maja BRIŠKI, tajnica – <i>Secretary</i>	Dr. sc. Marija HORVAT
Dr. sc. Ivan MIŠUR, tajnik – <i>Secretary</i>	Dr. sc. Nikolina ILLJANIĆ
Dr. sc. Radovan AVANIĆ	Dr. sc. Tvrtko KORBAR
Dr. sc. Koraljka BAKRAČ	Dr. sc. Duje KUKOĆ
Dr. sc. Adriano BANAK	Dr. sc. Tomislav KUREČIĆ
Dr. sc. Mirko BELAK	Dr. sc. Ozren LARVA
Dr. sc. Staša BOROVIĆ	Dr. sc. Jasmina LUKAČ REBERSKI
Dr. sc. Vlatko BRČIĆ	Dr. sc. Saša MESIĆ
Dr. sc. Mihovil BRLEK	Dr. sc. Slobodan MIKO
Dr. sc. Renato BULJAN	Dr. sc. Davor POLLAK
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Dr. sc. Lidija GALOVIĆ	Dr. sc. Andrej STROJ
Dr. sc. Tonći GRGASOVIĆ	Dr. sc. Ajka ŠORŠA
Dr. sc. Anita GRIZELJ	Dr. sc. Josip TERZIĆ
Dr. sc. Vlatko GULAM	Dr. sc. Kosta URUMOVIĆ
Dr. sc. Valentina HAJEK-TADESSE	Dr. sc. Lara WACHA

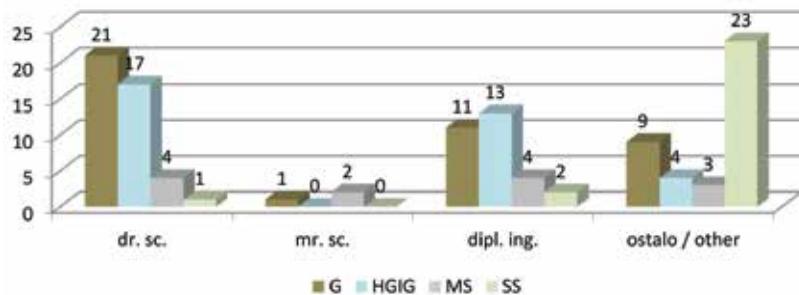


Zaposlenici HGI-CGS-a (foto T. Frangen) / Employees of the HGI-CGS (photo by T. Frangen)

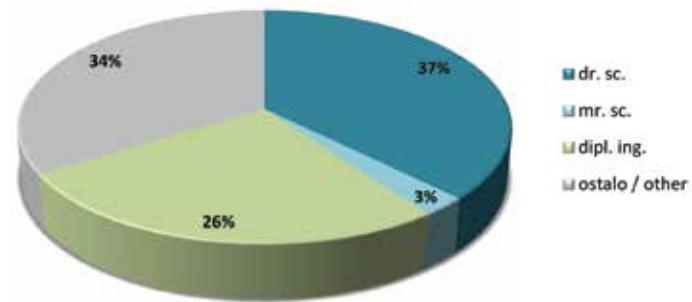


- █ Zavod za geologiju  
Department of Geology
- █ Zavod za mineralne sirovine  
Department of Mineral Resources
- █ Zavod za hidrogeologiju i inženjersku geologiju  
Department of Hydrogeology and Engineering Geology
- █ Stručne službe  
Administration and technical support

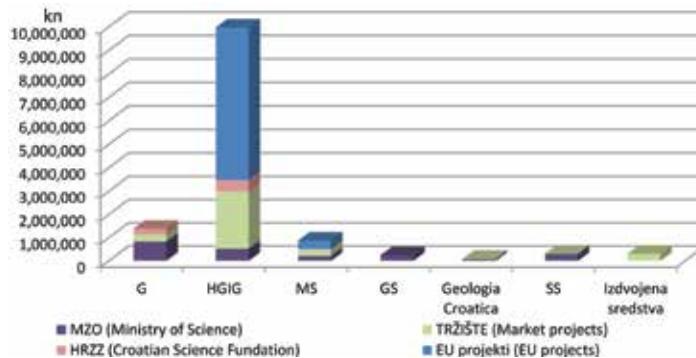
Struktura zaposlenika prema stručnoj spremi po zavodima 2018. godine  
Structure of employees according to professional qualifications per department in 2018



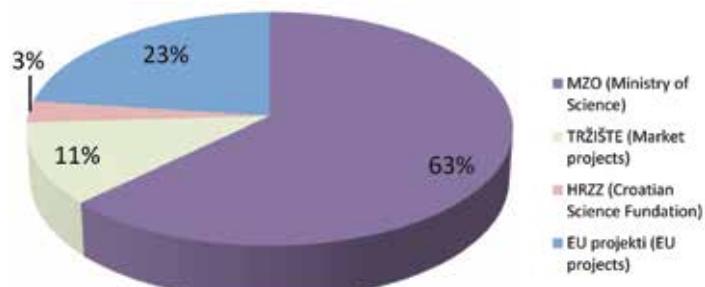
Obrazovna struktura zaposlenika HGI-CGS-a 2018.  
Educational structure of the HGI-CGS employees in 2018



Godišnji prihodi HGI-CGS-a u 2018.  
HGI-CGS Annual revenue in 2018



Godišnji prihodi HGI-CGS-a u 2018., ukupno 30 milijuna kn  
HGI-CGS Annual revenue in 2018, total of 30 million kn



# Zavod za geologiju

## Department of Geology

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Temeljna djelatnost Zavoda je izrada znanstveno i stručno relevantnih geoloških karata svih mjerila, vrsta i namjena, koje su ishodište za sva daljnja geološka, hidrogeološka i inženjerskogeološka istraživanja, kao i istraživanja mineralnih sirovina, te predstavljaju osnovu u prostornom planiranju i zaštiti okoliša. U zavodu se izvode različita specijalistička geološka istraživanja koja uključuju, između ostalog, stratigrafska, paleontoška, sedimentološka, mineraloška, petrološka i geokemijska istraživanja, a pružaju se i brojne laboratorijske usluge. U zavodu su 2009. godine bila zaposlena 43 djelatnika od čega 16 doktora znanosti, dok su 2018. godine zaposlena 42 djelatnika od čega 21 doktor znanosti.

Znanstvena djelatnost zavoda financira se od strane Ministarstva znanosti i obrazovanja (MZO) kroz namjensko višegodišnje institucijsko financiranje, kroz projekte finansirane od Hrvatske zaklade za znanost (HRZZ) i europske fondove.

The basic activity of the Department is the production of scientifically and professionally relevant geological maps of all scales, types, and purposes, which are the starting point for all further geological, hydrogeological, and engineering-geological research, as well as mineral resource exploration. They represent the foundation of spatial planning and environment protection. Various types of specialized geological research are carried out within the Department, including stratigraphical, palaeontological, sedimentological, mineralogical, petrological, and geochemical research. Numerous laboratory services are also provided. In 2009 the Department comprised 43 employees, 16 of which were PhDs, while in 2018 there were 42 employees, 21 of which were PhDs.

The Department's scientific activity is funded by the Ministry of Science and Education (MZO) through dedicated multiannual institutional financing, through projects financed by the Croatian Science Foundation (CSF) and EU funds.

After the funding of the programme "Geological maps of the Republic of Croatia" as a scientific project (zProjects of the MZOS) in 2013 ended, the scope of field research has witnessed a substantial decrease, which led to the challenge of continuous training of new employees. In order to prevent a decrease in the level of quality of geological mapping, we finance the production of new maps and education from the department's own funds.

During the last 10 years, in accordance with new trends in geological research, we have employed and educated young



Postupak izrade standardiziranog lista Osnovne geološke karte Republike Hrvatske (priredio V. Brčić)  
 The process of constructing a standardized sheet of Basic geological map of the Republic of Croatia RH (prepared by V. Brčić)



Istraživanje prapornih naslaga u blizini sela Zmajevac (Baranja) u sklopu projekta SAPIQ (foto L. Wacha)

Research of loess deposits near the settlement of Zmajevac (Baranja region) in the scope of SAPIQ project (photo by L. Wacha)



Mjerenje strukturnih elemenata u sklopu provođenja temeljnih geoloških istraživanja za projekt izgradnje nove žičare na Medvednici, Zagreb (foto M. Budić)

Measurement of structural elements in the scope of basic geological research for the project of new cable car on Medvednica Mt. in Zagreb (photo by M. Budić)

Nakon prestanka financiranja Programa „Geološke karte Republike Hrvatske“ kao znanstvenog projekta (zProjekti MZOS-a) 2013. godine, došlo je do značajnog smanjenja opsega terenskih istraživanja, pa se pojavio problem kontinuiranog ospozobljavanja novih djelatnika. Kako ne bi došlo do pada razine kvalitete geološkog kartiranja, vlastitim sredstvima financiramo izradu novih karata i edukaciju.

Tijekom zadnjih 10 godina smo, u skladu s novim trendovima u geološkim istraživanjima, zaposlili mlade istraživače i dodatno ih educirali za rad s modernim računalnim alatima pomoću kojih se izrađuju 3D geološki modeli podzemlja.

Laboratorij Zavoda je opremljen novim instrumentom za termičke analize i skenirajućim elektronskim mikroskopom koji je nadograđen BSE detektorom.

Uspostavljena je međunarodna znanstvena suradnja s LIAG Institutom (*Leibniz Institute for Applied Geophysics*) iz Hannovera, na realizaciji datiranja kvartarnih naslaga jadranskih otoka metodom optički i infracrveno stimulirane luminiscencije (OSL i IRSL), te s Laboratorijem za geokronologiju Sveučilišta u Beču (*Labor für Geochronologie, Department für Lithosphärenforschung, Universität Wien*) na realizaciji izotopnog datiranja kristalinskih stijena slavonskih planina i Medvednice. Osim toga, nastavljena je i suradnja s kolegama iz Mađarske (*Geological and Geophysical Institute of Hungary; University of Pécs, Department of Geology and Meteorology; Eötvös Loránd University*) sa svrhom korelacije naslaga i uskladišnja geoloških podataka duž hrvatsko-mađarske granice.

researchers to work with modern computer tools used for the construction of 3D geological models of the underground.

The Department's laboratory was equipped with a new instrument for thermal analyses and a scanning electron microscope upgraded with a BSE detector.

An international scientific co-operation has been established with the LIAG Institute (*Leibniz Institute for Applied Geophysics*) of Hanover with the aim to realise dating of the Quaternary sediments on Adriatic islands by optically and infrared stimulated luminescence (OSL and IRSL). Another co-operation was established with the Laboratory for Geochronology of the University of Vienna for the realisation of isotopic dating of crystalline rocks of the Slavonian mountains and Medvednica Mt. In parallel, the co-operation with Hungarian colleagues (*Geological and Geophysical Institute of Hungary; University of Pécs, Department of Geology and Meteorology; Eötvös Loránd University*) has continued with the purpose of correlation of sediments and harmonisation of geological data along the Croatian-Hungarian border.

Besides scientific research, applied research in the domain of petroleum geology, engineering geology, and geochemical research of soils for organic contaminants within the scope of mining-geological studies has also been carried out.

The Department has popularised geology in various ways. The project of setting up geological collections in schools and kindergartens was devised and started. We have actively participated in



Oluja mozgova na Kornatima (foto L. Wacha)  
Brainstorming at Kornati (photo by L. Wacha)



GeoTwin project: sedimentological excursion to Upper Oligocene – Lower Miocene succession in Denmark, conducted by Eric S. Rasmussen from GEUS (photo by M. Budić)

GeoTwin project: sedimentological excursion to Upper Oligocene – Lower Miocene succession in Denmark, conducted by Eric S. Rasmussen from GEUS (photo by M. Budić)

U zavodu su se, osim znanstvenih, izvodila i primijenjena istraživanja iz domene naftne geologije, inženjerske geologije i geokemijskih istraživanja tala na organska onečišćiva, te u okviru rudarsko-geoloških studija.

Zavod je popularizirao geologiju na razne načine. Osmišljen je i pokrenut projekt postavljanja geoloških zbirki u školama i vrtićima. Aktivno smo sudjelovali u pripremi prijave Geoparka Viški arhipelag za stjecanje statusa UNESCO globalnog geoparka u pripremi geoloških materijala za Geopark Imotski.

Organizirali smo 2015. godine dvotjedni međunarodni tečaj „Intensive Training Course on Soil Micromorphology“. Sudjelovali smo u organizaciji 4. i 5. hrvatskog geološkog kongresa 2010. i 2015. te međunarodnih geoloških skupova „7th International Workshop on the Neogene of Central and South Eastern Europe“ (NECSEE) u Velikoj 2017. godine te „9th Mid-European Clay Conference“ (MECC) u Zagrebu 2018. godine.

preparations to apply for the UNESCO global geopark status for the Vis archipelago geopark, and similar preparations are underway for Imotski lakes geopark.

In 2015, we organised a two-week international “*Intensive Training Course on Soil Micromorphology*”. We took part in the organisation of the 4<sup>th</sup> and 5<sup>th</sup> Croatian Geological Congress in 2010 and 2015, respectively, and of the international geological conferences “*7th International Workshop on the Neogene of Central and South Eastern Europe*” (NECSEE) in Velika in 2017, and the “*9th Mid-European Clay Conference*” (MECC) in Zagreb in 2018.

# Zavod za hidrogeologiju i inženjersku geologiju

## Department of Hydrogeology and Engineering Geology

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Zavod za hidrogeologiju i inženjersku geologiju (ZHGI) sastavljen je od znanstvenika i stručnjaka koji se bave geološkim inženjerstvom, odnosno primijenjenim dijelom geološke struke koji je kategoriziran u tehničke znanosti. ZHGIG je u ovih deset godina radio i radi na tri temeljna projekta, četiri znanstvena projekta, desetak većih projekata financiranih iz fondova Europske unije (EU), te mnogo tržišnih projekata. O zavodskim projektima, disertacijama, laboratorijima i novim istraživačkim grupama može se pročitati u tematskim tekstovima ove publikacije.

Osim tradicionalnih hidrogeologije i inženjerske geologije, u posljednje se vrijeme sve više znanstvenih uspjeha postiže u

The Department of Hydrogeology and Engineering Geology (DHGEG) comprises scientists and professionals working on geological engineering, i.e. the applied segment of the geological profession, which is categorised within the technical sciences. The DHGEG has in the past ten years worked on three fundamental projects, four scientific projects, a dozen larger projects financed through EU funds, and a number of market-oriented projects. More information about the Department's projects, dissertations, laboratories, and new research groups can be found in the thematic texts of this publication.

Apart from traditional hydrogeology and engineering geology, significant scientific success has recently been achieved in the area of geothermal energy, and geophysical research and remote sensing are being developed. During the last decade, the DHGEG has largely changed its way of doing business, which resulted in substantial increase in scientific production, number of employed scientists, and the shift of research endeavours towards scientific projects and projects financed by the EU. In the first half of the concerned period, the head of Department was Željka Brkić, and from 2013 to date, it has been headed by Josip Terzić. At the beginning of this period, there were a total of 26 employees in the Department. The production of scientific papers was very low, and their publication in relevant international journals was sporadic, with less than one paper published per year on average (for the entire Department). In that period, we understood that it was im-



Uzorkovanje podzemnih voda u Bibinjskom polju (Ravni kotari)  
Groundwater sampling in Bibinjsko polje (Ravni kotari region)



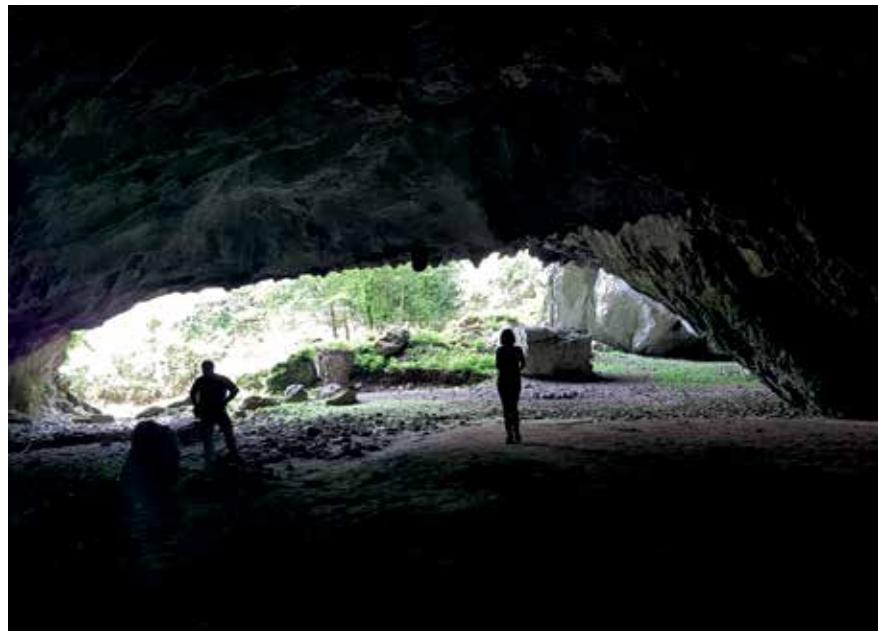
Istraživanje mineralnog izvorišta Mokošica  
Research of Mokošica mineral spring



Inženjerskogeološka istraživanja za potrebe izgradnje autoceste (foto D. Navratil)  
Engineering geological research for highway construction (photo by D. Navratil)

području geotermije, a razvijaju se geofizička i daljinska istraživanja. U zadnjem je desetljeću ZHGIG u velikoj mjeri promjenio način poslovanja, što je rezultiralo značajnim pojačanjem znanstvene proizvodnje, broja znanstvenih kadrova i usmjeravanjem istraživačkih npora prema znanstvenim projektima i projektima financiranim od strane EU. U prvoj polovici razmatranog razdoblja predstojnica zavoda bila je Željka Brkić, a od 2013. godine do danas predstojnik je Josip Terzić. Početkom ovog perioda u zavodu je bilo ukupno 26 zaposlenika. Producija znanstvenih radova u relevantnim svjetskim časopisima bila je veoma niska i objavljivalo se sporedično, u prosjeku manje od jednog rada godišnje (cijeli zavod). U tom razdoblju shvatili smo kako je važno pojačati znanstvenu komponentu rada, kao i natjecati se za EU projekte, kojima se sufinancira rad na našim temeljnim projektima, kupuje istraživačka oprema namijenjena znanstvenom radu i zapošljavaju se mladi istraživači izravno na projekte (trenutno jedina niša za dobivanje novih mladih stručnjaka). Tako se kao jedan od rezultata ovog pristupa ističe činjenica da u zavodu danas rade 34 zaposlenika. Projekti ove vrste u velikoj mjeri usmjerili radne napore većine istraživača te doprinijeli ogromnom porastu publiciranja relevantnih znan-

portant to enhance the scientific component of our work, as well as to compete for EU projects, which co-finance our fundamental projects, buy research equipment intended for scientific work, and directly employ young researchers (currently, this is the only niche for acquiring new young experts). Thus, the fact that the Department comprises 34 employees today is one of the highlights of this approach. Projects of this kind have largely focused work efforts and contributed to an enormous increase in publi-



Pogled iz špilje – izvora Tounjčice  
A view from the cave – spring of Tounjčica river

stvenih radova. U posljednjih nekoliko godina objavljujemo prosječno 4-5 članaka godišnje u referentnim časopisima. Za ilustraciju ovog porasta može se istaknuti činjenica kako se u zadnjih pet godina objavilo više znanstvenih radova nego u cijeloj povijesti do tada, što se može smatrati pravim publikacijskim valom. Ipak, niti ove brojke nas ne zadovoljavaju, te se kontinuirano radi na dalnjem porastu. U znanstvene radove redovito ulažemo vlastita sredstva ostvarena na tržištu, znanstvenim i EU projektima.

Tijekom proteklih deset godina u zavodu je doktoriralo desetero istraživača, a osmero je ostvarilo i izbore u znanstvena zvanja. Ukoliko se novim znanstvenicima ne omogući dobitivanje odgovarajućih radnih mesta, doći će do stagnacije – kako u publiciranju, tako i radu na projektima svih vrsta. Kao svojevrsna kruna porasta znanstvene produkcije, a zapravo i određene promjene u načinu razmišljanja i rada, dobiveni su prvi znanstveni projekti Hrvatske zaklade za znanost, a znanstvenici iz područja geološkog inženjerstva imaju ključnu ulogu u Obzor2020 projekatima GeoTwinn i GeoERA, u kojima sudjeluju i istraživači ostalih sastavnica našeg instituta. Zavodski laboratorijski nastavili su se razvijati i kupljena je brojna kvalitetna istraživačka oprema, u cijelosti sredstvima ostvarenim na znanstvenim, tržišnim i EU projektima.



Inženjerskogeološka istraživanja klizišta u Hrvatskoj Kostajnici (foto T. Frangen)  
Engineering geological research of a landslide in Hrvatska Kostajnica (photo by T. Frangen)

cation of relevant scientific papers. During the last several years, we have been publishing an average of 4–5 papers in reference journals. To illustrate this increase, more scientific papers were published in the last five years than in the entire history of the Department up to then, which can be considered a true publication tide. However, these numbers are still not satisfying, and we continue to work on a further increase. We regularly invest our own resources, acquired on the market, in scientific and EU projects, towards the generation of scientific papers.

During the past ten years, ten researchers obtained their PhDs at the Department, with eight also attaining scientific titles. If new scientists are not provided with appropriate working positions, there will be stagnation in terms of publications, as well as in terms of all types of projects at the Department. As a pinnacle of the increase in scientific production and the adaptive change in the mentality and work methods, the first projects of the Croatian Science Foundation have been approved, and scientists working in the realm of geological engineering obtained a key role in the Horizon2020 projects GeoTwinn and GeoERA. The researchers from other departments of our Institute also take part in these projects. The Departmental laboratories have continued to develop, and a lot of high-quality research equipment has been acquired, entirely financed by funds realised through scientific, market-oriented, and EU projects.

# Zavod za mineralne sirovine

## Department of Mineral Resources

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Zavod za mineralne sirovine (ZMS) provodi istraživanja mineralnih sirovina, geokemije okoliša, paleolimnološka istraživanja i geološka istraživanja podmorja. U istraživanjima sudjeluje 13 djelatnika.

Djelatnici i istraživači zavoda utvrđuju postojeća i potencijalna nalazišta mineralnih sirovina te utvrđuju zakonitosti postanka pojedinih tipova ležišta mineralnih sirovina. Pružaju savjetovanje o mineralnim resursima u RH, u svrhu održivog gospodarenja mineralnim sirovinama, te usko surađuju sa Sektorom za rudarstvo Ministarstva gospodarstva, kao i jedinicama regionalne lokalne samouprave. Ukidanjem financiranja znanstvene

The Department of Mineral Resources conducts research on mineral resources, environmental geochemistry, paleolimnology, and submarine geology. There are 13 employees that comprise this department.

The Department's employees and researchers determine the existing and potential deposits of mineral resources and investigate how the individual types of mineral resource deposits were generated. They provide counselling on mineral resources in the Republic of Croatia (RH) with the purpose of their sustainable management. Moreover, they tightly co-operate with the Mining Sector of the Ministry of Economy, as well as with units of



Istraživačka platforma „Q2”, s klipnim jezgrilom koje omogućuje uzorkovanje slijeda nekonsolidiranih jezerskih i morskih sedimenata (foto Ž. Dedić)

Research platform "Q2", with a piston corer that enables sampling of unconsolidated lake and marine sediments (photo by Ž. Dedić)

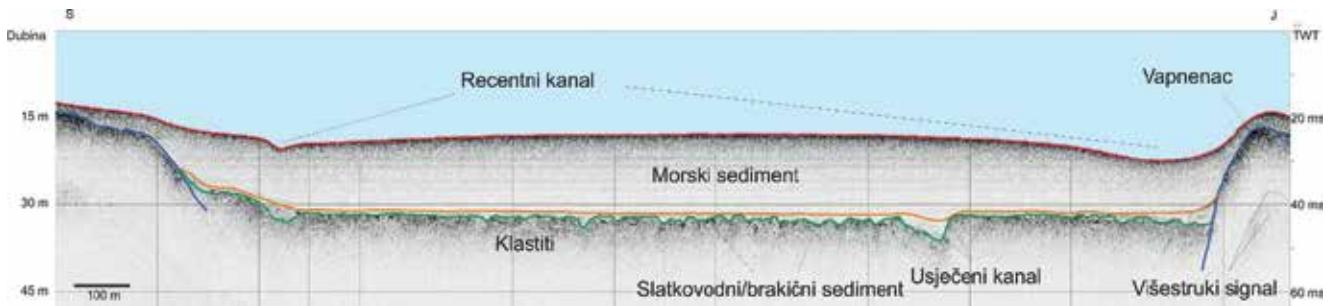


Ležište paleogenskog boksita u području Imotskog (foto S. Miko)  
Deposit of Paleogene bauxite in the area of Imotski (photo by S. Miko)

nih projekata Ministarstva znanosti i obrazovanja („zProjekata“) i prelaskom na višegodišnje institucijsko financiranje (VIF), financiranje izrade **Karte mineralnih sirovina** provodi se i kroz izradu rudarsko-geoloških studija pojedinih županija. Istraživanja mineralnih sirovina su posljednjih godina usmjereni na ne-metalne mineralne sirovine preko privrednih subjekata i međunarodnih projekata unutar programa za jugoistočnu Europu (SEE), kao što su SARMA (Održivo gospodarenje kamenim agregatima) i SNAPSEE (Održivo planiranje agregata u jugoistočnoj Europi). Djelatnici su posljednjih godina redovito sudjelovali u nizu projekata Obzor2020 vezanih za politike o mineralnim sirovinama, u sklopu kojih provode sistematizaciju baze podataka mineralnih sirovina u RH. Uspostavljanje informacijske platforme o mineralnim sirovinama očekuje se u narednim godinama kroz projekte GeoERA-e (Mintel4EU, Eurolithos, FRAME) i EIT Raw Materials (RESEERVE, REEBAUX).

the local government. Since the end of funding of scientific projects by the Ministry of Science and Education (zProjects) and the switch to multiannual institutional financing, the financing for the Map of Mineral Resources is achieved, in part, by conducting mining-geological studies in certain counties. The research on mineral resources has in recent years been shifted to non-metallic mineral resources through economic endeavours and international projects within the programme for South-Eastern Europe (SEE), such as SARMa (Sustainable Aggregates Resource Management) and SNAP-SEE (Sustainable Aggregates Planning in South East Europe). In recent years, employees have regularly participated in a number of Horizon2020 projects related to mineral policies, where systematisation of the mineral resources database of the RH is carried out. The establishment of an informational platform on mineral resources is expected in the following years through GeoERA projects (Mintel4EU, Eurolithos, FRAME) and EIT Raw Materials projects (RESEERVE, REEBAUX).

The Department's employees conduct environmental geochemistry research, paleolimnological research, and submarine geology research. These were connected with previous zProjects termed the **“Basic geochemical map of the RH”** and **“Holocene sediments as a record of changes in the use of land and the climate”**, and are continued in co-operation with economic projects, such as the paleolimnological projects of the lakes on the Eastern Adriatic coast (Hrvatske Vode), research on carbon and nitrogen in the soil of the RH (Croatian Agency for Environment and Nature), and CSF projects “Lost Lake Landscapes of the Eastern Adriatic Shelf” (LoLADRIA) and “Young researchers’ career development project – training of new doctoral students”. These projects enabled the establishment of a paleolimnological-marine group of researchers together with the Department of Geology. Field equipment for the sampling of long cores of lake and marine sediments (“Q2” platform) has been purchased, as well



Interpretirani geofizički profil snimljen geološkim dubinomjerom (ORE pinger) u području Novigradskog mora (izradio O. Hasan)  
Interpreted geophysical profile recorded using a geological sonar (ORE pinger) in the Novigrad Sea area (prepared by O. Hasan)



Glinište Rečica kod Karlovca (foto E. Kovačević Galović)  
Clay quarry Rečica near Karlovac (photo by E. Kovačević Galović)

Istraživači u zavodu provode geokemijska istraživanja okoliša, paleolimnološka istraživanja i geološka istraživanja podmorja. Ona su bila vezana za prethodne projekte „**Osnovna geokemijska karta RH**“ i „**Holocenski sedimenti kao zapis promjena u upotrebi zemljišta i klime**“, a nastavljena su projektima u suradnji s privrednim subjektima, kao što su paleolimnološki projekti jezera istočno jadranske obale (Hrvatske vode), istraživanja ugljika i dušika u tlima RH (Hrvatska agencija za okoliš i prirodu), te HRZZ projektima „Nestali jezerski krajobrazni istočno jadranskog šelfa“ (LoLADRIA) i „Projekt razvoja karijera mladih istraživača – izobrazba novih doktora znanosti“. Navedeni projekti omogućili su uspostavljanje paleolimnološko-marinske grupe istraživača zajedno sa Zavodom za geologiju. Nabavljena je terenska oprema za uzorkovanje dugih sljedova jezerskih i morskih sedimenata (platforma „Q2“), te geofizička akustična oprema (višesnopni i panoramski dubnomjeri). Uspostavljeni su laboratoriji u kojima se provodi priprema uzoraka, sedimentološke i mineraloške analize, analize ugljika i dušika, magnetskog susceptibiliteta te paleontološke analize kvarternih uzoraka. Uspostavljen je repozitorij jezgrinih sedimenata, u kojem se nalazi otprilike 150 m jezgrinih jezerskih i morskih sedimenata. Djelatnici su specijalizirani za rad na znanstvenoistraživačkim krstarenjima, te su 2017. godine sudjelovali na njemačkom istraživačkom brodu RV Poseidon u Jadranskom moru. Projekt „**Geološka karta podmorja**“ vezan je za EU projekt EMODnet Geology, u kojem ZMS sudjeluje od 2015. godine.

as geophysical acoustic equipment (multibeam and panoramic sonars). Laboratories have been established for carrying out sample preparation, sedimentological and mineralogical analyses, carbon and nitrogen analyses, magnetic susceptibility, and paleontological analyses of Quaternary samples. A repository of sediment cores has also been established, where approximately 150 m of lake and marine sediment cores are kept. The employees are trained for work on scientific-research cruises. In 2017, they participated in the research cruise on board the German research vessel RV Poseidon in the Adriatic Sea. The project “**Geological Map of the Croatian Adriatic Sea**” is associated with the EU project EMODnet Geology that Department has been engaged in since 2015.

# Predstavljanje strategije HGI-CGS-a

## Introduction to the Strategy of the HGI-CGS

Autor teksta / Author of the text: dr. sc. **Slobodan MIKO**

Misija HGI-CGS-a tijekom razdoblja od 2019. do 2023 godine je stići nova znanja i pozicionirati se kao vodeći znanstveni centar u području geoznanosti i geološkog inženjerstva, slijedeći međunarodno priznate istraživačke prakse i standarde te uvažavajući razvojne prioritete RH. Kroz blisku suradnju znanstvenika u okviru aktualnih projekata HGI-CGS-a očekuje se unapređenje kapaciteta istraživačkih grupa na četiri važna područja: (1) 3D geološko istraživanje i modeliranje, (2) modeliranje toka podzemnih voda i transporta onečišćenja, (3) daljinsko prikupljanje podataka o geohazardima i njihove prostorne analize i (4) geotermalna energija. Osnovna znanstvenoistraživačka djelatnost HGI-CGS-a je program izrade geoloških karta koji se temelji na suvremenim dosezima različitih geoloških disciplina. Istraživanjem državnog teritorija kroz izradu geoloških karata, geologija dobiva značajnu nacionalnu i regionalnu komponentu.

Program se sastoji od 8 tematskih cjelina:

1. Osnovna geološka karta RH;
2. Osnovna hidrogeološka karta RH;
3. Osnovna inženjerskogeološka karta RH;
4. Osnovna geokemijska karta RH;
5. Karta mineralnih sirovina RH;
6. Geološka karta jadranskog podmorja RH;
7. Strukturno-geomorfološka karta RH;
8. Geotermalna karta RH.

Također se planira razvoj metodologije istraživanja za potrebe potpovršinskog prostornog planiranja kao podlogu za donošenje odluka o istraživanju i eksploataciji određenih energetskih i vodnih resursa i mineralnih sirovina, te izgradnji infrastrukture. HGI-CGS će i dalje provoditi temeljna geološka istraživanja, razvijati specijalnosti iz različitih grana geologije i geološkog inženjerstva, držati korak sa suvremenim instrumentalnim metodom analiza, a njihove rezultate koristiti kao podlogu za sva područja istraživanja i redovito kroz publikacije prezentirati znanstvenoj zajednici i popularizirati u javnosti.

The mission of the Croatian Geological Survey (HGI-CGS) from 2019 to 2023 is to acquire new knowledge and position itself as the leading science centre in the field of geosciences and geological engineering, following internationally recognised research practice and standards, and taking into account the development priorities of the Republic of Croatia (RH). Through close collaboration of scientists within the current HGI-CGS' projects, the capacity of research groups is expected to improve in four important areas: (1) 3D geological exploration and modelling, (2) groundwater flow modelling and contamination transport, (3) remote data collection on geohazards and their spatial analyses and (4) geothermal energy. The basic scientific research activity of the HGI-CGS is the conduction of a programme of geological mapping, based on contemporary capabilities of different geological disciplines. By exploring the territory of the country through construction of geological maps, geology gains a significant national and regional component.

The programme consists of eight topics:

1. Basic Geological Map of the RH;
2. Basic Hydrogeological Map of the RH;
3. Basic Engineering Geological Map of the RH;
4. Basic Geochemical Map of the RH;
5. Map of Mineral and Energy Resources of the RH;
6. Geological Map of the Croatian Adriatic Sea;
7. Structural Geomorphological Map of the RH;
8. Geothermal Map of the RH.

In addition, the development of the research methodology is needed for sub-surface spatial planning as a basis for decision-making in the exploration and exploitation of certain energy, water, and mineral resources, and the construction of infrastructure. The HGI-CGS will continue to perform basic geological research and develop its expertise in different branches of geology and geological engineering. The Department will strive to keep up with modern instrumental methods of analyses and use their results as a basis for all areas of research. Moreover, the HGI-



Strateški dokument znanstvenoistraživačke djelatnosti Hrvatskog geološkog instituta od 2019. do 2023. zasnovan je na definiranim ciljevima i konceptu novog tematskog usmjerenja temeljnih znanstvenih istraživanja i interdisciplinarnosti. Ostvaruju se prepostavke za oblikovanje i razvoj prepoznatljive znanstvenoistraživačke ustanove s naglaskom na znanstvenu izvrsnost i kompetitivnost. Intenzitet znanstvenoistraživačkog rada te ostvareni rezultati jamac su provedbe iskazanih strateških ciljeva tijekom sljedećeg razdoblja, uz preuzetu obvezu dalnjeg jačanja ljudskih potencijala kao najvrjednije sastavnice HGI-CGS-a.

CGS will regularly present these results to the scientific community through publications and promote them among the public.

The strategic plan regarding the scientific research activity of the HGI-CGS for the period from 2019 to 2023 is based on established goals and the concept of a new thematic shift to fundamental scientific research and interdisciplinarity. Prerequisites for the structure and the development of a recognized scientific research institution are being achieved with an emphasis on scientific excellence and competitiveness. The intensity of scientific research work and achieved results assure the implementation of pre-set strategic goals over the next period, with the commitment to further strengthen human resources as the most valuable component of the HGI-CGS.



Pregled raznovrsnih terenskih istraživanja djelatnika HGI-CGS-a  
Overview of diverse fieldworks of the HGI-CGS employees



Istraživanje na izvoru Zvir u Rijeci (foto T. Frangen) / Research at the Zvir spring in Rijeka (photo by T. Frangen)



3

## Razvoj u proteklom desetljeću

*Development in the  
past decade*

# Kadrovi kroz vrijeme

## Human Resources in Time

Autorica / Author: dr. sc. **Staša BOROVIĆ**

Prikupljanje podataka / Data collection: **Mladenka JURČIĆ**

Ukupni broj djelatnika HGI-CGS-a nije se značajnije mijenjao u proteklom desetljeću te se, uz manje iznimke, kretao između 110 i 115 zaposlenika. Posljednjih je godina zamjetan blagi trend povećanja, što je posljedica zapošljavanja mladih znanstvenika i stručnjaka izravno i u cijelosti na teret sredstava projekata Hrvatske zaklade za znanost (dvoje doktoranada i jedan poslijedoktorand), te EU projekata (osmero stručnih i viših stručnih suradnika geologa).

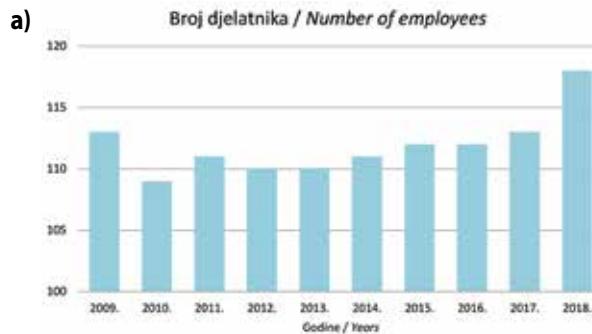
Struktura zaposlenika prema spolu je također bila relativno ujednačena, uz blagi porast broja zaposlenica (s 40 % na 46 %) u posljednjih deset godina. Ravnopravni odnos kolegica i kolega ogleda se i u činjenici da žene zauzimaju većinu vodećih pozicija u institutu (predsjednica i zamjenica predsjednice Znanstvenog vijeća te predstojnice dvaju od triju zavoda, pravna tajnica).

Obrazovna struktura zaposlenika je povoljna i obilježena kontinuiranim trendom poboljšanja. Udio geologa (znanstvenika i stručnjaka) je 65 %, dok ostatak čini laboratorijsko i geološko tehničko osoblje, kao i pomoćne tehničke i administrativne službe. Broj doktora znanosti se u deset godina povećao s 27 na 43, dakle za punih 60 %, što smatramo velikim uspjehom. Budući da znanstvenici HGI-CGS-a pripadaju dvama znanstvenim područjima – prirodnim i tehničkim znanostima – vrijedi naglasiti iznimno napredak u području tehničkih znanosti (geološkog inženjerstva). Broj doktora znanosti iz tog područja, djelatnika

The total number of employees of the HGI-CGS did not vary significantly in the past decade, and was constantly around 110 – 115. A slight increasing trend has been recorded in the past few years, as a consequence of employing young scientists and professionals directly to, and funded in total from, the projects of the Croatian Science Foundation (two doctoral and one postdoctoral researcher) and EU projects (eight professional associates and higher associates).

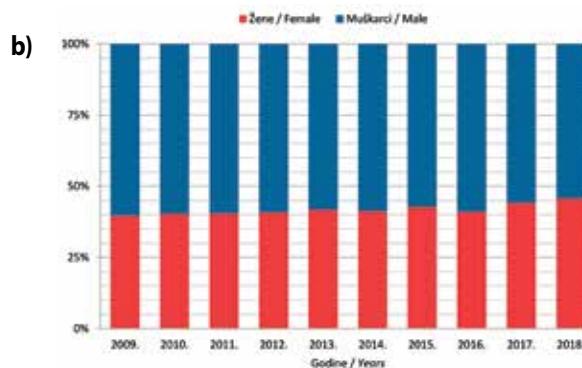
Gender structure of the employees was also relatively constant, with a slight increase in the share of female employees (from 40 % to 46 %) in the past ten years. Gender equality at the HGI-CGS is visible in the fact that many female colleagues occupy lead roles (chair and chair deputy of the Scientific council, heads of two out of three departments, legal secretary).

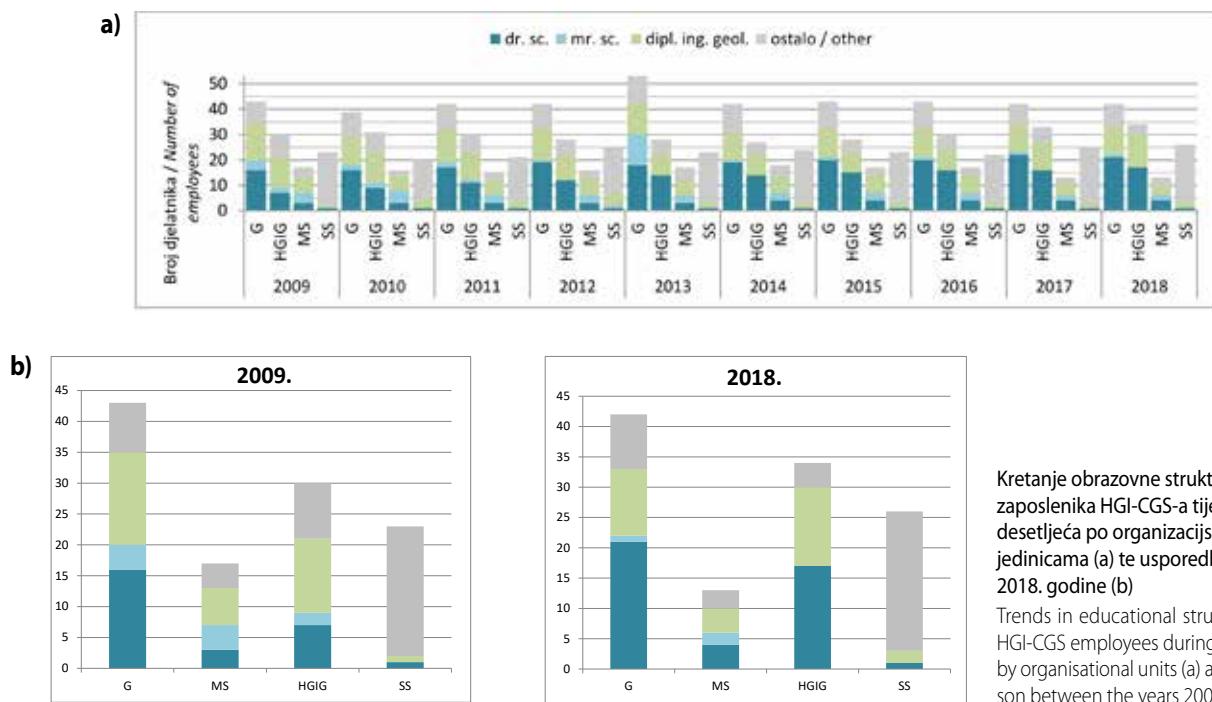
Educational structure of the employees is favourable and marked by continuous improvement. The proportion of geologists (scientists and professional experts) is 65 %, while the rest are laboratory and geology technicians, and other technical and administrative personnel. The number of PhDs has increased from 27 to 43 in the past ten years, i.e. 60 %, which we consider to be a great success. Since the scientists of the HGI-CGS work in two different fields of science – natural and technical sciences – it is important to point out an exceptional increase in the field of technical sciences (geological engineering). The number of PhDs in that field,



Kretanje broja zaposlenika HGI-CGS-a (a) te udjela ženskih i muških zaposlenika (b) tijekom desetljeća

Trends in the number of employees of the HGI-CGS (a) and the proportions of female and male employees (b) during the decade



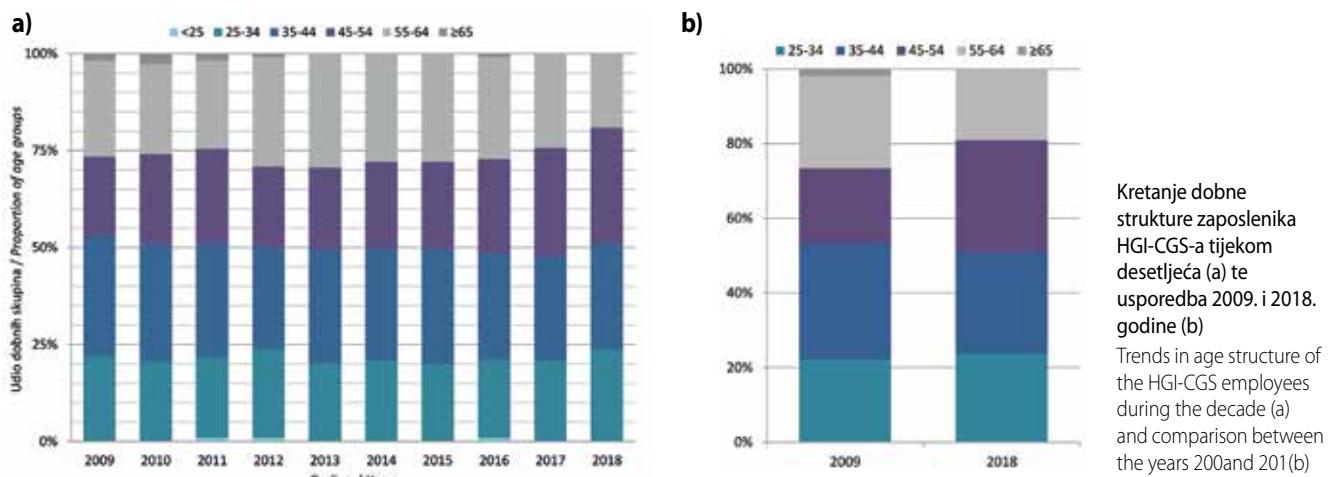


Zavoda za hidrogeologiju i inženjersku geologiju, u istom se razdoblju povećao sa 7 na 17, dakle za 140 %, što predstavlja veliki iskorak u kvaliteti primijenjenih geoloških istraživanja, kako u HGIG-u, tako i na razini države.

Dobna struktura zaposlenika je tijekom proteklog desetljeća bila relativno ujednačena, no zapaža se trend porasta broja zaposlenika u dobnoj skupini od 45 do 54 godine starosti od čak 50 % što je, nažalost, posljedica restriktivne politike zapošljavanja u znanstvenom sektoru RH. Taj se problem nastoji premostiti zapošljavanjem mladih geologa u cijelosti na teret sredstava kompetitivnih znanstvenih i stručnih nacionalnih i EU projekata, a za budućnost predstavlja izazov u pogledu zadržavanja takvog odlično obučenog i specijaliziranog kadra.

who work in the Department of Hydrogeology and Engineering Geology, has increased by 140 % in the same time period (from 7 to 17). That represents a leap in the quality of applied geological research, at the level of HGIG, and for the whole country.

Age structure of the employees has been relatively constant in the decade past, but a trend of 50 % increase is recorded for the age group of employees between 45 and 54 years of age. That is an unfortunate consequence of restrictive employment policies in the research sector at national level. To overcome this problem, efforts are made to employ young colleagues to work posts funded entirely from competitive national and EU project funds. The challenge for the future will therefore be keeping these well trained and specialised employees at the institute.



Kretanje dobne strukture zaposlenika HGIG-a tijekom desetljeća (a) te usporedba 2009. i 2018. godine (b)  
Trends in age structure of the HGIG employees during the decade (a) and comparison between the years 2009 and 2018 (b)

# Specijalizacije kroz doktorate

## Specialisations Through PhD-s

Autorica teksta / Author of the text: dr. sc. **Staša BOROVIĆ**

Hrvatski geološki institut je tijekom proteklog desetljeća kontinuirano radio na unaprjeđenju ljudskih resursa i usavršavanju djelatnika u različitim znanstvenim poljima i temama. Doktorate znanosti je u navedenom razdoblju steklo ukupno dvadeset i peto djelatnika, od čega četrnaestero u području prirodnih znanosti – polje geologija, te jedanaestero u području tehničkih znanosti – polje rudarstvo, nafta i geološko inženjerstvo. Samim time, desetljeće iza nas je obilježeno velikim napretkom u znanstvenom smislu u odnosu na prethodna razdoblja, što je izuzetno značajno za budućnost HGI-CGS-a kao javnog znanstvenog instituta.

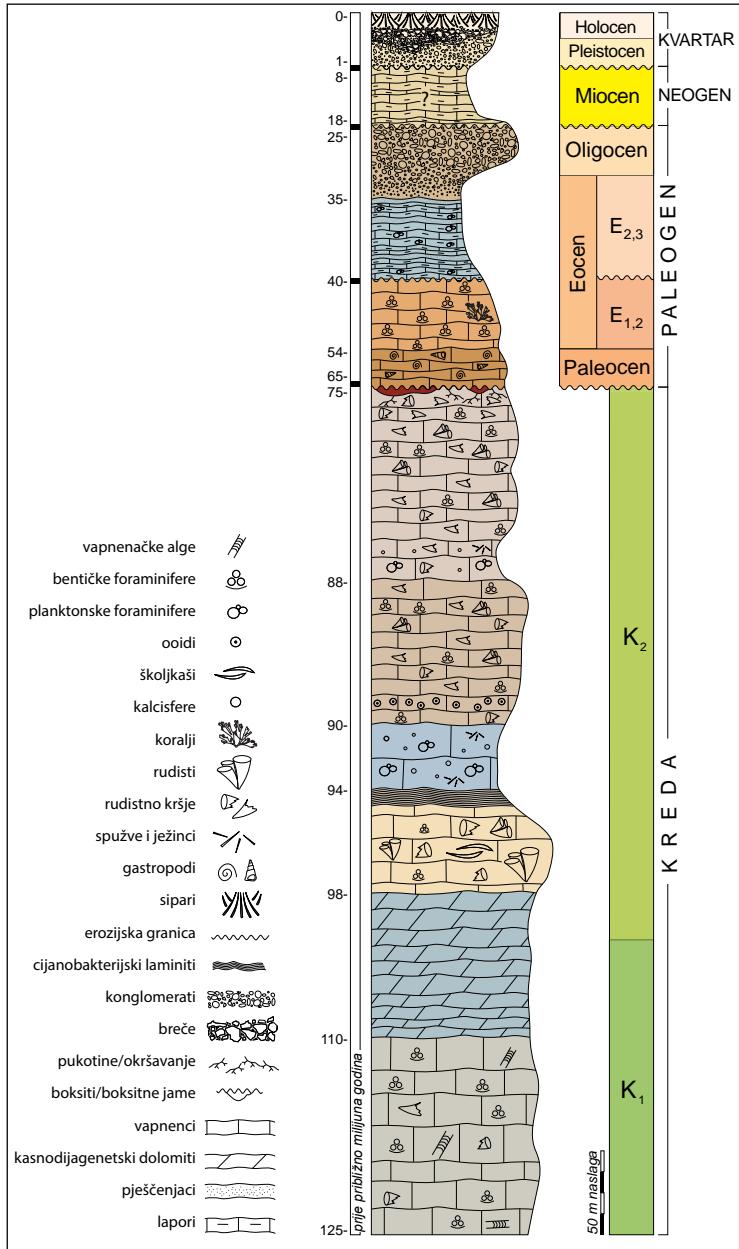
Doktorati znanstvenih novaka i ostalih doktoranada usmjereni su prema temama temeljnih projekata HGI-CGS -a, kao i prema znanstvenim temama koje su odabранe kao strateški značajne za institut. Većina je disertacija imala područje istraživanja u Hrvatskoj (23). Budući da se državni teritorij sastoji od dva dijela podjednake veličine, a veoma različitih geoloških obilježja, i disertacije su u podjednakoj mjeri obrađivale oba karakteristična područja: panonski (12) i dinaridski dio (11). Primot su se doktorandi sposobili za korištenje brojnih metoda neophodnih za suvremena geoznanstvena i primjenjena geološka istraživanja, od kojih su mnoge po prvi puta primjenjivane u sklopu izrade disertacija.

Doktorandi u polju geologije su se specijalizirali u temama stratigrafije, istraživanja paleookoliša (paleoklimatske, paleoekološke i paleogeografske rekonstrukcije), mikropaleontologije, geokemije okoliša, urbane geokemije, petrografije i geneze ležišta mineralnih sirovina. Osam je disertacija obrađivalo panonsko područje Hrvatske, dok ih je šest izrađeno o dinaridskom dijelu. Razvijane su kompetencije iz područja geološkog kartiranja i izrade sofisticiranih geoloških stupova i profila, biostratigrafske i litostratigrafske raščlambe, stratigrafske klasifikacije i korelacije, analize stabilnih i radioaktivnih izotopa, petrografskih, mineraloških, geokemijskih, sedimentoloških i

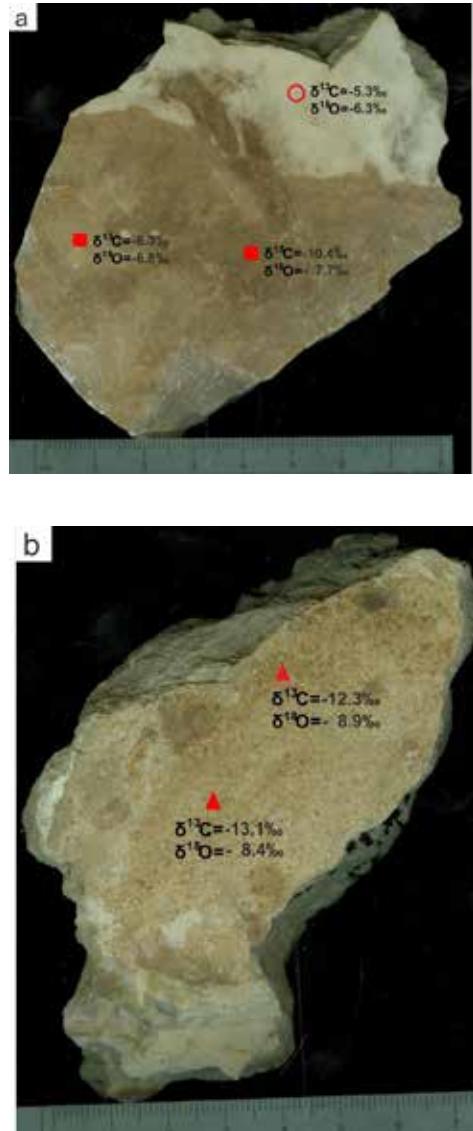
In the past decade, the Croatian Geological Survey (HGI-CGS) has been continuously working on the improvement of human resources management and the specialisation of employees in various scientific fields and subjects. A total of 25 employees received their PhDs within the last ten years, 14 of those in the area of natural sciences – within the field of geology, and 11 in technical sciences – the fields of mining, petroleum, and geological engineering. With this alone, the past decade was marked by a big advancement in the scientific sense with regard to the previous periods, which is exceptionally significant for the future of the HGI-CGS as a public scientific institute.

Research assistants and other PhD candidates within the institute were directed towards the topics of the HGI-CGS' fundamental projects, as well as scientific topics considered to be strategically important for the Institute. The geographical research areas of most PhD students were in Croatia (23). As the country comprises two parts of equal size and highly different geological characteristics, the PhD dissertations dealt with both of these areas to an equal extent: the Pannonian (12), and the Dinaric (11) regions. The PhD students were simultaneously trained to use numerous methods, indispensable in contemporary geoscientific and applied geological research, many of which were applied for the first time in the process of the PhD study.

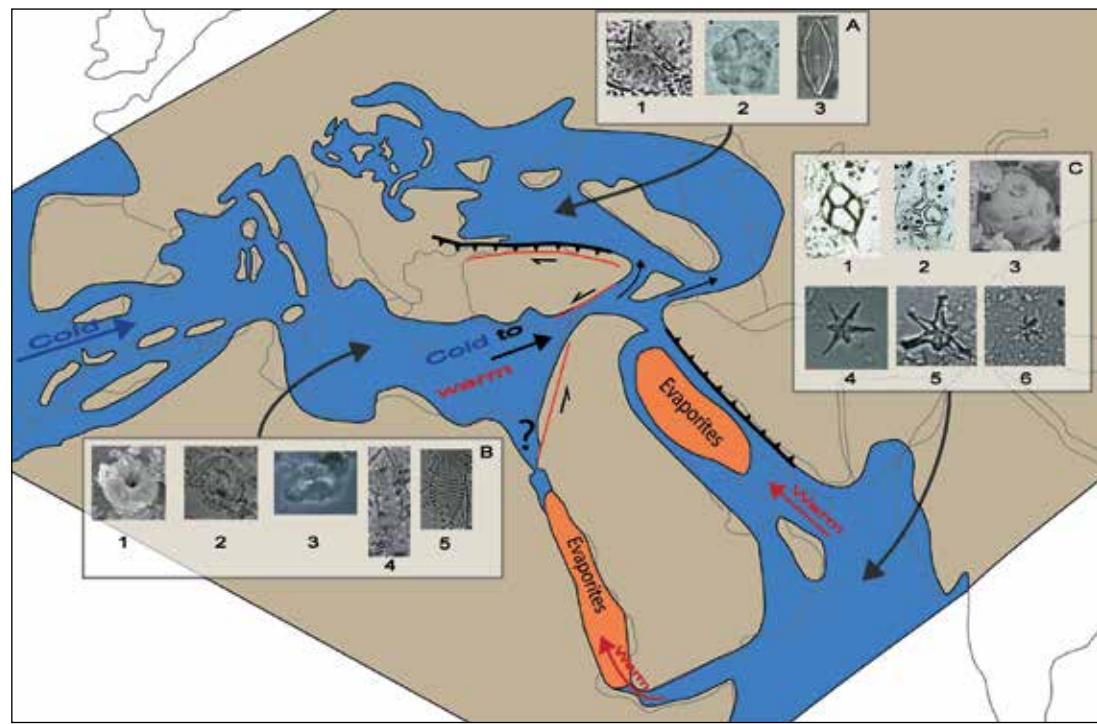
PhD candidates in the field of geology specialised in subjects of stratigraphy, research of paleoenvironment (paleoclimatic, paleoecological, and paleogeographical reconstructions), micro-paleontology, environmental geochemistry, urban geochemistry, petrography, and genesis of mineral resource deposits. Eight dissertations dealt with the Pannonian region of Croatia, while a further six dealt with the Dinaric region. Competences were developed in the field of geological mapping and production of sophisticated geological columns and profiles, biostratigraphical and lithostratigraphical analyses, stratigraphical classification and correlation, analysis of stable and radioactive isotopes, pe-



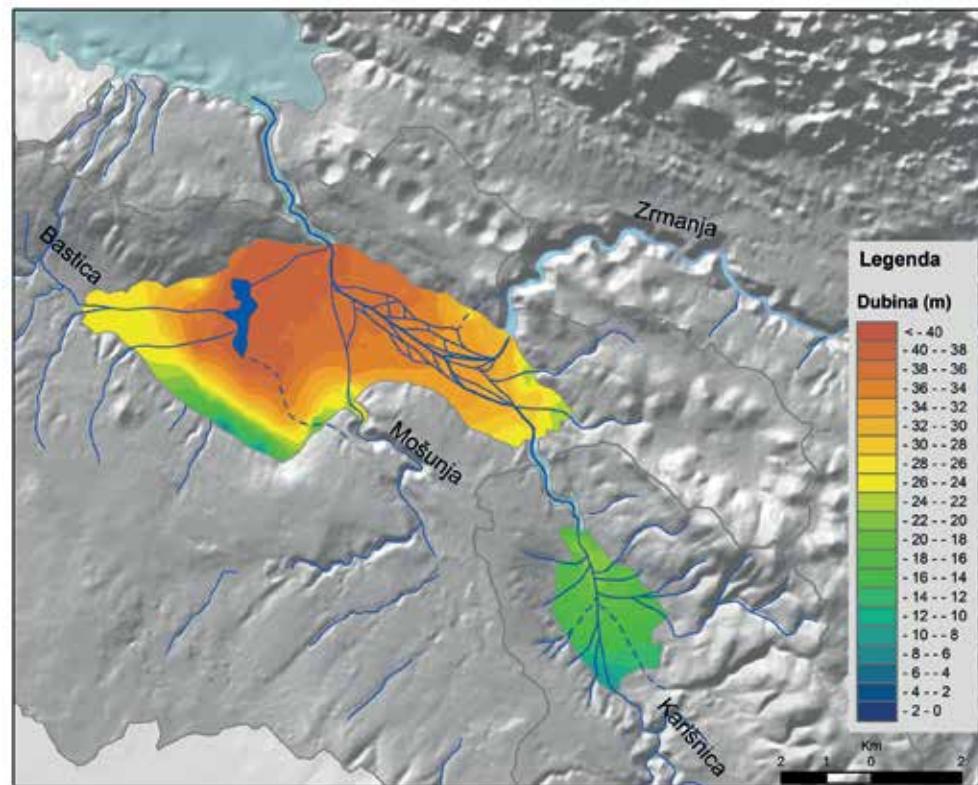
Geološki stup i stratigrafski položaj naslaga na području Imotskog / The geological column and stratigraphic position of the deposits in the Imotski region (V. Brčić)



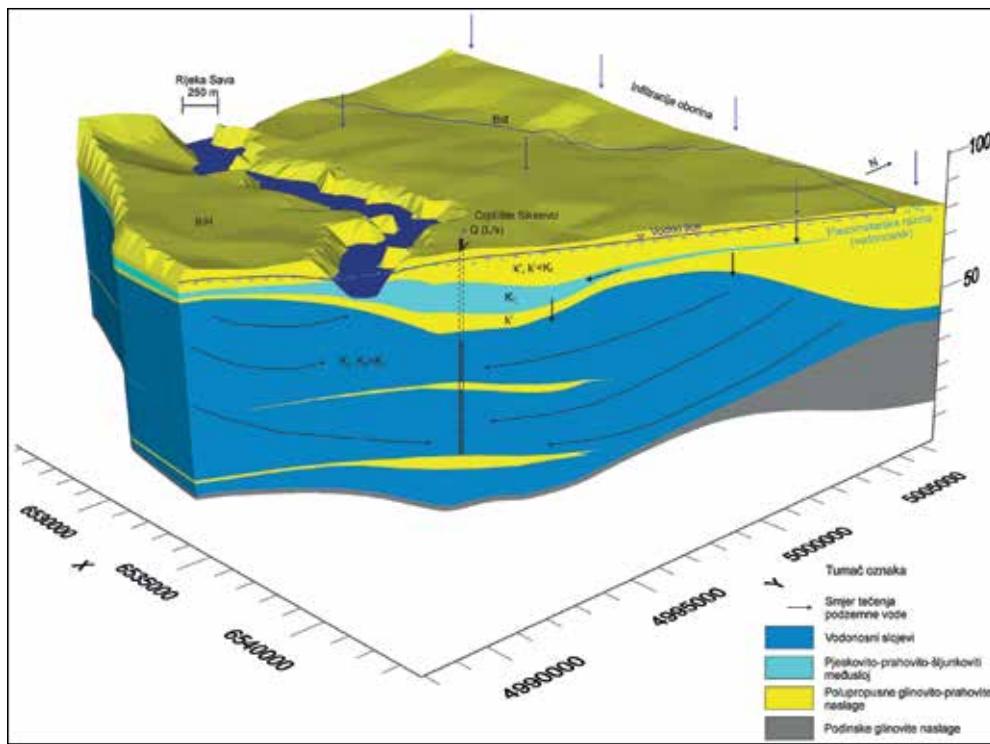
Vrijednosti  $\delta^{13}\text{C}$  i  $\delta^{18}\text{O}$  u ‰ u odnosu na Vienna PeeDee Belemnite standard (VPDB) uzorkovanih biogenih kalkreta (kvadrat i trokut) i marinskih karbonata (krug), koji karakteriziraju regionalni K-Pg subaerski nekonformitet /  $\delta^{13}\text{C}$  i  $\delta^{18}\text{O}$  values in ‰ relative to the Vienna PeeDee Belemnite standard (VPDB) of selected biogenic calcrite (square and triangle) and host marine carbonate (circle) samples from the regional K-Pg subaerial unconformity (M. Brlek)



Dopunjena Röglova paleogeografska rekonstrukcija s provodnim vrstama karakterističnim za sarmat za područja Istočnog Paratethysa, Mediterana i Indo-Pacifika / Emended Rögl's palaeogeographic reconstruction with characteristic species for Sarmatian of Eastern Paratethys, Mediterranean and Indo-Pacific regions (I. Galović)



Paleookolišna rekonstrukcija područja Novigradskog i Karinskog mora tijekom ranog holocena prije prodora mora. Plavom bojom označeni su vodotoci, koji su kao i topografija rekonstruirani prema geofizičkim podacima i dostupnim topografskim podacima / Paleoenvironment reconstruction of Novigrad and Karin Sea areas during early Holocene, before seawater ingress. Watercourses (in blue) and topography were reconstructed from geophysical and available topographic data (O. Hasan)



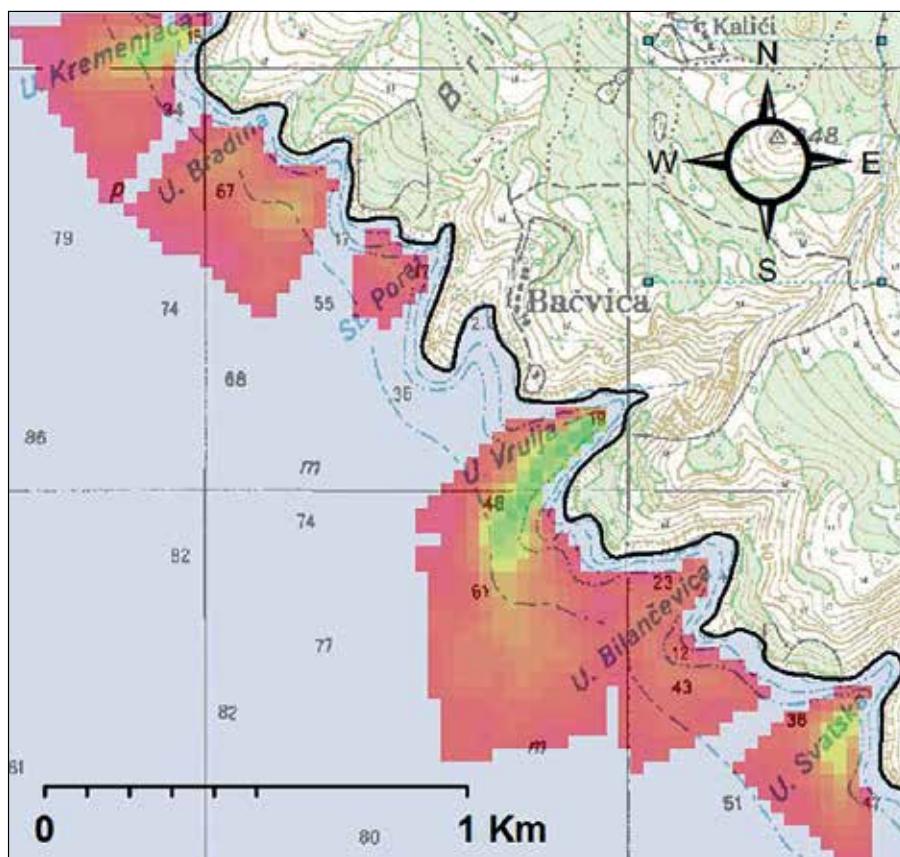
Konceptualni 3D model vodonosnog sustava zahvaćenog na vodocrpilištu Sikirevci / Conceptual 3D model of the aquifer system tapped at the Sikirevci pumping site (M. Briški)

geokronoloških istraživanja, uzorkovanja, obrade i analize jezgara sedimenata te snimanja, obrade i interpretacije podataka akustičkih geofizičkih metoda.

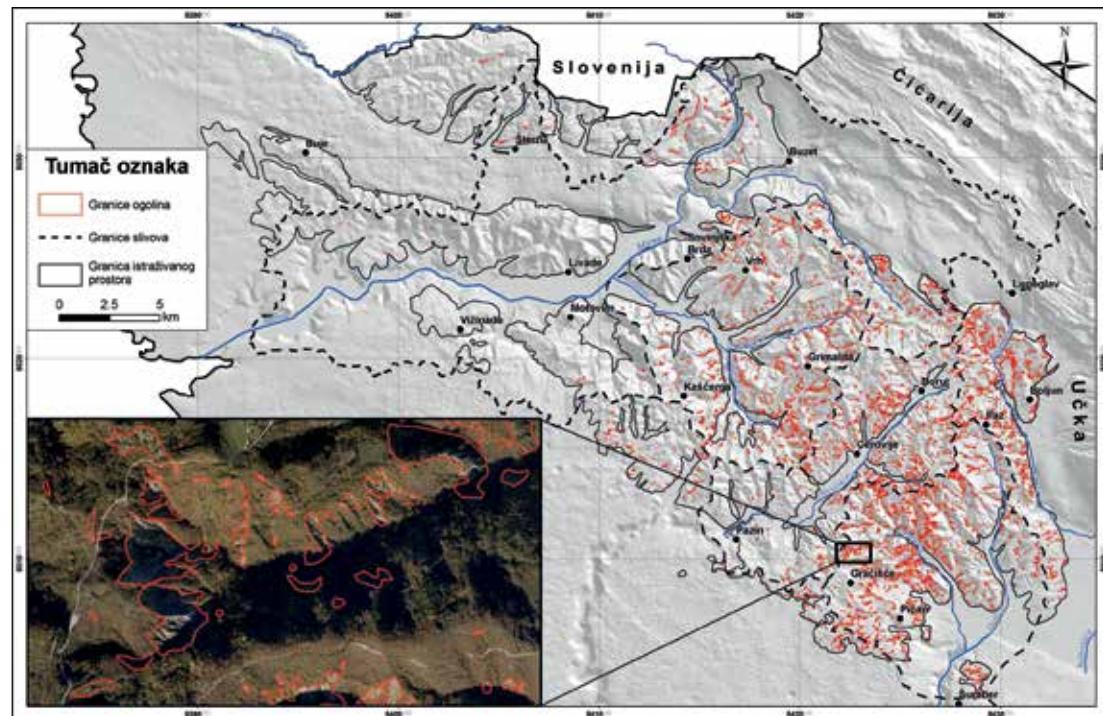
U polju geološkog inženjerstva pet disertacija se bavilo hidrogeologijom (dvije vezano uz istraživanja vodonosnika s međuzrnskom poroznošću u panonskom dijelu Hrvatske te tri s pukotinskom i krškom poroznošću u dinarskom dijelu), četiri inženjerskom geologijom (jedna u panonskom i tri u dinarskom dijelu), te dvije istraživanjem hidrotermalnih sustava (jedna na prostoru Italije te jedna u panonskom dijelu Hrvatske). Kroz proces izrade disertacija razvijale su se kompetencije iz hidrogeološkog i inženjerskogeološkog kartiranja, hidroloških mjerena i monitoringa, hidrokemijskih uzorkovanja i mjerena, trasiranja, određivanja hidrogeoloških parametara u različitim mjerilima i različitim metodologijama primjenjenim panonskom i dinarskom dijelu Hrvatske, detaljnih snimanja diskontinuiteta, kategorizacije stijenskih masa, statističke obrade geometrijskih značajki diskontinuiteta, utvrđivanja *in situ* razdiobe blokova, daljinska (satelitski podatci, LIDAR, bespilotne letjelice) i beskontaktna istraživanja te modeliranja toka fluida i topline.

trographical, mineralogical, geochemical, sedimentological, and geochronological research, sampling, processing, and analysis of sediment cores, as well as in recording, processing, and interpretation of data from acoustic geophysical methods.

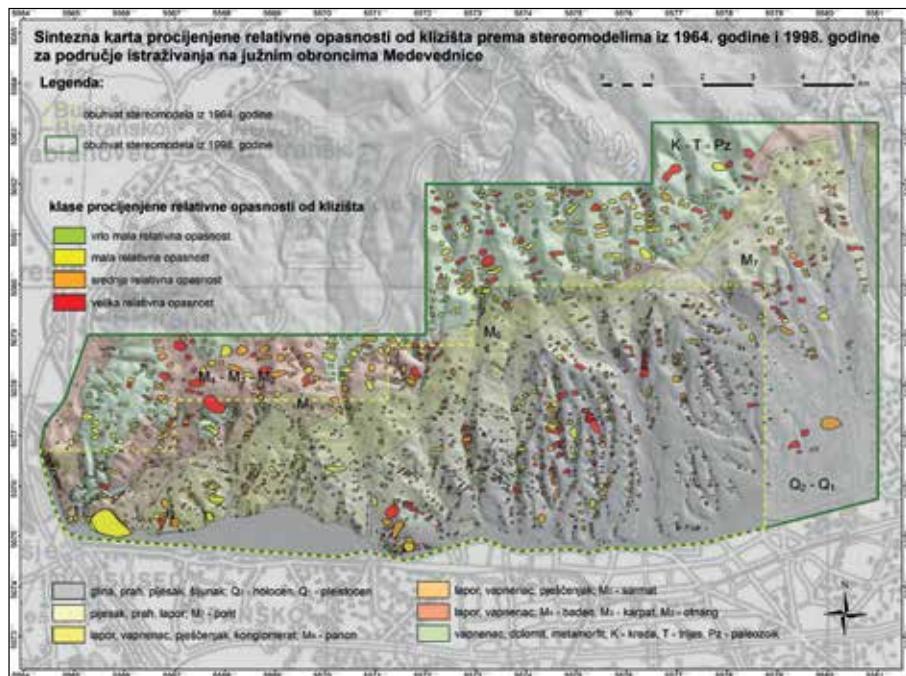
In the field of geological engineering, five dissertations were in the field of hydrogeology (two involved research on aquifers with intergranular porosity in the Pannonic region of Croatia and three dealt with fracture and karst porosity in the Dinaric region), four in engineering geology (one in the Pannonic and three in the Dinaric region), and two conducted research of hydrothermal systems (one on the territory of Italy and one in the Pannonic region of Croatia). During the PhD studies, competences were developed in hydrogeological and engineering-geological mapping, hydrological measurements and monitoring, hydrochemical sampling and measurements, tracer testing, determination of hydrogeological parameters at different scales and by various methodologies appropriate for Pannonic and Dinaric regions of Croatia, detailed recordings of discontinuities, categorisation of rock mass, statistical processing of the geometrical characteristics of discontinuities, determination of *in situ* block distribution, remote (satellite data, LIDAR, unmanned aerial vehicles) and contact-free research, as well as modelling of fluid and heat flow.



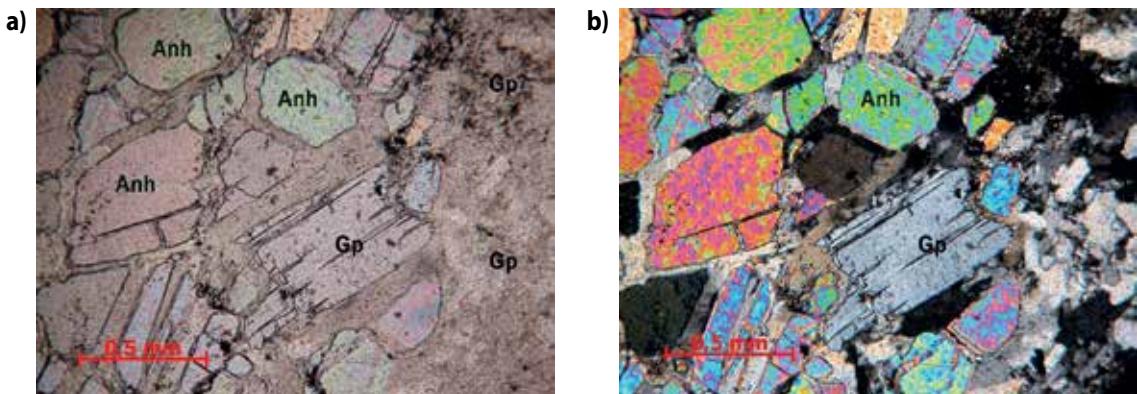
Temperaturne anomalije površine mora vidljive na Landsat 7 (ETM+) snimci, izazvane priobalnim i podmorskim istjecanjem podzemne vode / Temperature anomaly of sea-water surface detected by Landsat 7 (ETM+), caused by coastal and submarine groundwater discharge (A. Stroj)



Raspširjanje ogolina na istraživanom području u Istri / Extension of gullies in the research area in Istria (V. Gulam)



Sintezna karta procijenjene relativne opasnosti od klizišta prema stereomodelima iz 1964. i 1998. godine za područje istraživanja na južnim obroncima Medvednice / Synthetic map of relative landslide danger according to stereomodels from 1964 and 1998 for the area of research on the southern slopes of the Medvednica Mt. (L. Podolszki)



Uzorak Mk-Anh: kontakt između anhidrita i sekundarnog gipsa; anhidrit s jasno vidljivim sustavima kalavosti i živim interferencijskim bojama II i III reda – (a) bez analizatora, (b) s analizatorom (Gp-gips, Anh-anhidrit) / Mk-Anh sample: Contact between anhydrite and secondary gypsum; anhydrite with clear visibility of cleavage and interference colors II and III order- (a) without analyzer, (b) with analyzer (Gp-gypsum, Anh-anhydrite) (Ž. Dedić)

Stečene kompetencije i usvojene metodologije zasigurno će podići znanstvenu razinu istraživanja u sklopu temeljnih projekata HGI-CGS-a: različitih karata. Isto tako, omogućiti će produktivan rad na postojećim kompetitivnim znanstvenim projektima, kao i uspješnu prijavu novih – osobito onih namjenjenih istraživačima na početku karijere. Kroz tržišne se projekte naših znanstvenika ove spoznaje prenose i široj stručnoj i općoj javnosti te doprinose boljem i sigurnijem gospodarenju brojnim resursima u državi.

Popis svih doktorskih disertacija nalazi se u poglavljju Publikacije.

Acquired competences and methodologies will undoubtedly raise the scientific level of research within the HGI-CGS' fundamental projects: productions of different types of geological maps. Moreover, they will enable productive work on existing competitive scientific projects, as well as the successful application for new ones, especially those intended for early career researchers. The findings obtained by our researchers through market-oriented projects are transferred to the wider professional and general public and in that way contribute to the better and safer management of numerous resources in the country.

The list of all PhD dissertations can be found in the chapter Publications.

# Usavršavanja, škole, radionice

## Specialisations, Schools, Workshops

Autori teksta / Authors of the text: dr. sc. **Koraljka BAKRAČ**, dr. sc. **Nikolina ILIJANIĆ**, dr. sc. **Josip TERZIĆ**, dr. sc. **Staša BOROVIĆ**

U proteklih deset godina istraživači HGI-CGS-a sudjelovali su na brojnim usavršavanjima koja se mogu grupirati u nekoliko osnovnih skupina.

Kako je jedna od temeljnih misija HGI-CGS-a geološko kartiranje različitih namjena i mjerila, djelatnici svih triju zavoda usavršavali su se u korištenju geografskih informacijskih sustava u prostornim analizama, izradi tematskih karata te digitalnoj kartografiji. Osim toga, za potrebe kartografije djelatnici su se usavršavali i u korištenju grafičkih alata. Za suvremena istraživanja potrebni su i napredni specijalistički programi različite namjene (interpretacija seizmičkih i bušotinskih podataka, geološko modeliranje i rekonstrukcija, simulacije toka fluida i topline) te se edukacija odvijala usporedno s nabavom pojedinih softvera (ShapeMetrix3D, MOVE, Petrel, FEFLOW).

U skladu s tematskom usmjerenošću pojedinih zavoda, djelatnici su se usavršavali u mnogobrojnim disciplinama. U ZG TO su bile teme istraživanja foraminifera, ostrakoda, palinomorfa, stabilnih izotopa i morskih paleookoliša. U ZGHIG najvažnije su teme bile inženjerskogeološka istraživanja u tunelima, hidrogeološko modeliranje u krškim terenima ili vodonosnicima



Analiza geokemijskog sastava jezgri sedimenata pomoću XRF-a (core scanner) u MARUM centru u Bremenu (foto I. Razum)  
Chemical analysis of sediment cores by XRF (core scanner) at MARUM centre in Bremen (photo by I. Razum)

During the last 10 years, researchers from the Croatian Geological Survey (HGI-CGS) participated in numerous specialisations that can be categorised into several basic groups.

Because geological mapping for different purposes and at different scales is one of the core missions of the HGI-CGS, the employees of all three departments specialised in the use of geographic information systems for spatial analyses, the creation of thematic maps, and digital cartography. In addition, for the purposes of cartography, the employees also specialised in the use of graphic tools. Modern research requires advanced specialised software for different purposes (interpretation of seismic and borehole data, geological modelling and reconstruction, fluid flow and heat simulations). Thus, the education and training has been carried out in parallel with the procurement of specific software (ShapeMetrix3D, MOVE, Petrel, FEFLOW).

The researchers specialised in many disciplines in line with the thematic orientation of individual departments. In the Department of Geology, researchers were specialised in foraminifera, ostracods, palynomorphs, stable isotopes, and marine paleo-environment research. In the Department of Hydrogeology and Engineering Geology, researchers specialised in engineering-geological research of tunnel construction, hydrogeological modelling in karst and fracture porosity aquifers, advanced landslide research, and research related to statistical data processing and databases. Finally, researchers of the Department of Mineral Resources specialised in the analyses of clay minerals, SEM microscopy, and processing of sediment cores obtained by drilling into the ocean floor. In order to better understand regional relations, the researchers of all departments participated in a workshop on geodynamics and evolution of the Pannonian Basin.

Many courses were directly linked to newly-acquired equipment. These trainings were connected to the procurement of every more complex apparatus for hydrochemical and engineering geological laboratory. They were also necessary for unmanned aerial vehicles utilization and for the acquired equipment for geo-



Obuka za provođenje seizmičkih istraživanja  
Seismic exploration training

pukotinske poroznosti, napredne metode izučavanja klizišta, te teme vezane uz statističku obradu podataka i baze podataka. U ZMS najznačajnije su bile teme analize minerala glina, SEM mikroskopije i obrade jezgri sedimenata dobivenih bušenjem oceanskog dna. Djelatnici svih zavoda su u svrhu boljeg shvaćanja regionalnih odnosa sudjelovali na radionici o geodinamici i evoluciji Panonskog bazena.

Veliki je broj tečajeva izravno povezan s novonabavljenom opremom. Te su edukacije vezane uz svaki složeniji uređaj iz laboratorijskog hidrokemikaljnog i inženjerskog geološkog laboratorija, trening za korištenje bespilotnih letjelica i svake od nabavljenih geofizičkih metoda (plitka seizmika, električna tomografija i (audio) magnetotellurika, višesnopni dubinomjer).

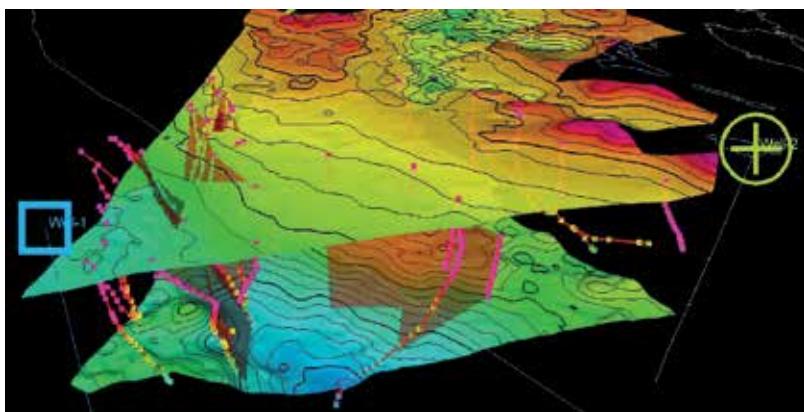
Brojni su zaposlenici učili strane jezike, najviše engleski, ali i talijanski, njemački i ruski, te se usavršavali u specifičnim vještinama poput normiranja laboratorijskih prijave i implementacije projekata. Veliki je broj položio stručni ispit čime su osposobljeni za samostalno bavljenje geološkim istraživanjima.

Uza sve to, istraživači HGI-CGS-a sudjelovali su u radu stotina konferencijskih skupova i radionica te se time dodatno usavršavali u prezentirajujući rezultata istraživanja, te uspostavljali kontakte za buduće projekte. Treba naglasiti kako HGI-CGS kontinuirano učestvuje i u školovanju tehničkog i administrativnog osoblja.

physical research (for shallow seismic, electrical tomography and (audio) magnetotellurics, and the multibeam echosounder).

Numerous employees have mastered foreign languages, mostly English, but also Italian, German, and Russian. Furthermore, employees have specialised in specific skills such as standardising the laboratory facilities, as well as in project application and implementation. A large number of employees passed the state licence exam, allowing them to work as independent engineers in geological explorations.

Moreover, researchers from the HGI-CGS participated in hundreds of conferences, meetings, and workshops, further improving their presentation skills of research results and establishing contacts for future projects. It should be emphasized that the HGI-CGS is also continuously investing in the education of technical and administrative staff.



Primjer strukturno-stratigrafske interpretacije bušotinskih i 2D seizmičkih podataka na području sjevernog Jadrana. Vidljivi su pojedinačni rasjedi (ružičaste linije) te seizmički horizonti koji prikazuju kompleksnu morfologiju i strukturalni sklop krovine i podine karbonata (3D rekonstrukcija izrađena upotrebom akademске licence softvera Schlumberger Petrel 2017) (izradio M. Šepić)

An example of the structural-stratigraphic interpretation of well and 2D seismic data in the Northern Adriatic area. Individual faults (pink lines) and seismic horizons show the complex morphology and structure of the base and top of the carbonate complex (3D reconstruction performed using academic license of Schlumberger Petrel 2017 software) (prepared by M. Šepić)

# Međunarodna mobilnost

## International Mobility

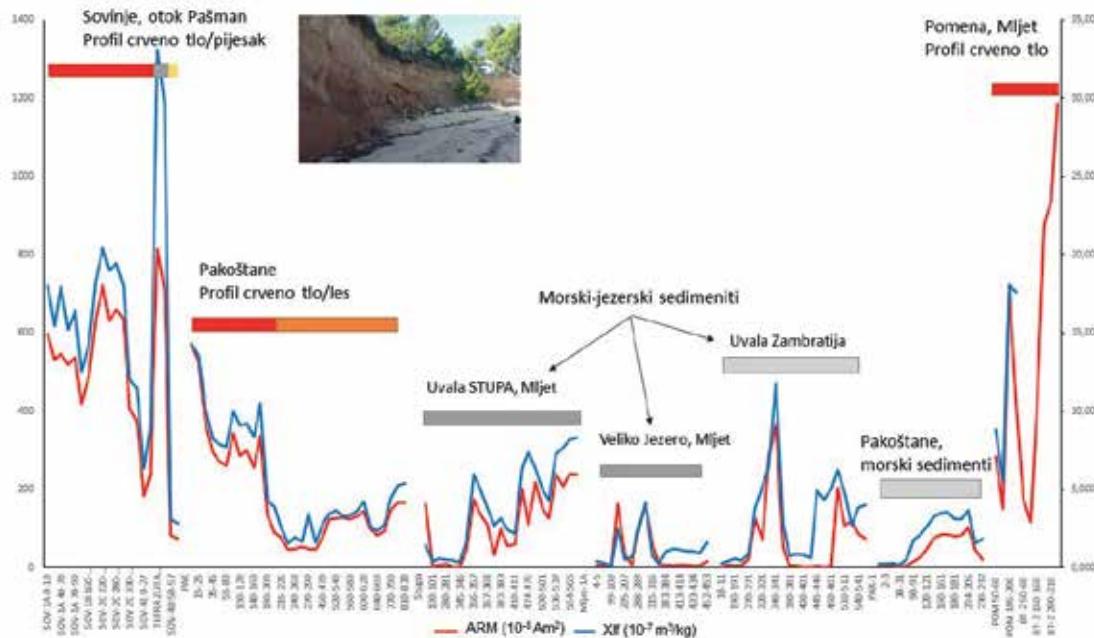
Autori teksta / Authors of the text: dr. sc. **Nikolina ILIJANIĆ**, dr. sc. **Duje KUKOČ**, dr. sc. **Ivan MIŠUR**, dr. sc. **Lara WACHA**, dr. sc. **Staša BOROVIĆ**

U programima međunarodne istraživačke mobilnosti je tijekom zadnjeg desetljeća sudjelovalo četvero djelatnika HGI-CGS-a u svojstvima doktoranada i/ili poslijedoktoranada.

Putem doktorskih i postdoktorskih stipendija L. Wache, prilikom istraživanja kvarternih naslaga počelo se sustavno koristiti datiranje sedimenata metodom optički stimulirane luminescencije te je ostvarena uspješna suradnja s institutom Leibniz-Institut für Angewandte Geophysik u Hanoveru (Njemačka) i National Taiwan University u Taipeiju (Tajvan). Suradnja je rezultirala brojnim publiciranim radovima u međunarodno priznatim znanstvenim časopisima te prijavom nekoliko projekata, a postoji i inicijativa da se u HGI-CGS osnuje laboratorij za tu metodu.

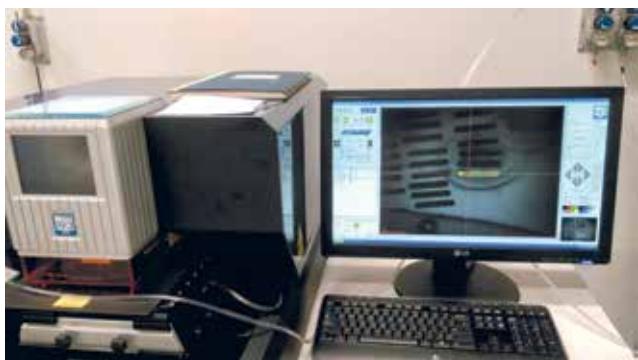
Four employees of the Croatian Geological Survey (HGI-CGS) took part in programmes of international research mobility as PhD candidates and/or Post-Doc researchers.

With the support of PhD and Post-Doc scholarships of L. Wacha, the systematic method of dating sediments by optically stimulated luminescence has been initiated during the research of Quaternary deposits, and a successful co-operation has been established with the Leibniz-Institute for Applied Geophysics in Hanover (Germany) and the National Taiwan University in Taipei (Taiwan). The co-operation resulted in numerous published papers in internationally acclaimed scientific journals and in the implementation of several projects, with the initiative to establish a laboratory employing this method in the HGI-CGS.



Prikaz razlike u vrijednostima magnetskih parametara (ARM i Xlf) za različite sedimente sekvence (crvena tla, les, pijesci, morski i jezerski sedimenti) (priredila N. Ilijanić)

Display of the difference in magnetic parameter values (ARM and Xlf) for different sediment sequences (red soils, loess, sands, marine, and lake sediments) (prepared by N. Ilijanić)

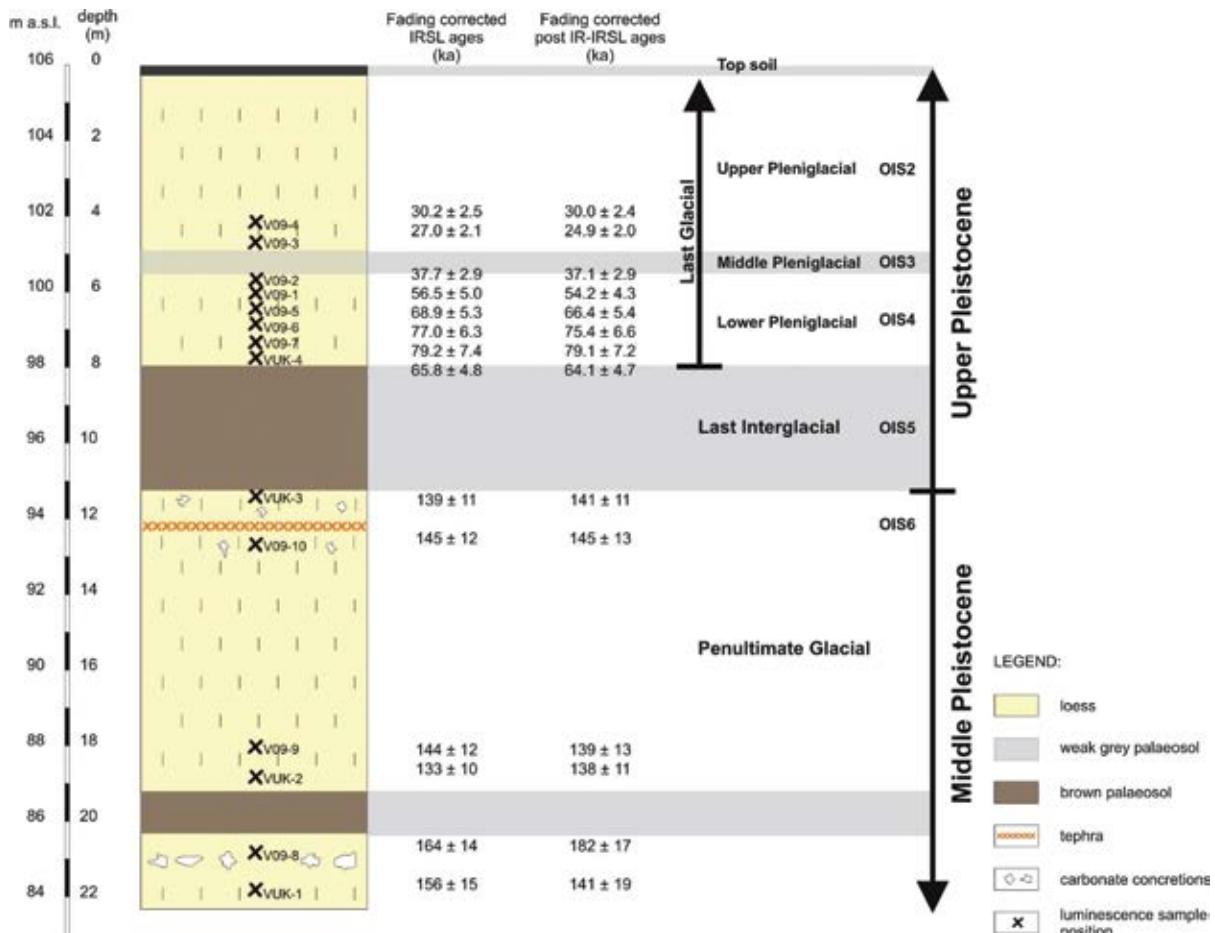


Fotografija *in situ* mjerenja na cirkonima iz uzorka metasedimente stijene Medvednice. Mjerjenje se vrši na LA-MC-ICP-MS instrumentariju na Tehničkom Sveučilištu u Grazu (foto I. Mišur)

„In situ“ measurements of the zircons from the sample of metasediment from Medvednica Mt. Measurements were performed at the Graz University of Technology on LA-MC-ICP-MS instrumentation

The collaboration of the HGI-CGS with the University of Vienna (Laboratory for Geochronology), under the research scholarship of I. Mišur, enabled the mastering and application of laser ablation multi-collector inductively coupled plasma mass spectrometry (LA-MC-ICP-MS) for dating of metasedimentary rocks. Furthermore, new knowledge has been gained on the methods of analysis of acquired data, as well as experience on thermodynamic modelling of associations of mineral phases. During the stay in Vienna, the researchers could attend lectures of renowned European geologists and exchange experiences with colleagues from all over the world. This also provided an opportunity to learn and work in one of the most modern laboratories for geochronology in Europe.

PhD candidate N. Ilijanić was awarded a scholarship to conduct scientific research in British universities. She conducted her PhD studies in the renowned centre for environmental magnetism,



Stratigrafija Gorjanovićevog prapornog profila u Vukovaru bazirana na korigiranim IRSL i post-IR IRSL podacima starosti (Wacha i Frechen, 2011). Datirana su izvršena u Leibniz institutu za primjenjenu geofiziku u Hanoveru

The stratigraphy of the Gorjanović loess section based on fading corrected IRSL and post-IR IRSL dating results (figure from Wacha & Frechen, 2011). Measurements were performed at the Leibniz Institute for Applied Geophysics in Hanover, Germany

Suradnja HGI-CGS-a sa Sveučilištem u Beču (laboratorij za geokronologiju) kroz istraživačku stipendiju I. Mišura, omogućila je savladavanje i primjenu LA-MC-ICP-MS-a za datiranje metasedimentnih stijena. Također, stekla su se nova saznanja o metodama analize dobivenih podataka, kao i iskustvo u termo-dinamskom modeliranju zajednice mineralnih faza. Tijekom boravka u Beču bilo je moguće prisustvovati predavanjima renomiranih europskih geologa i razmjenjivati iskustva s kolegama iz cijelog svijeta. To je bila prilika za učenje i rad u jednom od najmodernijih laboratorijskih zgrada za geokronologiju u Europi.

Doktorandica N. Ilijanić dobila je stipendiju za znanstveno istraživanje na britanskim sveučilištima. Iskoristila ju je u renomiranom centru za okolišni magnetizam, Lancaster Environment Centru Sveučilišta u Lancasteru, pod mentorstvom profesorice Barbare Maher. Tijekom studijskog boravka izvršila je mjerjenja magnetskih svojstava sedimenata i tala, na temelju kojih je utvrđivala prisutnosti pojedinih magnetičnih minerala. Rezultate istraživanja magnetske mineralogije koristila je u paleookolišnim istraživanjima uvjeta taloženja tijekom kasnog pleistocena i holocena u jezerskim i morskim sedimentima i utvrđivanju porijekla materijala, i rezultati će biti objavljeni u znanstvenim radovima. Navedena stipendija omogućila je uspostavljanje suradnje s profesoricom Maher te je nakon toga kolegica višekratno posjetila laboratorij, što će se nastaviti i u budućnosti.

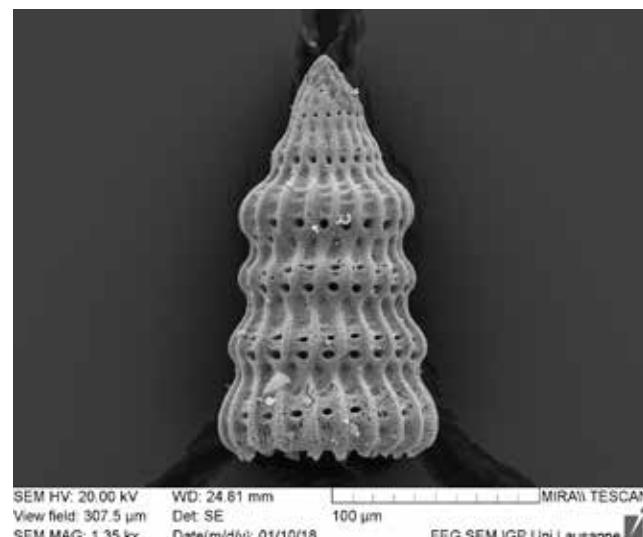
Poslijedoktorand se usavršavao na Sveučilištu u Lozani (Švicarska), radeći na reviziji taksonomije pojedinih gornjokrednih radiolarijskih taksona, te njihovih stratigrafiskih raspona. Cilj je bio pridonijeti stvaranju globalno primjenjive radiolarijske zonacije za razdoblje gornje krede. Usavršavanje je financirala Švicarska nacionalna znanstvena fondacija (SNSF). Preliminarni rezultati predstavljeni su na više međunarodnih i nacionalnih kongresa (D. Kukoč).

Cilj HGI-CGS-a je u predstojećem razdoblju povećati broj ovakvih znanstvenih razmjena radi bolje fluktuacije ideja i noviteta u područjima naših istraživanja.

the Lancaster Environment Centre at the University of Lancaster, under the mentorship of prof. Barbara Maher. During the study, she carried out measurements of magnetic properties of sediments and soil, based on which she determined the presence of certain magnetic minerals. She used the results of research of magnetic mineralogy in paleoenvironmental research of sedimentation conditions during the Late Pleistocene and the Holocene in lake and marine sediments, and in the determination of the origin of materials. The results are to be published in numerous scientific papers. This scholarship enabled the establishment of cooperation with prof. Maher, and the PhD candidate has subsequently visited the laboratory several times and will continue to do so in the future.

Another Post-Doc researcher, D. Kukoč, specialised in the revision of taxonomy of certain Upper Cretaceous radiolarian taxa and their stratigraphical ranges at the University of Lausanne (Switzerland). The aim was to contribute to the establishment of a globally applicable radiolarian zoning for the Upper Cretaceous period. This endeavour was financed by the Swiss National Science Foundation (SNSF). Preliminary results have been presented at several international and national congresses.

The aim of the HGI-CGS is to increase the number of such scientific exchanges in the upcoming period for a better exchange of ideas and novelties in our research areas.



Radiolarija *Dictyomitria torquata* Foreman, kampan, zaljev San Miguel, Panama (foto D. Kukoč)  
Radiolarian species *Dictyomitria torquata* Foreman, Campanian, San Miguel Gulf, Panama

# Popularizacija geologije

## Popularisation of Geology

Autor teksta / Author of the text: dr. sc. **Tonći GRGASOVIĆ**

Hrvatski geološki institut veliku pažnju obraća popularizaciji geologije te su ovdje izdvojene samo najznačajnije aktivnosti.

Aktivnost s najvećim brojem sudionika je „Upoznaj zemlju, zaviri u mikroskop“ koju je, u okviru Hrvatskog geološkog društva, osmisnila Lidija Galović iz našeg Instituta. Geolzi posjećuju osnovne i srednje škole i, uz pomoć uzoraka fosila, minerala i stijena, djecu upoznaju s geologijom. Slične akcije posjeta osnovnim školama održane su na Korčuli, u Krasnom, Virju, Vukovaru i Zagrebu. Spomenimo i sudjelovanje na znanstvenim piknicima u Zagrebu i Rijeci.

Zalaganjem Josipa Halamića, Mirka Belaka i suradnika utemeljena je Geološka zbirka Zadarske županije u OŠ Bartula Kašića i izdana bogato ilustrirana knjiga. Zbirka je uspostavljena i u OŠ Zrinskih i Frankopana u Otočcu.

Nisu zaboravljeni ni najmlađi, pa je tako napravljena geološka radionica u Eko-vrtiću Sisak Stari.

Pojedini zaposlenici HGI-CGS-a, najčešće u sredina gdje žive, ali i drugdje, održali su brojna predavanja i radionice za djecu i odrasle, vrtiće, škole, članove različitih društava i ustanova ili



S akcije „Upoznaj zemlju, zaviri u mikroskop“

From the “Meet the Earth – peek into the microscope!” action



Geološka zbirka Zadarske županije u OŠ Bartula Kašića  
Geological collection of the Zadar County in the Bartul Kašić elementary school

The Croatian Geological Survey (HGI-CGS) puts significant efforts into the promotion of geology, and only the most significant activities are featured in this text.

The activity with the largest number of participants is “Meet the Earth – peek into the microscope!”, devised within the Croatian Geological Society by Lidija Galović from our Institute. In this activity, geologists visit elementary and high schools, teaching children about geology with the help of fossil, mineral, and rock samples. Similar visits to primary schools were held on the island of Korčula, in Krasno, Virje, Vukovar, and Zagreb. Scientific picnics were part of the efforts, held in Zagreb and Rijeka.

Josip Halamić, Mirko Belak, and associates founded the Geological collection of the Zadar County in the Bartul Kašić elementary school and published a richly illustrated book as part of this project. A collection has also been founded in the Zrinski and Frankopani elementary school in Otočac.

Even the youngest children were not neglected, with a geological workshop held in the Eko-kindergarten Sisak Stari.

lokalne zajednice, bilo da se radi o upoznavanju s osnovama geologije, prezentaciji tema vezanih za obližnje geološke lokalitete, kao npr. na Braču, u Čakovcu, Hvaru, Zagrebu i drugdje ili prezentaciji izrađenih stručnih elaborata (o rezervama mineralnih sirovina, zonama sanitарне заštite izvorišta, geotermalnom potencijalu i sl.).

Tonći Grgasović organizirao je tečaj Geologija za planinare u četiri planinarska društva u Zagrebu i Makarskoj.

Neki projekti predviđeli su diseminaciju znanja, kao što su GEOSEKVA (Dubrovnik, Rijeka, Zadar), CAMARO-D i PROLINE-C (Karlovac, Ivanić Grad, Zagreb), SAPIQ (Đurđevac, Krasno), GeoMapping (Čakovec, Knin, Osijek, Zadar, Zagreb).

Djelatnici instituta su više puta nastupili i na televiziji, manje na radiju, uglavnom u vezi tema i projekata iz geološkog inženjerstva, a neke vijesti te spoznaje iz elaborata i znanstvenih radova prenijele su i novinske kuće.

Uvriježila se i praksa prezentiranja izdanih osnovnih geoloških karata, pa su tako održane prezentacije na Visu, Cresu, Hvaru, Braču i u Splitu.

Izdvojimo i radove na uspostavi i međunarodnoj verifikaciji geopolarka Viški arhipelag u Komiži, gdje je bio angažiran Tvrtko Korbar.

U okviru projekta OneGeology, uz geološku kartu, napravljen je simpatična internetska stranica s osnovnim geološkim pojmovima za djecu.



Geološka radionica u Eko-vrtiću Sisak Stari.  
Geological workshop in the Sisak Stari Eko-kindergarten



Geologija za planinare

Geology for hikers

Individual HGI-CGS employees have, mostly in their own surroundings, but also elsewhere, held numerous lectures and workshops for children and grownups, in kindergartens, schools, for members of various societies and institutions, or local communities, in the forms of introductions to the basics of geology, presentations of topics connected with nearby geological sites, e.g. on the island of Brač, in Čakovec, Hvar, Zagreb, or elsewhere, or presentations of professional reports (with regard to mineral resource reserves, sanitary protection zones of water supply sources, geothermal potential, etc.).

Tonći Grgasović held a course titled "Geology for hikers" at four hiking clubs in Zagreb and Makarska.

Some projects envisaged dissemination of knowledge, such as the GEOSEKVA (Dubrovnik, Rijeka, Zadar), CAMARO-D and PROLINE-C (Karlovac, Ivanić Grad, Zagreb), SAPIQ (Đurđevac, Krasno), and GeoMapping (Čakovec, Knin, Osijek, Zadar, Zagreb).

The employees of HGI-CGS appeared on TV at numerous occasions, less frequently on the radio, mostly regarding topics and projects in geological engineering, while some news and findings from reports and scientific papers were also communicated by newspapers.

The practice of presenting published basic geological maps also became common, with presentations held on Vis, Cres, Hvar and Brač islands, and in the city of Split.

Efforts on the establishment and international verification of the Vis archipelago geopark in Komiža, where Tvrtko Korbar was engaged, should also be highlighted.

As part of the OneGeology project, a website has been published containing basic geological terms for children, alongside a geological map.

# Suradnja sa sveučilištem

## Collaboration with the University

Autorica teksta / Author of the text: dr. sc. **Staša BOROVIĆ**

Znanstvenici HGI-CGS-a su u proteklom desetljeću održavali i razvijali suradnju sa sveučilištima u obliku nastave, mentorstva i suradnje u sklopu različitih vrsta projekata.

U nastavi je sudjelovalo jedanaestero istraživača na tri fakulteta Sveučilišta u Zagrebu: Prirodoslovno-matematičkom fakultetu (Geološki odsjek), Rudarsko-geološko-naftnom fakultetu te Građevinskom fakultetu. Jedan je znanstvenik na taj način izabran u naslovno zvanje redovitog profesora te troje u zvanje naslovnih docenata. Ostali su znanstvenici sudjelovali u izvođenju nastave u funkciji gostujućih predavača, od čega je većina pokrivala cijele kolegije te su zahvaljujući tom angažmanu trenutno u fazi izbora u znanstveno-nastavno zvanje naslovnih docenata. Također, neki su istraživači HGI-CGS-a dugogodišnji povremeni sudionici nastave, gdje predstavljaju studentima procese izrade osnovnih karata (temeljne projekte HGI-CGS-a). Neki od ovih angažmana

During the past decade, scientists from the Croatian Geological Survey (HGI-CGS) have been maintaining and developing collaborations with universities by teaching, mentoring, and collaboration within a variety of projects.

Eleven researchers participated in teaching at three faculties of the University of Zagreb: the Faculty of Science (Department of Geology), the Faculty of Mining, Geology and Petroleum Engineering, and the Faculty of Civil Engineering. One scientist has since been appointed as a tenured professor and three as assistant professors. Other scientists participated in the teaching as guest lecturers. Most of them covered entire courses and owing to this engagement, they are currently in the phase of being granted the title of a titular assistant professor. Moreover, some of the researchers from the HGI-CGS participate in long-time occasional teaching, where they present students with the process of making basic maps, which constitute the main projects of the

HGI-CGS. Some of these engagements exceed a decade, but most often last about five years. Collaboration with the Faculty of Civil Engineering has been established over the past two years and a continuation of the lecturers' work from the HGI-CGS is expected, in order to improve the future designers' knowledge of geological principles in various geotechnical interventions.

The subjects of the courses held by HGI-CGS scientists can also be categorized according to the Institute's orientation towards fundamental and applied research. Among the courses on geoscientific subjects, employees of HGI-CGS have taught geological mapping, the geology of the Republic of Croatia, technical petrography, and methods of paleontological research. Among the courses on applied geology, they have



Studenti Prirodoslovno-matematičkog fakulteta Sveučilišta u Zagrebu na geološkom kartiranju kod Žaborića (foto J. Halamić)

Students of the Faculty of Science (Department of Geology) during fieldwork in geological mapping in Žaborić (photo by J. Halamić)

i premašuju opseg proteklog desetljeća, a većinom se kreću oko pet godina. Suradnja s Građevinskim fakultetom je uspostavljena u posljednje dvije godine te se očekuje nastavak rada predavača iz HGI-CGS-a kako bi se unaprijedilo poznavanje geoloških zakonitosti kod budućih projektanata različitih geotehničkih zahvata.

Tematike kolegija koje predaju znanstvenici HGI-CGS-a mogu se, u skladu s usmjerenosću instituta na temeljna i primijenjena istraživanja, također grupirati na taj način. Od kolegija geoznanstvene tematike, djelatnici HGI-CGS-a su izvodili nastavu iz geološkog kartiranja, geologije RH, tehničke petrografije i metoda paleontoloških istraživanja. Inženjerska geologija, hidrogeologija i geologija rudnih ležišta su teme koje su naši znanstvenici pokrivali iz područja primijenjene geologije.

S obzirom na znanstveno-nastavna zvanja i dugogodišnje stručno i znanstveno iskustvo, kolege i kolege su sudjelovali u procesu visokog obrazovanja i kao mentori i komentori s po-djednakom učestalošću. Tijekom proteklih deset godina petero znanstvenika je (ko)mentoriralo 28 ocjenskih radova, od čega je deset doktorskih disertacija, a ostatak su završni i diplomski radovi. Najčešće su teme radova bile rekonstrukcija paleookoliša i inženjerska geologija, a ostale uključuju regionalnu geologiju, sedimentologiju, paleontologiju, geochemiju, mineralogiju i petrografiju.

Osim suradnje u preddiplomskoj, diplomskoj i poslijediplomskoj nastavi, HGI-CGS sa sveučilištima surađuje i u sklopu znanstvenih i stručnih projekata opisanih u poglavljvu „Projekti“ (GEOSEKVA, TRANITAL, ISSAH, LoLADRIA financirani od strane HRZZ-a, kao i drugi kompetitivni i komercijalni projekti).



Terenska nastava sa studentima Građevinskog fakulteta Sveučilišta u Zagrebu na velikom klizištu u Hrvatskoj Kostajnici (foto I. Kosović)  
Fieldwork with the students from the Faculty of Civil Engineering at the large landslide in Hrvatska Kostajnica (photo by I. Kosović)



Terenska vježba studenata Prirodoslovno-matematičkog fakulteta Sveučilišta u Zagrebu u kamenolomu Hruškovec na Kalniku (foto J. Halamić)

Field excercise of the students of the Faculty of Science (Department of Geology) in Hruškovec quarry on the Kalnik Mt. (photo by J. Halamić)

taught engineering geology, hydrogeology, and geology of mineral deposits.

Owing to the obtained titles in scientific teaching and the long-time professional and scientific experience, HGI-CGS scientists have participated in the process of higher education as mentors and co-mentors at equal frequency. During the past ten years, five scientists have (co)mentored 28 theses, 10 of which were doctoral dissertations and the rest were bachelor and master theses. The most common subjects of the theses were the reconstruction of paleoenvironments and engineering geology, while others included regional geology, sedimentology, paleontology, geochemistry, mineralogy, and petrography.

In addition to the participation in undergraduate, graduate and postgraduate courses, the HGI-CGS cooperates with universities in the scientific and professional projects described in the "Projects" section (projects GEOSEKVA, TRANITAL, ISSAH, LoLADRIA, funded by the Croatian Science Foundation, as well as other competitive and commercial projects).

# Nabavljena laboratorijska oprema

## Acquired Laboratory Equipment

<https://sestar.irb.hr/>

U Hrvatskom geološkom institutu (2009–2018) uz već postojeću kapitalnu opremu – rendgenski difraktometar PANalytical X'Pert Powder i atomski apsorpcijski spektrometar PerkinElmer AA-*Analyst* 700, nabavljena je sljedeća laboratorijska oprema:

1. Analizator za stabilne izotope, Picarro L2130-i,
2. TOC analizator, QbD1200,
3. Laserski difraktometar, Shimadzu
4. Pretražni elektronski mikroskop, JEOL JSM-35 CF i
5. Analizator dušika i ugljika, Thermo Fisher Scientific Flash 2000,

te je 2009. godine je utemeljen Inženjerskogeološki laboratorij.

Analizator za stabilne izotope i TOC analizator su uvelike unaprijedili hidrogeološka istraživanja, laserski difraktometar ubrzao granulometrijsko određivanje veličine čestica u sedimentima dok je analizator dušika i ugljika omogućio rutinsko određivanje njihovog udjela u sedimentima i tlu. Snimanje i analiza uzorka pomoću pretražnog elektronskog mikroskopa našli su primjenu u paleontološkim i mineraloškim istraživanjima, ali i istraživanju mikrotekstura i struktura različitih vrsta



Analizator za stabilne izotope

Stable isotope analyser

Alongside the existing capital equipment – the PANalytical X'Pert Powder X-ray diffractometer and the PerkinElmer AA-*Analyst* 700 atomic absorption spectrometer, the following laboratory equipment has been acquired by the Croatian Geological Survey (2009 – 2018):

1. Stable isotope analyser, Picarro L2130-i,
2. TOC analyser, QbD1200,
3. Laser diffractometer, Shimadzu,
4. Scanning electron microscope, JEOL JSM-35 CF and
5. Nitrogen and carbon analyser, Thermo Fisher Scientific Flash 2000.

In 2009, the engineering-geological laboratory was founded.

The stable isotope analyser and the TOC analyser have greatly enhanced hydrogeological research, and the laser diffractometer has accelerated granulometric determination of particle sizes in sediments. Meanwhile, the nitrogen and carbon analyser have enabled routine determination of their share in sediments and soil. The recording and analysis of samples using a scanning electron microscope has found its application in paleontological and mineralogical research, but also in the research of micro textures and structures of various rock types, while the X-ray diffractometer and the atomic absorption spectrometer have become indispensable in the analysis of mineral and chemical compositions of samples investigated in the HGI-CGS.

What follows is a short overview of the acquired and existing laboratory equipment.

### Stable isotope analyser, Picarro L2130-i

The stable isotope analyser is a laboratory instrument for measuring the ratio of oxygen and hydrogen stable isotopes in water. It uses a laser to excite electrons within the atoms and by measuring the differences in energy levels, determines the isotope ratio. The narrower fields of this application are hydrogeological and isotope researches. The instrument was purchased using the

stijena, dok su rendgenski difraktometar i atomski apsorpcioniski spektrometar postali neizostavni u metodi analize mineralnog i kemijskog sastava uzorka koji se istražuju u HGI-CGS-u.

Slijedi kratki prikaz navedene nabavljene i postojeće laboratorijske opreme.

### **Analizator za stabilne izotope, Picarro L2130-i**

Analizator za stabilne izotope je laboratorijski uređaj za mjerjenje omjera stabilnih izotopa kisika i vodika u vodi. Pomoću lasera pobuđuje elektrone u atomima te mjeranjem razlike u energiji određuje omjer izotopa. Uža područja primjene su: hidrogeološka/izotopna istraživanja. Instrument je nabavljen sredstvima Europske komisije (85% iznosa) i HGI-CGS-a (15% iznosa) u sklopu projekta DRINKADRIA, IPA Adriatic Cross Border Cooperation Programme 2007–2013.

### **TOC analizator, QbD1200**

TOC analizator je laboratorijski uređaj za mjerjenje ukupnog i otopljenog organskog ugljika (TOC, DOC) i ukupnog i otopljenog anorganskog ugljika (TIC, DIC) u vodi, s automatskim uzorkivačem. Instrument najprije pomoću kiseline  $H_3PO_4$  zakiseli uzorak pretvarajući anorganski ugljik u  $CO_2$ , te mjeri TIC. Zatim se u prisutnosti UV zračenja i snažnog oksidansa  $(NH_4)_2S_2O_8$  organski ugljik oksidira u ugljični dioksid te se pomoću nedisperzivnog infracrvenog detektora mjeri sav  $CO_2$ . Uređaj detektira  $CO_2$  signal i prikazuje ga u obliku krivulje. Područje ispod krivulje predstavlja vrijednosti TOC. Uža područja primjene su hidrogeološka/kemijska istraživanja. Instrument se koristi i za analiziranje TOC-a u otpadnim vodama. Instrument je nabavljen u sklopu projekta TRANITAL financiranog od strane Hrvatske zaklade za znanost.

### **Laserski difraktometar, Shimadzu**

Laserski difraktometar služi za mjerjenje veličine čestica u otopini (mjerjenje veličine čestica sedimenata i čestica u vodi). Pri mjerenu koristi laser valne duljine 680 nm. Kada se zraka svjetlosti sudari sa česticom, djelomično se apsorbira, a djelomično difraktira. Nastaje niz refleksa uvjetovanih veličinom mjerениh čestica u uzorku ili otopini u kojoj je uzorak raspršen. Raspršena zraka detektira se na 78 koncentričnih detektorskih elemenata senzora te još pet detektora koji mjere povratno raspršenje, i jedan detektor bočno. Uređaj ima raspon mjerena od 0,017 do 2500  $\mu\text{m}$ . Za mjerjenje je potrebno 0,1–0,3 g uzorka.



TOC analizator (uređaj za mjerjenje TOC, DOC, TIC i DIC u vodi s automatskim uzorkivačem)

TOC analyser (device for measuring TOC, DOC, TIC and DIC in water with automatic sampler)

funds from the European Commission (85 %) and HGI-CGS (15 %) as a part of the DRINKADRIA project, IPA Adriatic Cross Border Co-operation Programme 2007–2013.

### **TOC analyser, QbD1200**

The TOC analyser is a laboratory device for measuring total and dissolved organic carbon (TOC and DOC), and total and dissolved inorganic carbon (TIC and DIC) in water, with an automatic sampler. The instrument acidifies the sample with  $H_3PO_4$ , thereby converting the inorganic carbon to  $CO_2$  and measures TIC. After that it oxidizes the  $CO_2$  in the presence of strong oxidant  $(NH_4)_2S_2O_8$  under the UV light and measures total  $CO_2$  using a non-dispersive infrared detector. The instrument detects the  $CO_2$  signal and displays it in a form of curve. The area below the curve represents the TOC value. The narrower fields of application comprise hydrogeological and chemical investigations. It is also used to analyse TOC in wastewaters. This instrument was purchased as part of the project TRANITAL, financed by the Croatian Science Foundation.

### **Laser diffractometer, Shimadzu**

The laser diffractometer is used for measuring the size of particles in a solution (size measurement of sediment particles and particles in water). It uses laser light of 680 nm wavelength for measurement. When the laser light collides with a particle, it is partially absorbed and partially diffracted. The dispersed ray is detected on the sensor's 78 concentric detector elements and another five de-

Pomoću ćelije za male uzorke („batch cell“) može se mjeriti i manje uzorke. Za izračun raspodjele veličine čestica iz difrakcijskih slika koristi se Fraunhoferova difrakcijska teorija.

### Pretražni elektronski mikroskop, JEOL JSM-35 CF

Hrvatski geološki institut posjeduje iz donacije Zavoda za botaniku i istraživanje biološke raznolikosti Sveučilišta u Beču pretražni elektronski mikroskop JEOL JSM-35 CF sa sistemom scintilator – fotomultiplikator s pojačalom i kolektorom predviđenim tvornički za rezoluciju 60–150 Å i povećanja od 10 do 180.000 puta. Radi na 10 kV i 20 kV u visokom vakuumu i služi za pregledavanje uzorka u čvrstom agregatnom stanju, maksimalne veličine do 76 mm. Uzorci prije snimanja moraju biti napareni zlatom ili ugljikom. Za to se koristi uređaj Balzers Union Sputtering device. Pomoću EDS Oxford X-act 10 mm SDD detektora moguća je i elementna analiza uzorka i semikvantitativna kemijska analiza. Za snimanje u „backscatter“ području koristi se Oxford Link Tetra detektor. Pretražna elektronska mikroskopska analiza omogućava karakterizaciju površine materijala.

### Rendgenski difraktometar, PANalyticalX'Pert Powder

Rendgenski difraktometar koristi se za kvantitativne i kvalitativne rendgenske analize praškastih uzoraka metodom rendgenske difrakcije, a omogućuje određivanje kristalnih struktura, preferiranu orientaciju i debljinu slojeva i određivanje kemijskog sastava. Uređaj je opremljen keramičkom rendgenskom cijevi Cu anode ( $\text{CuK}\alpha$  zračenje valne duljine  $\lambda=1,5405 \text{ \AA}$ ) za stvaranje

tectors that measure the backscatter, as well as one more detector on the side. The device has a measuring range from 0.017  $\mu\text{m}$  to 2500  $\mu\text{m}$ . A sample amount of 0.1–0.3 g is needed for measurement. With a batch cell, smaller samples can also be measured. The Fraunhofer diffraction theory is used for calculating the distribution of particle sizes from diffraction images.

### Scanning electron microscope, JEOL JSM-35 CF

HGI-CGS owns a JEOL JSM-35 CF scanning electron microscope which was a donation from the Department of Botany and Biodiversity Research of the University of Vienna, with the scintillator – photomultiplier system with an amplifier and a collector with a default resolution of 60–150 Å and magnification of 10 to 180,000 times. It operates at 10 kV and 20 kV in high vacuum and serves for analysis of samples in the solid aggregate state, with a maximum size of up to 76 mm. Before analysis, the samples have to be sputtered with gold or carbon. The Balzers Union Sputtering device is used for this purpose. With the help of the EDS Oxford X-act 10 mm SDD detector, elemental sample analysis and semi-quantitative chemical analysis are also possible. The Oxford Link Tetra detector is used for recording in the backscatter area. The scanning electron microscope analysis enables characterisation of a material's surface.

### X-ray diffractometer, PANalyticalX'Pert Powder

The X-ray diffractometer is used for quantitative and qualitative X-ray analyses of powder samples by X-ray diffraction and enables the determination of crystalline structures, preferred orientation and layer thickness, as well as determination of chemical com-



Laserski difraktometar  
Laser diffractometer



Pretražni elektronski mikroskop  
Scanning electron microscope



Rendgenski difraktometar  
X-ray diffractometer

rendgenskog zračenja, vertikalnim goniometrom  $\theta$ - $\theta$  geometrije i PIXcel detektorm. Uža područja primjene su identifikacija i kvantifikacija minerala i istraživanje minerala glina.

### **Atomski apsorpcijski spektrometar, PerkinElmer, AAnalyst 700**

PerkinElmer AAnalyst 700 je atomski apsorpcijski spektrometar s WinLab32 za AA softver. Uredaj ima automatsku zamjenu atomizera, što omogućava prelazak s plamene na grafitnu tehniku i obrnuto pomoću softverskih komandi. Uža područja primjene su u kemiji, geokemiji i hidrogeokemiji za analizu kemijskih elemenata (Na, K, Ca, Mg, Sr, Li, Cr, Fe, Mn, Zn, Cu, Ni, Mo, Co, Cd, Pb, As, Al, Ag, Au, Ba, Se, V, Tl) različitih geoloških materijala (stijene, vode, tla), ali i bioloških materijala.

### **Analizator dušika i ugljika, Thermo Fisher Scientific, Flash 2000 NC Analyzer**

Analizator dušika i ugljika u sprezi s pratećim programom Eager Xperience služi za određivanje ukupnog ugljika (TC) i dušika (TN) u uzorcima sedimenata i tala, te za određivanje ukupnog organskog ugljika (TOC) i ukupnog anorganskog ugljika (TIC).

### **Inženjerskogeološki laboratoriј**

Inženjerskogeološki (IG) laboratoriј financiran je isključivo iz sredstava Zavoda za hidrogeologiju i inženjersku geologiju. Laboratorijska istraživanja usmjerena su na određivanje petro-



Atomski apsorpcijski spektrometar  
Atomic absorption spectrometer

position. The device is equipped with a Cu anode ceramic X-ray pipe (CuK $\alpha$ 1 radiation of  $\lambda = 1.5405 \text{ \AA}$  wavelength) for generating X-ray radiation, a  $\theta$ - $\theta$  geometry vertical goniometer, and a PIXcel detector. The narrower fields of application are identification and quantification of minerals and research of clay minerals.

### **Atomic absorption spectrometer, PerkinElmer, AAnalyst 700**

The PerkinElmer AAnalyst 700 is an atomic absorption spectrometer equipped with WinLab32 for AA software. The device has an automated atomiser changing system, which enables switching from flame to graphite and vice versa by software commands. The narrower fields of application are within chemistry, geochemistry, and hydrogeochemistry, for the analysis of chemical elements (Na, K, Ca, Mg, Sr, Li, Cr, Fe, Mn, Zn, Cu, Ni, Mo, Co, Cd, Pb, As, Al, Ag, Au, Ba, Se, V, Tl) of various geological materials (rocks, water, soils), but also biological materials.

### **Nitrogen and carbon analyser, Thermo Fisher Scientific, Flash 2000 NC Analyzer**

The nitrogen and carbon analyser combined with the accompanying Eager Xperience programme serve to determine total carbon (TC) and nitrogen (TN) in sediment and soil samples, and for the determination of total organic carbon (TOC) and total inorganic carbon (TIC).

grafskih, fizičkih i mehaničkih značajki stijena i tala, s osnovnom namjenom osiguranja kvalitetnih podataka za potrebe znanstveno-istraživačkog rada te gospodarskih projekata.

U sklopu laboratorijskih mogućnosti je obaviti sljedeća ispitivanja za stijene: određivanje jednoosne tlačne čvrstoće, indirektne vlačne čvrstoće (Brazilski test), čvrstoće u točki (PLT) i Schmidtovog odskoka.

### Hidraulična preša, ELE International ADR 2000

Hidraulična preša koristi se za određivanje jednoosne tlačne i indirektne vlačne čvrstoće. Ispitivanje se provodi na uzorcima pripremljenim prema standardu (oblik valjka ili prizme, odnos visine i promjera 2,5-3,0 : 1, promjer oko 54 mm). Opterećenje se nanosi na uzorak koji je smješten između dvije čelične ploče, s konstantnim povećanjem do sloma uzorka. Bilježi se maksimalna sila kod koje je došlo do sloma.

### Uređaj za određivanje čvrstoće u točki (Point Load Test – PLT)

PLT predstavlja indeks čvrstoće koji se određuje postupkom opterećenja u točki. Uređaj za ispitivanje sastoji se od sustava za nanošenje opterećenja, sustava za mjerjenje sile koja je potrebna da se uzorak slomi i sustava za mjerjenje razmaka između dviju točaka na mjestu kontakta uzorka sa šiljcima. Uzorci stijene lome se primjenom koncentriranog opterećenja preko para zaobljenih konusnih šiljaka. Prema obliku uzorka test mo-



Analizator dušika i ugljika  
Nitrogen and carbon analyser

## ENGINEERING-GEOLOGICAL LABORATORY

The engineering-geological (EG) laboratory was financed exclusively by funds from the Department of Hydrogeology and Engineering Geology. Laboratory research is aimed at determining petrographical, physical, and mechanical characteristics of rocks and soils, with the basic purpose of ensuring high-quality data for scientific-research and commercial projects.

The following tests can be carried out for rocks within the laboratory: determination of uniaxial compressive strength, indirect tensile strength (Brazilian test), point load strength test (PLT), and the Schmidt rebound.

### Hydraulic press, ELE International ADR 2000

The hydraulic press is used to determine uniaxial compressive and indirect tensile strength. Testing is carried out on standardized samples (cylinder or prism shape, height and diameter ratio 2.5–3.0 : 1, diameter ca. 54 mm). The load is applied to a sample positioned between two steel plates, and continuously increased until the sample breaks. The maximum force at the breaking point is recorded.

### Device for determining strength at a point (Point Load Test – PLT)

PLT represents a strength index determined by a point load procedure. The testing device consists of a load application system, a system for measuring force necessary for the sample to split, and a system for measuring the distance between two points at the contact position of the sample and spikes. Rock samples are split by application of concentrated load from a pair of rounded conical spikes. Depending on sample shape the test can be diametrical, axial, prismatic, or on an irregularly shaped sample. The PLT can also be carried out in the field.

### Schmidt hammer

The Schmidt hammer is a device used for estimating uniaxial compressive strength of rocks in the laboratory and in the field. Measurement of Schmidt strength is based on the "rebound" principle with elastic mass impact on a flat surface. The weight rebound size is measured.

With the aim of classifying the soils according to the USCS classification (*Unified Soil Classification System*) in the EG laboratory, the following features can be determined: granulometric compo-



Hidraulična preša (a,b), uređaj za određivanje čvrstoće u točki (c) i Schmidtov čekić (d)  
Hydraulic press (a, b), device for point strength determination (c) and the Schmidt hammer (d)

že biti dijametalni, aksijalni, prizmatični ili na uzorku nepravilnog oblika. PLT je moguće provesti i na terenu.

sition by dry sieving, granulometric composition by areometering, liquid limits by conical penetrometer, plasticity, and density limits of solid particles.

### Schmidtov čekić

Schmidtov čekić je uređaj koji se koristi za procjenu jednoosne tlačne čvrstoće stijena u laboratoriju i na terenu. Mjerjenje Schmidtove čvrstoće zasniva se na principu "odskoka" pri udaru elastične mase na neku ravnu površinu. Pri tome se mjeri veličina odskoka utega.

Za klasifikaciju tala prema USCS klasifikaciji (*Unified Soil Classification System*) u IG laboratoriju moguće je odrediti: granulometrijski sastav suhim sijanjem, granulometrijski sastav areometriranjem, granice tečenja konusnim penetrometrom, granice plastičnosti i gustoće čvrstih čestica.



Određivanje granulometrijskog sastava suhim sijanjem (a), određivanje granulometrijskog sastava areometriranjem (b), određivanje granice tečenja konusnim penetrometrom (c), određivanje granice plastičnosti (d) i određivanje gustoće čvrstih čestica (e)

Determination of granulometric composition by dry sieving (a), determination of granulometric composition by areomterizing (b), determination of liquid limits by conical penetrometer (c), determination of plasticity limits (d) and determination of solid particle density (e)

# Nabavljena oprema za *in situ* uzorkovanja i mjerjenja

## Acquired Equipment for In Situ Sampling and Measurements

<https://sestar.irb.hr/>

U posljednjih deset godina značajno su osvremenjene metode uzorkovanja i mjerjenja te je nabavljena brojna oprema za *in situ* rad. Ističu se plutajuća istraživačka platforma, set Eijkelkamp za udarno bušenje heterogenih tala, bušilica za uzmajanje i oblikovanje cilindričnih uzoraka stijena i potopna crpka namijenjena za crpljenje i uzorkovanje podzemne vode u bušotinama.

### Platforma Q2

Plutajuća istraživačka platforma dimenzija 3x4 m s tronožnim tornjem (Uwitec) i tri vitla koristi se za jezgrovanje jezerskih, morskih ili riječnih nekonsolidiranih sedimenata. Uzorkovanje se izvodi pomoću klipnog jezgrila duljine 2 ili 3 m, promjera unutarnje cijevi 60 mm. Za uzorkovanje se može koristiti i gravitacijsko jezgrilo duljine do 150 cm ili Van Veenovo grabilo. S ovom platformom moguće je uzorkovanje na dubini do 70 m vodenog stupca. Platforma je mobilna, može se transportirati na prikolici i pokretati vanbrodskim motorom ili vući čamcem.

### Set Eijkelkamp za udarno bušenje heterogenih tala

Set za udarno bušenje upotrebljava se za uzorkovanje neporemećenih kontinuiranih uzoraka tla do dubine 15 m. Set se sastoji od benzinske udarne bušilice (Atlas Copco Cobra TT), sustava jezgrila i bušaćih šipki, te patenta za izvlačenja kolone iz bušotine. U setu su jezgrila promjera 10 cm duljine 50 cm i 100 cm, jezgrilo duljine 200 cm promjera 50 cm, te jezgrilo duljine 100 cm s unutarnjom plastičnom cijevi za uzorkovanje slabo konsolidiranog (rastresitog, jako vlažnog) tla.

In the past ten years, sampling and measurement methods have been significantly modernised, and a lot of equipment for *in situ* work has been purchased. A floating research platform, an Eijkelkamp set for impact drilling of heterogeneous soils, a drill for collecting and forming cylindrical rock samples, and a submersible pump intended for pumping and sampling of groundwater from drilled wells stand out among the equipment.

### Q2 platform

The floating research platform of 3 x 4 m with a tripod tower (Uwitec) and three winches is used for core sampling of lake, marine, or river unconsolidated sediments. Sampling is performed by a 2 m or 3 m long piston corer with a 60 mm inner tube. A gravitational corer up to 150 cm long or a Van Veen grab sampler can also be used. With this platform, sampling at a depth of up to 70 m of water column is possible. The platform is mobile, and it can be transported on a barge and moved with a boat engine or a tugboat.



Plutajuća istraživačka platforma  
Floating research platform



**Set Eijkelkamp za udarno bušenje heterogenih tala**  
Eijkelkamp set for impact drilling of heterogeneous soils



**Udarna bušilica, sustav jezgrila i bušačih šipki**  
Impact drill, corer and drilling bar system



**Terensko bušenje direktno na stijeni**  
Fieldwork drilling directly on a rock

and powered by an outboard engine. It can be transported on a trailer and pulled by a boat.

### Eijkelkamp set for percussion drilling of heterogeneous soils

The percussion drilling set is used for the sampling of undisturbed continuous soil samples up to a depth of 15 m. The set is composed of a petrol percussion drill (Atlas Copco CobraTT), a system of corers and drilling rods, and a system for pulling a core out of a borehole. The set contains corers of 10 cm in diameter and 50 to 100 cm long, a 200 cm long corer with a 50 cm diameter, and a 100 cm long corer with an internal plastic pipe for sampling weakly consolidated (loose, very moist) soil.

### Drill for cylindrical samples, Hilti, DD 120

The drill is intended for collecting and forming cylindrical rock samples, which are required for various laboratory tests. The drilling diameter is 54 – 144 mm. Apart from field drilling directly on a rock, sampling can also be carried out on chosen blocks of rocks, in the field or in a laboratory.

### Submersible pump, Eijkelkamp, MP 1/Redi-Flo2

The submersible pump is intended for the pumping and sampling of groundwater from drilled wells with an internal diameter of at least 50 mm and a depth of up to 60 m. The pump operates



**Bušilica za cilindrične uzorke u laboratoriju**  
Drill for cylindrical samples in a laboratory

## Bušilica za cilindrične uzorke, Hilti, DD 120

Bušilica je namijenjena za uzimanje i oblikovanje cilindričnih uzoraka stijena, kakvi su potrebni za različita laboratorijska ispitivanja. Promjer bušenja je od 54 mm do 144 mm. Osim terenskog bušenja direktno na stijeni, uzorkovanje je moguće provesti i na odabranim blokovima stijena, na terenu ili u laboratoriju.

## Potopna crpka, Eijkelkamp, MP 1/Redi-Flo2

Potopna crpka namijenjena je crpljenju i uzorkovanju podzemne vode u buštinama s unutarnjim promjerom od najmanje 50 mm i do dubine 60 m. Crpka radi preko konvertera u frekvencijskom području od 25 do 400 Hz. Kod 400 Hz, crpka osigurava protok od 1 m<sup>3</sup>/h na 74 m. Veliki kapacitet ove crpke osigurava crpljenje veće količine podzemne vode. Pođešavanje crpke na mali kapacitet omogućava crpljenje vrlo male količine podzemne vode („low flow“) primjerene za uzorkovanje.

Pregled sve ostale opreme Hrvatskog geološkog instituta – laboratorijske, terenske i kabinetske, dostupan je u sklopu Baze podataka instrumenata za znanstvena istraživanja – Šestar (<https://sestar.irb.hr/>).

through a converter in the frequency area of 25–400 Hz. At 400 Hz, the pump operates a 1 m<sup>3</sup>/h flow at 74 m. The large capacity of this pump enables pumping of large quantities of groundwater. The pump can be tuned to manage small capacities, enabling the pumping of a very small quantity of water (*low flow*), appropriate for sampling.

The overview of all remaining HGI-CGS equipment in the laboratories, for fieldwork, and office, is available from the database of scientific research instruments – Šestar (<https://sestar.irb.hr/>).



Potopna crpka  
Submersible pump

# Informatička oprema

## IT Equipment

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U proteklom desetljeću HGI-CGS sustavno je ulagao u unaprjeđenje informatičke infrastrukture. Od većih infrastrukturnih radova svakako ističemo preseljenje serverske sobe koja je ranije bila smještena u podrumskim prostorima instituta gdje uvek postoji opasnost od poplave. Nova je serverska soba opremljena u skladu sa svim tehničkim i sigurnosnim standardima koji su propisani za takve vrste prostora. HGI-CGS je 2014. godine od Ministarstva gospodarstva, poduzetništva i obrta dobio na korištenje jak poslužitelj (server) i sustav za pohranu podataka. Također, za potrebe Agencije za ugljikovodike, HGI-CGS pruža uslugu izrade i održavanja kartografskog preglednika. Zahvaljujući novoj opremi ostvaren je važan pomak u brzini pristupa informacijama te njihovoj sigurnosti.

Kao član CARNET-a, obveza HGI-CGS-a bila je uvesti sigurnosnu politiku informacijskog sustava te urediti interne pravilnike, što je 2016. godine i napravljeno te je sigurnosna politika postala obvezna za sve zaposlenike. Informatička služba razvija i nova aplikativna rješenja. Tako je izrađen "e-lab", web aplikacija koja se koristi za predaju i pregled poslova te distribuciju zadataka unutar geoloških laboratorijskih.

Među mnogim GIS alatima koji se koriste, u HGI-CGS-u su najzastupljeniji ESRI-jevi proizvodi. Zbog vrlo visoke cijene održavanja te sve veće potražnje za licencama uspostavljen je i središnji repozitorij licenci s 10-tak licenci s potrebnim dodatcima (ekstenzijama) u verzijama za određeni broj korisnika. Prateći rad slično ustrojenih ustanova iz cijele Europe (pa i svijeta) kao alternativa se preporučuje uporaba aplikacija otvorenog koda, čime se povećava broj radno dostupnih GIS i ostalih licenci.



Postavljanje nove serverske sobe  
Setting up the new server room

In the last decade, the Croatian Geological Survey (HGI-CGS) has been systematically investing in the advancement of IT infrastructure. Among the infrastructure works of a larger scale, we must highlight the relocation of the server room, which had been located in the Institute's basement spaces, where there is a constant danger of flooding. The new server room is equipped in accordance with all technical and safety standards prescribed for this type of room. In 2014, the HGI-CGS received a strong server and a data storage system from the Ministry of Economy, Entrepreneurship, and Crafts. Moreover, the HGI-CGS provides web map service production and maintenance for the Croatian Hydrocarbon Agency. Owing to the new equipment, an important step forward with regard to speed in information access and security has been made.

As a member of CARNET, the HGI-CGS had an obligation to implement an IT system security policy and organise internal regulations, which was accomplished in 2016, and security policy has become obligatory for all employees. The IT service also develops new application solutions. Hence, the "e-lab" has been developed, a web application used for submitting and reviewing work, and distributing tasks within geological laboratories.

Among the many GIS tools in use, the ESRI products are the most represented at HGI-CGS. Because of the high maintenance price and the steadily growing demand for licences, a central licence repository with a dozen licences with necessary additions (extensions) in the concurrent versions has also been established. Following the work of similarly organised institutions from around Europe (and the world), the use of open source

Postojeća mrežna stranica HGI-CGS-a dostupna je javnosti od sredine 2009. godine te je glavna i najveća publikacija instituta. Od tada se posjećenost stranice višestruko povećala. Povodom 110. godišnjice instituta bit će predstavljena i nova i modernija stranica.

applications is recommended as alternative, thus increasing the number of GIS and other licences available for work.

The existing HGI-CGS website has been publicly available since mid-2009 and is the Institute's main and largest publication. Since its launch, the number of visits to the website has increased many times over. A new and modernized website is to be launched on the occasion of the Institute's 110<sup>th</sup> anniversary.

**Vijesti**

Druge načelne mrežne realizacije PROLINE-CI u Matuljima  
U organizaciji Hrvatskog geodetskog inženjeringa je druge načelne mrežne realizacije PROLINE-CI učinjeno u Programu infrastrukturne razvojne Interreg Centralna Europe 2014.-2020. U okviru ovog projekta potvrđujući - inzervisni putjevi na dio južne Dalmacije, mrežnica je uspostavljena u Matulju te je prizvukom novih vozilnih komunikacija.

**Zavodi**

Zavod za geotektoniku  
Zavod za hidrogeologiju i hrvatsku geodeticu  
Zavod za mineralnu sировинu

**kontakt**

Adresa: Hrvatski geodetski i kartografski zavod, 10. listopadova 1, 10 000 Zagreb  
Telefon: +385 1 6160 888  
Email: [hgi@hgi.hr](mailto:hgi@hgi.hr)

Izgled nove mrežne stranice  
Preview of the new web site

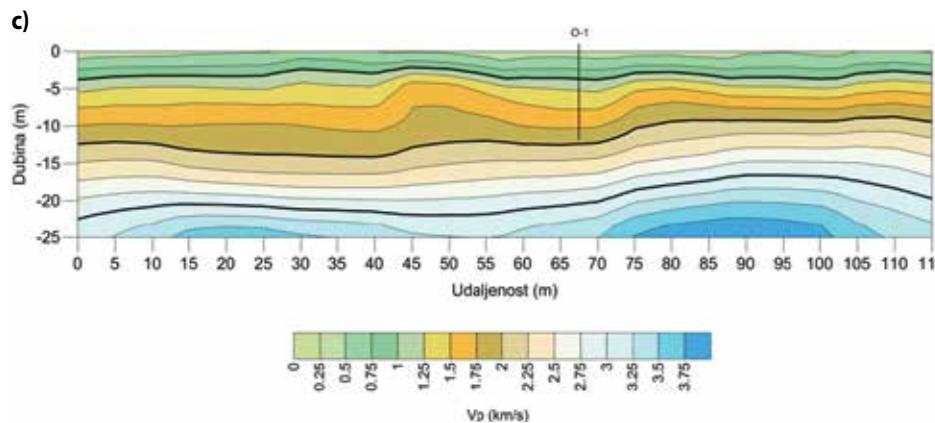
# Geofizička oprema

## Geophysical Equipment

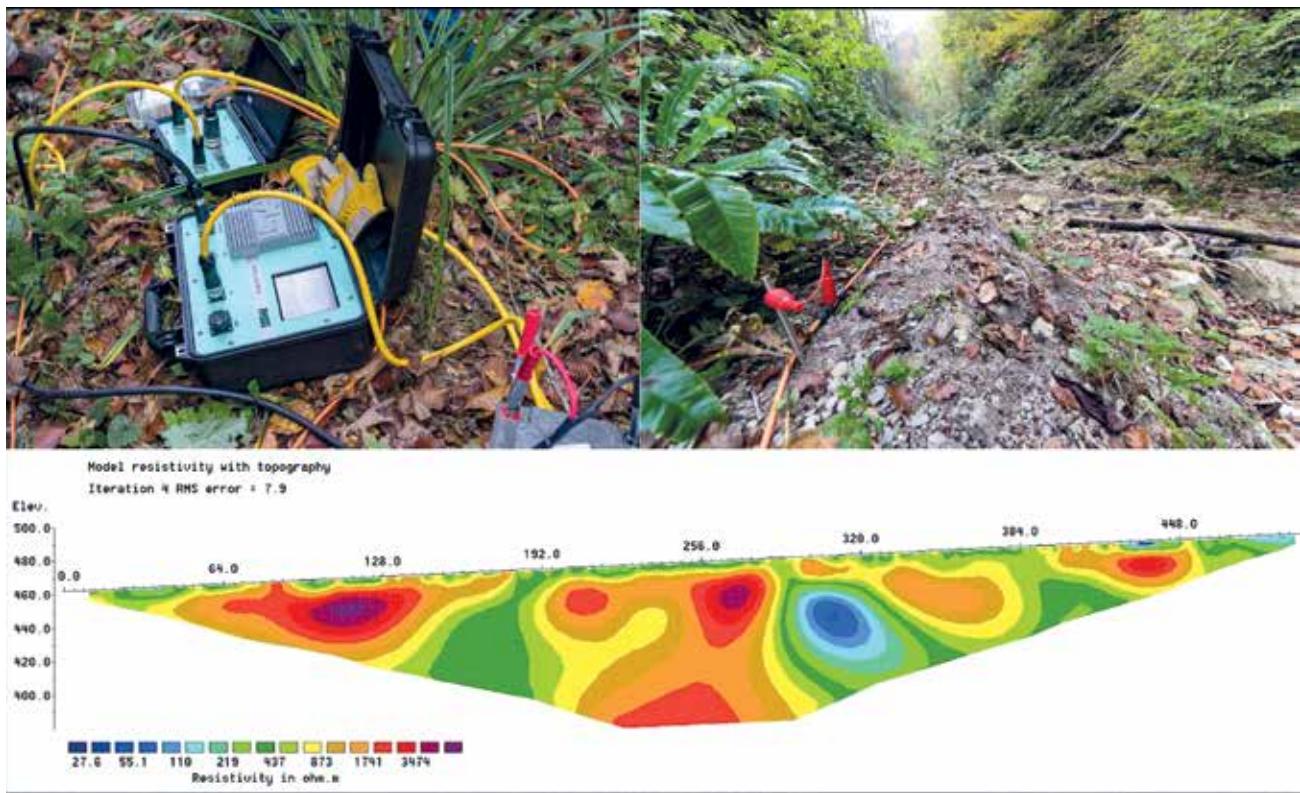
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Nabavom opreme za provođenje geofizičkih istraživanja tijekom 2017. i 2018. godine postavljeni su temelji Laboratorija za geofizička istraživanja, čije je osnivanje predviđeno strateškim dokumentom HGI-CGS-a. Do sada su djelatnici HGI-CGS-a koristili rezultate ovih istraživanja, no nabavom opreme za seizmičko refrakcijsko i električno tomografsko profiliranje, magnetotelursko sondiranje te višesnopnog dubinomjera, najvećim dijelom iz sredstava ostvarenih na tržišnim projektima Zavoda

The purchase of equipment for performing geophysical research during 2017 and 2018 laid the foundations for the Laboratory for geophysical research, the foundation of which is planned in a strategic document of the HGI-CGS. To date, HGI-CGS employees have been using the results of such research, but with the procurement of equipment for seismic refraction and electrical resistivity tomography profiling (ERT), magnetotelluric sounding (MT), and a multibeam sonar, mostly from funds realised through



Postavljanje seizmičkog refrakcijskog profila s 24-kanalnim geofonskim rasporedom (a); snimanje seizmičkih valova (b); obrađeni rezultati mjerjenja (c)  
Setup of a seismic refraction profile with a 24-channel geophone array (a); recording seismic waves (b); processed measurement results (c)



Terensko mjerjenje profila električne tomografije i obrađeni rezultati mjerjenja  
Fieldwork measurements of electric tomography profiles and processed measurement results

za hidrogeologiju i inženjersku geologiju, započinje novo poglavlje geofizičkih istraživanja u HGI-CGS-u.

Oprema za izvođenje seizmičkih mjerena sastoji se od višekanalnog seismografa model GEA 24 (proizvođača P.A.S.I.), piezoelektričnog startera te vertikalnih 10 Hz i 4,5 Hz geofona (50 kom) s potrebnim kablovima i spojnicama, softwarea za obradu i inverziju podataka ZOND ST 2D i terenskog računala Panasonic Toughbook CF-19. Osim toga, nabavljena su i dva interkonekcija kabla ukupne duljine 150 m koji omogućuju serijsko spajanje dvaju seismografa za izvođenje mjerena metodom refleksijske seismike.

Oprema za geoelektričnu tomografiju sastoji se od instrumenta POLARES 2.0 (proizvođača P.A.S.I.), kompleta višeektrodnih kablova i multipleksora, te 64 elektrode i spojnice. Maksimalna duljina snimanja iznosi 630 m s dubinom zahvata od oko 130 m. Uz opremu je nabavljen i software Res2DInv za obradu i inverziju podataka. Nakon nabavke opreme provedena je edukacija zaposlenika te je snimljeno desetak profila u svrhu hidrogeološke prospexije terena.

market-oriented projects of the Department of Hydrogeology and Engineering Geology, a new chapter of geophysical research at the HGI-CGS has begun.

The equipment for conducting seismic measurements consists of a multichannel seismograph GEA 24 (produced by P.A.S.I.), a piezoelectric starter, and vertical 10 Hz and 4.5 Hz geophones (50 pcs.) with necessary cables and connectors, data processing and inversion software ZOND ST 2D, and a Panasonic Toughbook CF-19 fieldwork computer. Besides that, two interconnection cables of a total length of 150 m, enabling the serial connection of two seismographs for carrying out measurements by seismic reflection, have also been purchased.

The equipment for ERT consists of POLARES 2.0 instruments (P.A.S.I.), a set of multielectrode cables and multiplexers, and 64 electrodes and connectors. The maximum recording length is 630 m, with depth of penetration of up to ca. 130 m. Alongside the equipment, the Res2DInv data processing and inversion software has also been purchased. Following the equipment purchase, employee education has also been carried out and a do-



Magnetotelurika – priprema za akviziciju podataka na udaljenoj referentnoj točki  
(foto A. Vetrov)

Magnetotellurics – preparations for data acquisition at a remote reference site  
(photo by A. Vetrov)

Magnetotelurika je metoda kojom se mjeri električna otpornost podzemlja, dakle, služi za otkrivanje i analizu podzemnih fenomena koji uzrokuju veliki kontrast otpornosti ili karakteristične vrijednosti i raspored otpornosti. Imala dvije prednosti pred ostalim geoelektričnim metodama: (1) registrira prirodno električno i magnetsko polje Zemlje (nije potrebno generirati polje) te (2) dubina zahvata ovisi isključivo o frekvenciji koje se registrira, pa se mogu zahvatiti izrazito velike dubine (više desetaka kilometara) uz uvjet da se snima dovoljno dugo. Kupljena su tri kompleta opreme koji omogućuju simultanu akviziciju AMT i MT podataka uz korištenje udaljene referentne točke. Ovom opremom prvenstveno se planiraju istraživati geotermalni sustavi te kontakt mora i slatke podzemne vode.

Višesnopni dubinomjer emitira zvučne valove lepezastog oblika kroz voden stupac do dna, te prema odzivu s dna mjeri točnu dubinu. WASSP S3 koristi istodobno 224 bočno usmjerene zrake sa širinom snopa od 120°, dok je frekvencija odašiljača zvuka 160 kHz. Za određivanje položaja uređaj koristi Hemisphere V103 GPS GNSS antenu sa SBAS korekcijama, dok inercijalna jedinica služi za korekciju ljudljana, posrtanja i valjanja. Optimalna dubina do koje se uređaj može koristiti je 200 m, a maksimalna 400 m. Osim dubine, ovaj uređaj mjeri i intenzitet povratnih valova (backscatter) koji ovisi o veličini čestica i konsolidiranosti sedimenta. Koristit će se za kartiranje geomorfoloških karakteristika dna, kvalitetnije izmjere izdizanja razine mora, kao i za detektiranje položaja i morfologije podmorskih izvora (vrulja).

en profiles have been recorded with the purpose of hydrogeological prospection.

MT sounding measures the distribution of electrical resistivity of the subsurface, serving for discovery and analysis of subterranean phenomena that cause high resistivity contrast or characteristic values and resistivity distribution. It has two advantages over other geoelectrical methods: (1) it registers the Earth's natural electric and magnetic fields (field generation is not necessary), and (2) the depth of penetration depends exclusively on the frequency that is being registered, so extremely large depths can be covered (several tens of kilometres) provided that the recording lasts long enough. Three sets of equipment that enable simultaneous acquisition of AMT and MT data with the use of a remote reference point have been purchased. This equipment will primarily be applied in the research of geothermal systems and mixing zones of seawater and fresh groundwater.

A multibeam sonar emits fan-shaped sound waves through a water column to its bottom, and measures exact depth according to the response received from the bottom. The WASSP S3 simultaneously uses 224 sideways oriented rays with a 120° beam width, while the sound transmitter frequency is 160 KHz. For determining position, it uses a Hemisphere V103 GPS GNSS antenna with SBAS corrections, while the inertial unit serves for correcting oscillations, pitching, and rolling. The optimal depth of use for the device is 200 m, and maximum is 400 m. Apart from depth, this device also measures the intensity of backscatter, which depends on the particle size and sediment consolidation. It will be used for the mapping of geomorphological characteristics of the seabed, higher quality measurements of sea level rising, as well as detecting positions and the morphology of submarine springs (vrulje).

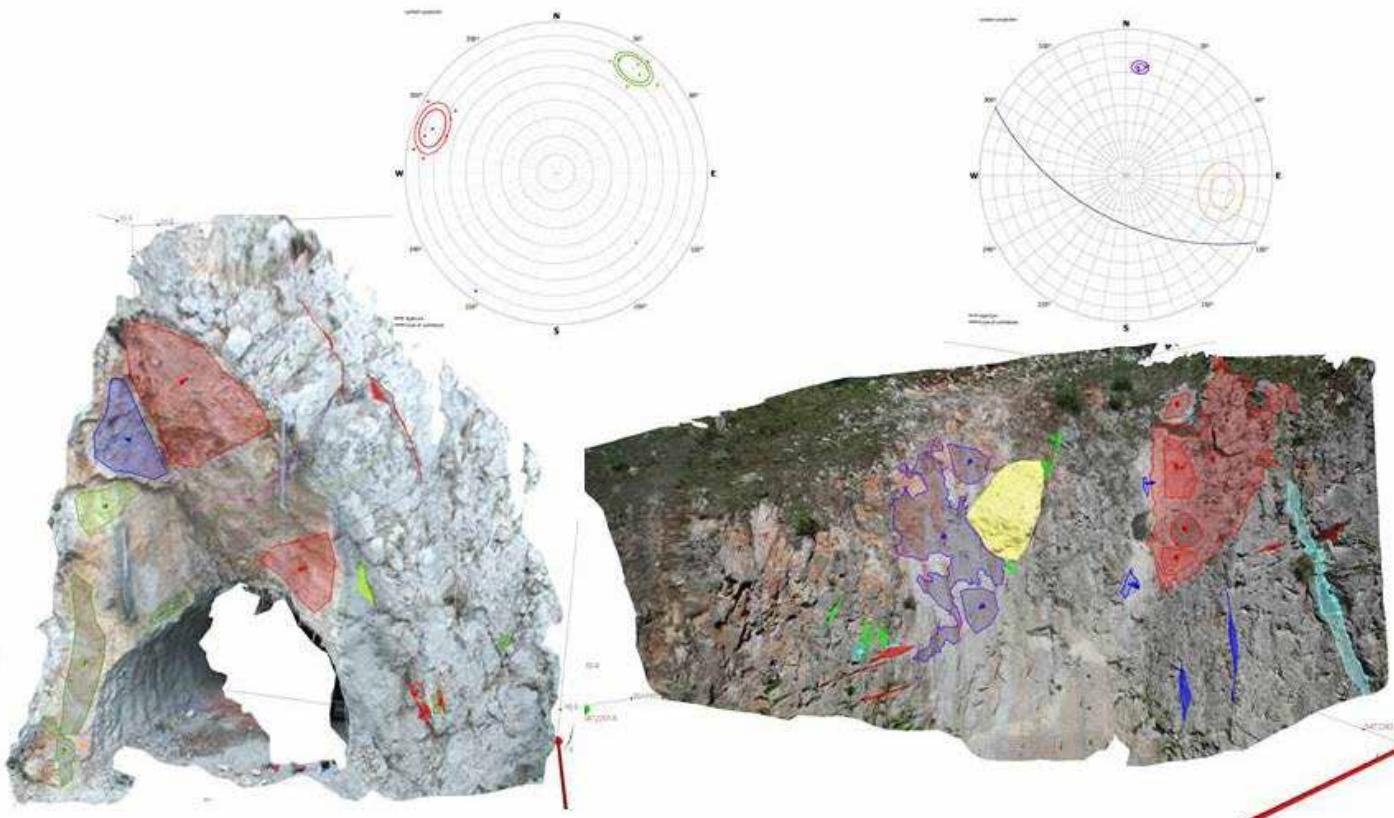
# Oprema za daljinska i beskontaktna istraživanja

## Equipment for Remote and Contact-Free Sensing

Autori teksta / Authors of the text: dr. sc. Dražen NAVRATIL, dr. sc. Tihomir FRANGEN

Djelatnici ZHIG-a uz klasična inženjerskogeološka istraživanja u stijenskim masama (izrada IG karata različitih mjerila, detaljna snimanja diskontinuiteta, kategorizacije stijenskih masa, statistička obrada geometrijskih značajki diskontinuiteta, utvrđivanje *in-situ* razdiobe blokova – ISBD) provode navedena istraživanja na nedostupnim izvedenim i prirodnim kosinama

Alongside classic engineering-geological research in rock masses (production of engineering-geological maps at various scales, detailed discontinuity measurements, rock mass categorisations, statistical processing of geometrical characteristics of discontinuities, determination of *in situ* block distribution – ISBD), the employees of the Department of Hydrogeology and Engineering



Lijevo: Odron na portalu južne cijevi tunela u kanjonu Čelevečke Reke kod Demir Kapije i dijagram polova normala izdvojenih setova diskontinuiteta na portalu tunela (Lambertova projekcija jednakih površina); Desno: 3D model, mjerena orijentacija diskontinuiteta i procjena volumena nestabilnog bloka u dijelu zasjeka Gornje Dražovo na pruzi Zagreb GK – Rijeka te dijagram polova normala dvaju diskontinuiteta koji formiraju klin s naznačenom orijentacijom kosine tragom ravnine (Lambertova projekcija jednakih površina) (izrađeno sustavom ShapeMetrix3D)

Left: Landslide on the portal of the southern tube of the tunnel in the Čelevečka Reka canyon near Demir Kapija and the diagram of poles of normals of identified discontinuity sets on the tunnel portal (Lambert Equal-Area projection); Right: 3D model, measurements of discontinuity orientations and the estimation of the volume of unstable block in the cutting slope Donje Dražovo on the Zagreb GK - Rijeka railway and the diagram of poles of normals of two discontinuities forming a wedge, with the plane trace marking the slope orientation (Lambert Equal-Area projection) (produced by the Shapemetrix3D system)



Model klizišta u Hrvatskoj Kostajnici izrađen iz snimki bespilotnom letjelicom Sensefly eBee Plus  
Model of a landslide in Hrvatska Kostajnica produced from recordings by Sensefly eBee Plus UAV

ma. Na takvim se lokacijama koriste alpinističke tehnike i metode beskontaktnog mjerjenja pomoću stereoparova digitalnih fotografija sustavom ShapeMetriX3D (3GSM GmbH, Austria). Neovisno radi li se o nepristupačnim ili pristupačnim izdancima (zasjecima), iskustva u navedenoj problematici ukazuju na neophodnost većeg broja snimljenih podataka o geometrijskim značajkama diskontinuiteta radi pouzdanije statističke obrade i omogućavanja kvalitetnijih rezultata za geotehničke proračune. Kombinacija klasičnih metoda i metoda beskontaktnog mjerjenja geometrijskih značajki diskontinuiteta u stijenskim masama osigurava dovoljan broj podataka za daljnje analize. U današnje vrijeme razvijeno je više sustava i metoda za beskontaktno mjerjenje diskontinuiteta na otvorenim čelima i u tunelima. Općenito ih možemo podijeliti na metode snimanja 3D laserskim skenerom i fotogrametrijske metode. Beskontaktna metoda mjerjenja za koju je razvijen programski paket i oprema pod nazivom ShapeMetriX3D (3G Software & Measurement GmbH; 2007) bazira se na snimanju stereoparova i tehnologiji 3D vizualizacije (eng. computer vision algoritam).

ShapeMetriX3D je inovativan sustav za mjerjenje i procjenu površina pomoću 3D modela dobivenih snimanjem digitalnih

Geology (DHGEG) carry out the remote and contact-free sensing in inaccessible artificial and natural slopes. In such locations, mountaineering techniques and methods of contact-free measurement with digital photography stereopairs by the ShapeMetriX3D (3GSM GmbH, Austria) system are applied.

Regardless of whether the outcrops are accessible or not, the experience gained in these projects points to a necessity of obtaining more data on geometrical characteristics of discontinuities for more reliable statistical processing and higher quality results in terms of geotechnical estimates. The combination of classical methods and methods of contact-free measurement of geometrical characteristics of discontinuities in rock masses ensures a sufficient amount of data for further analyses.

Presently, several systems and methods for contact-free measuring of the discontinuity on open fronts and in tunnels have been developed. In general, they can be divided into methods of recording by a 3D laser scanner and photogrammetric methods. The contact-free measuring method, for which the programme package and equipment entitled ShapeMetriX3D (3G Software & Measurement GmbH; 2007) have been developed, is based on the recording of stereopairs in 3D visualisation technology (computer vision algorithm).

fotografija bez stativa (iz ruke). Posebno se to odnosi na površine u stijenama, odnosno njihovu geološku / geotehničku procjenu. ShapeMetriX3D nije osmišljen kao fotogrametrijski računalni program, nego kao sustav za rješavanje problematičke iz inženjerske geologije, geotehnike i geometrije općenito.

Ubrzani razvoj bespilotnih letjelica omogućuje njihovu široku primjenu, te je ZHGIG nabavio eBee Plus bespilotnu letjelicu s fiksnim krilima opremljenu RGB i termalnom kamerom. Ona omogućuje snimanje velikih površina, te izradu digitalnih modela površine i ortofoto podloga s centimetarskom preciznošću. U sklopu safEarth projekta nabavljena je multirotor bespilotna letjelica koja je također opremljena RGB i termalnom kamerom. Ona omogućuje snimanje manjih površina u vrlo visokoj rezoluciji. Nabavljenе letjelice su začetak Laboratorija za daljinska istraživanja, čije se uspostavljanje očekuje u narednom periodu, sukladno strateškim odrednicama HGI-CGS-a.

The ShapeMetriX3D is an innovative system for measurement and assessment of surfaces with the help of 3D models obtained by recording digital photographs without a tripod (handheld). This pertains in particular to rock surfaces, i.e. their geological / geotechnical assessment. The ShapeMetriX3D was not devised as photogrammetric computer programme, but rather as a system for solving engineering-geological, geotechnical, and general geometrical problems.

The accelerated development of unmanned aerial vehicles (UAVs) enabled their widespread use, and the DHGEG has purchased an eBee Plus UAV with fixed wings equipped with RGB and thermal cameras. This device enables the recording of large surfaces and the production of digital surface models and orthophoto bases with centimetre precision. As part of the safEarth project, a multirotor UAV has been purchased, also equipped with RGB and thermal cameras. This device enables the recording of smaller surfaces at very high resolution. These purchased UAVs represent the starting efforts of the Laboratory for remote sensing, the establishment of which is expected in the upcoming period, in accordance with strategic determinants of the HGI-CGS.



**Snimanje ogoline kod Šterne u Istri bespilotnom letjelicom**  
Recording a gully near Šterna in Istria by a multirotor UAV



Uzorkovanje na Šmitovom jezeru (foto J. Terzić) /  
Sampling at the Šmit lake (photo by J. Terzić)

4

Projekti  
Projects



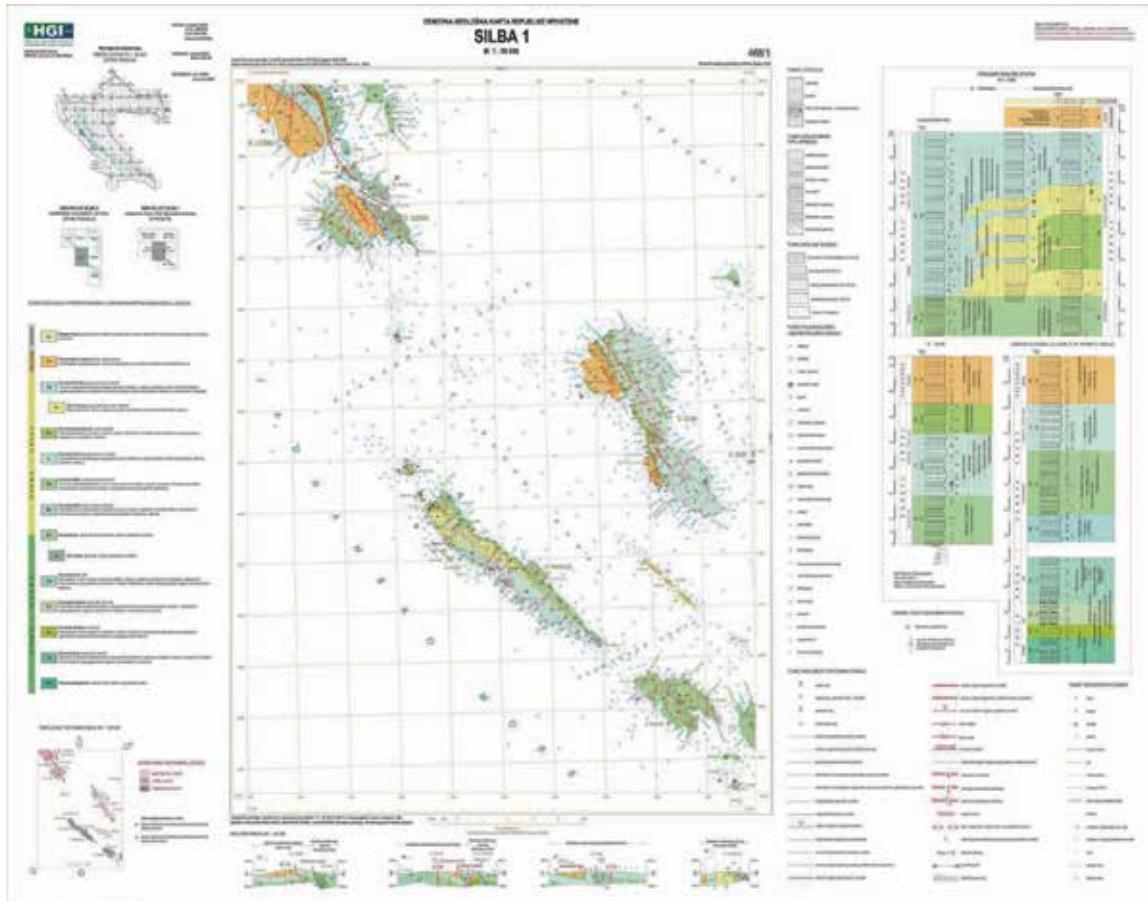
# Osnovna geološka karta Republike Hrvatske 1: 50.000

## Basic Geological Map of the Republic of Croatia 1: 50,000

Glavni istraživač / Principal investigator: dr. sc. **Tvrko KORBAR**

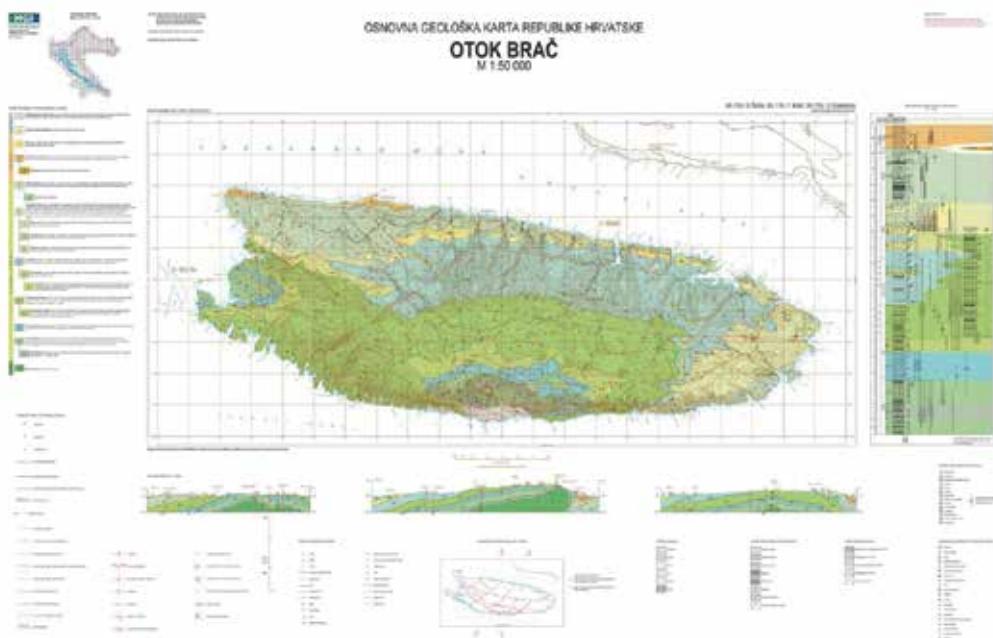
U razdoblju od 2007. do 2014. godine Osnovna geološka karta (OGK) RH je financirana kao znanstveni projekt Ministarstva znanosti, obrazovanja i sporta (MZOS br. 181-1811096-1093), a do 2011. voditelj je bio dr. sc. Marko Šparica. U proteklom 10-godišnjem razdoblju u okviru projekta su objavljeni brojni

In the period from 2007 to 2014, the Basic geological map (BGM) of the Republic of Croatia (RH) was financed as a scientific project by the Ministry of Science, Education, and Sports (MZOS no. 181-1811096-1093), the head of which was Marko Šparica, PhD, up until 2011. In the past 10-year period, numerous scientific pa-

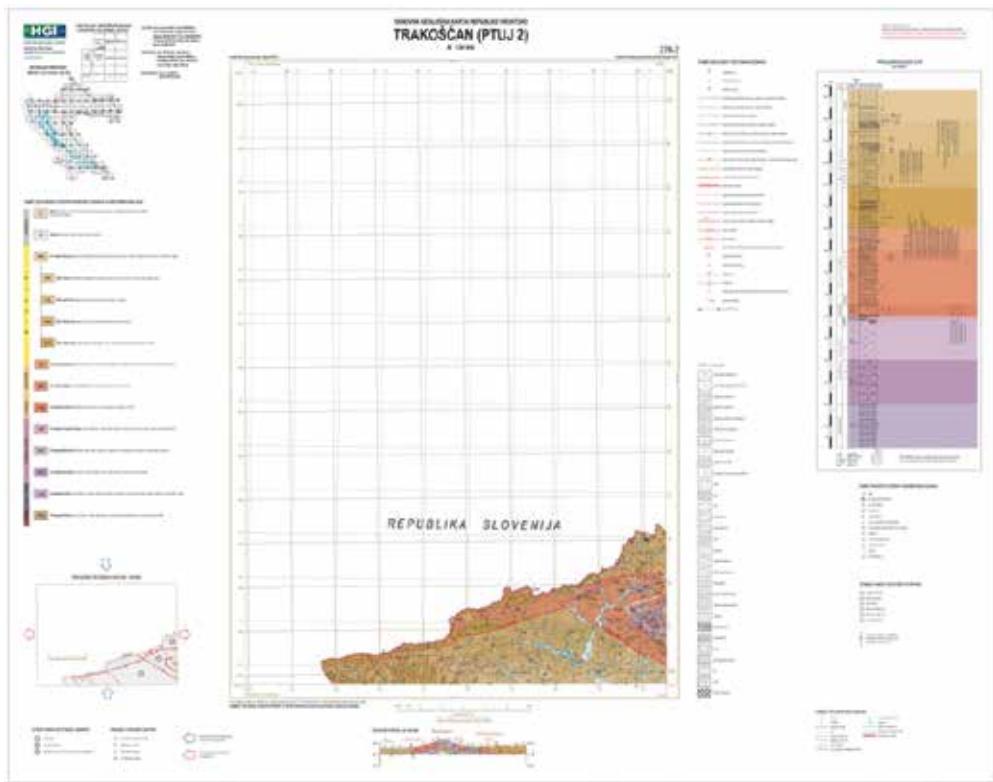


Prikaz lista OGK RH Silba (Fućek et al., 2018).

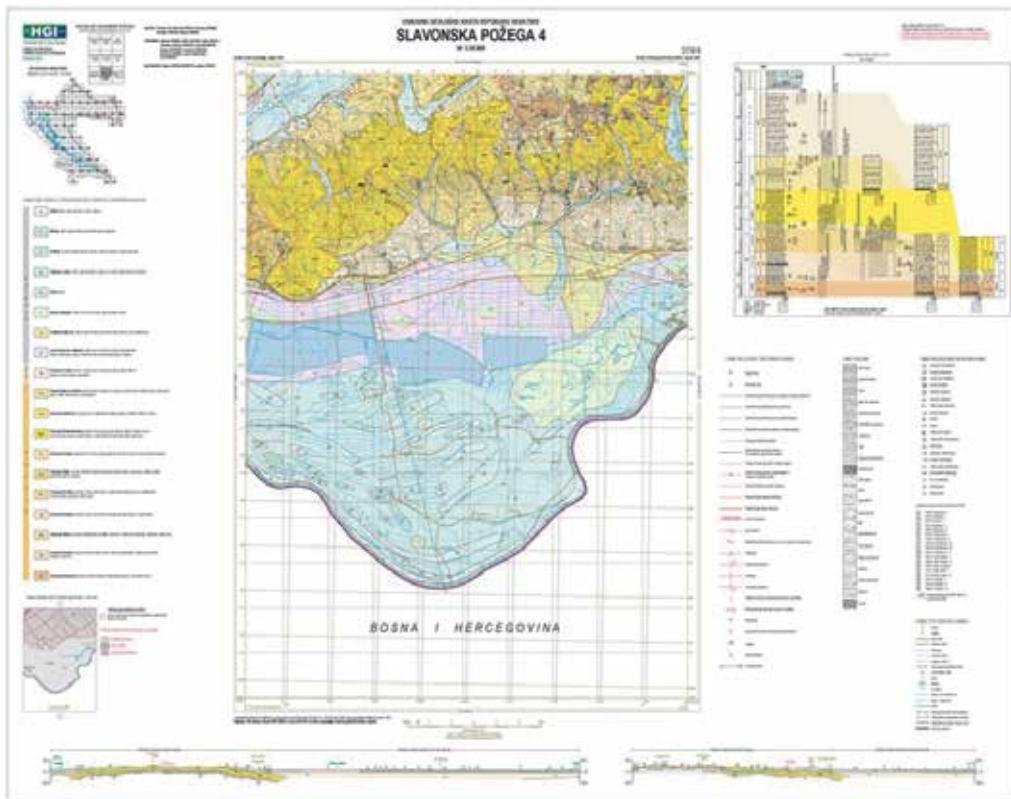
Display of the BGM of RH sheet Silba-(Fućek et al., 2018)



Prikaz lista OGK RH Otok Brač (Jelaska et al., 2015).  
Display of the BGM of RH sheet Island of Brač (Jelaska et al., 2015)



Prikaz lista OGK RH Trakošćan/Ptuj-(Avanić et al., 2015)  
Display of the BGM of RH sheet Trakošćan/Ptuj-(Avanić et al., 2015)



Prikaz lista OGK RH Slavonska Požega (Filjak et al., 2016).  
Display of the BGM of RH sheet Slavonska Požega-(Filjak et al., 2016)

znanstveni radovi te je izrađeno 10-ak doktorata. Projekt je organiziran prema projektnim područjima/skupinama, pri čemu su za objavljivanje odgovorni voditelji pojedinih listova karte, a za koordinaciju voditelji područja/skupina: 2012-2017. SZ Hrvatska (R. Avanić), Slavonija (M. Belak), Istra, Kvarner i sjeverna Dalmacija (L. Fuček), Srednja i Južna Dalmacija (T. Korbar) te u razdoblju 2017. do danas: Panon (A. Grizelj) i Dinaridi (T. Korbar).

Krajem 2012. godine došlo je do značajnog napretka u hrvatskoj geološkoj kartografiji jer su prema Uputama za izradu OGK RH (Korbar et al.) objavljeni prvi standardizirani listovi: Cres-2 (Fuček et al.) i Vis-3 i Biševo-1 (Korbar et al.).

Usprkos finansijskim problemima, 2014. smo nastavili s finalizacijom i objavljivanjem novih listova pa su objavljena još dva lista: Vis-4 (Oštarić et al.) i Cres-4 (Fuček et al.).

Najveći broj listova objavljen je 2015.: Otok Brač (Jelaska et al.), Cres i Lošinj (Fuček et al.), Omiš 3 i 4 te Otok Hvar (Oštarić et al.), Konavle (Prtoljan et al.), Rovinj-3 (Matičec et al.) i Trakošćan/Ptuj-2 (Avanić et al.).

pers were published within the project, and a dozen PhD dissertations were defended. The project has been organised by project areas/groups, with leaders responsible for publication of specific sheets, and area/group leaders for coordination: 2012–2017 NW Croatia (R. Avanić), Slavonia (M. Belak), Istria, the Kvarner area, and Northern Dalmatia (L. Fuček), Central and Southern Dalmatia (T. Korbar), and in the period from 2017 up to date: Pannonian (A. Grizelj) and the Dinarides (T. Korbar).

At the end of 2012, a significant advancement occurred in Croatian geological cartography, as the first standardised sheets were published according to the Guidelines for compilation of the BGM of the RH (Korbar et al., 2012): Cres-2 (Fuček et al.), and Vis-3 and Biševo-1 (Korbar et al.).

Despite financial problems, in 2014 we continued the finalisation and publication of new sheets, leading to additional two sheets being published: Vis-4 (Oštarić et al.) and Cres-4 (Fuček et al.).

The largest number of sheets was published in 2015: Island of Brač (Jelaska et al.), Cres and Lošinj (Fuček et al.), Omiš-3 and 4, and the Island of Hvar (Oštarić et al.), Konavle (Prtoljan et al.), Rovinj-3 (Matičec et al.), and Trakošćan/Ptuj-2 (Avanić et al.).

Tijekom 2016. godine objavljeni su listovi Dugi otok (Fuček et al.), Otok Mljet (Husinec et al.) te listovi Slavonska Požega 3 i 4 (Filjak et al.).

2017. godine objavljeni su listovi Šolta, Čiovo, V. i M. Drvenik (Korbar et al.) te Rovinj-1 (Matičec et al.).

Početkom 2018. godine objavljen je list Silba-1 (Fuček et al.). Do kraja 2018. u planu je finalizacija listova Rovinj-2 i Požeška gora kao cjelina, a u narednom razdoblju i izrada tumača za objavljene listove.

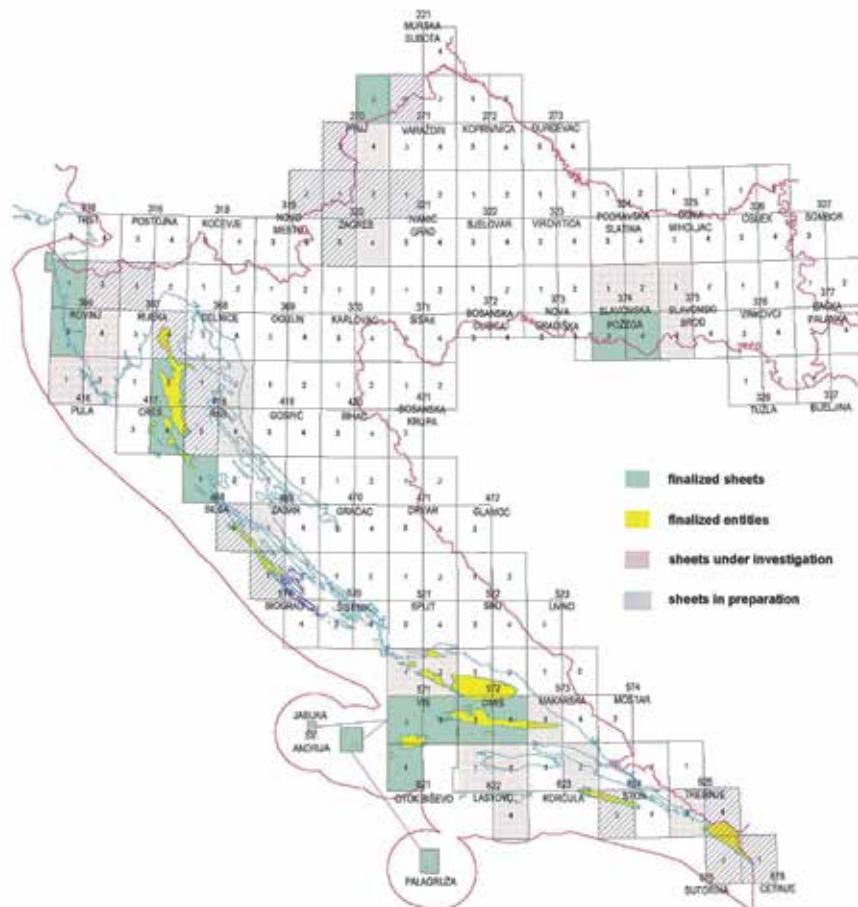
Finalizacija započetih listova, odnosno nastavak geološkog kartiranja na drugim područjima RH, uvelike ovisi o financiranju ove temeljne djelatnosti Zavoda za geologiju HGI-CGS-a. Tako su, npr., uz sufinanciranje terenskih troškova od strane NP Kornati, tijekom 2018. iskartirani otoci na području tog nacionalnog parka.

During 2016, the sheets Island of Dugi otok (Fuček et al.), Island of Mljet (Husinec et al.), and the sheets Slavonska Požega-3 and 4 (Filjak et al.) were published.

In 2017, the sheets Šolta, Čiovo, V. and M. Drvenik (Korbar et al.), and Rovinj-1 (Matičec et al.) were published.

At the beginning of 2018, the sheet Silba-1 (Fuček et al.) was published. By the end of 2018, the completion of sheets Rovinj-2 and Požeška gora is planned, and in the following period the production of explanatory notes for the published map sheets.

The finalisation of the initiated sheets, i.e. the continuation of geological mapping in other areas of the RH, largely depends on the financing of this fundamental activity of the Department of Geology of the HGI-CGS. In 2018, for example, the islands in Kornati National Park (NP) were mapped with the co-financing of field-work by NP authority.



Shema listova OGK RH s označenim stupnjem izrađenosti. Objavljeni listovi dostupni su na [www.hgi-cgs.hr](http://www.hgi-cgs.hr).

A scheme of the BGM of the RH sheets with their degree of completion. Published sheets are available at [www.hgi-cgs.hr](http://www.hgi-cgs.hr)

# Osnovna geokemijska karta Republike Hrvatske

## Basic Geochemical Map of the Republic of Croatia

Glavni istraživač / Principal investigator: dr. sc. **Josip HALAMIĆ**

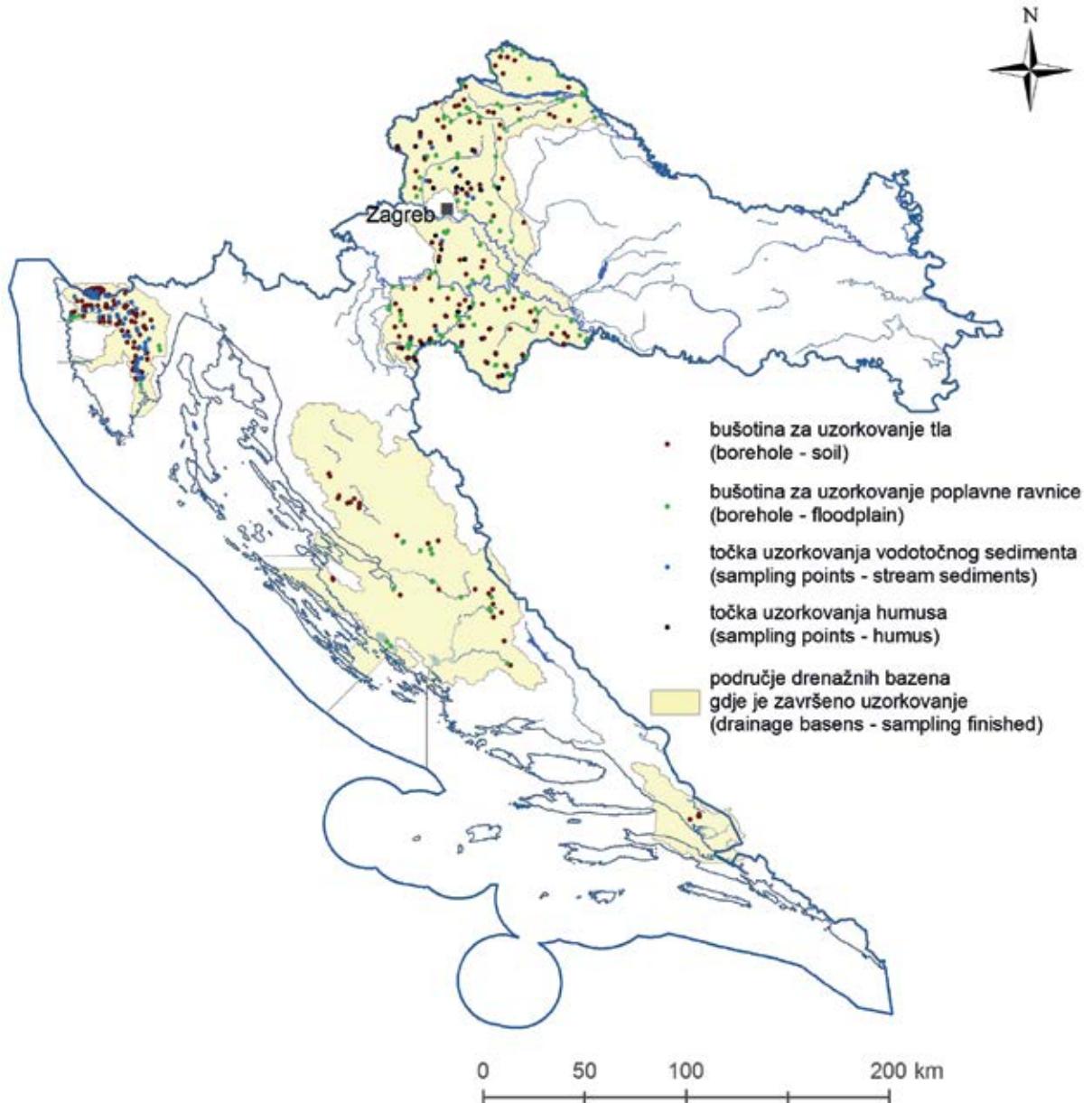
Autori teksta / Authors of the text: dr. sc. **Josip HALAMIĆ**, dr. sc. **Ajka ŠORŠA**

Nakon završetka uzorkovanja površinskog dijela tla za kompletan teritorij RH i tiskanja Geokemijskog atlasa prema programu istraživanja temeljnog projekta Osnovna geokemijska karta RH čitav državni teritorij podijeljen je na oko 200 pojedinačnih sljevova ujednačene veličine. Metodologija istraživanja prilagođena je izradi Geokemijskog atlasa Europe – FOREGS (2005. i 2006.). Unutar tako izdvojenog sljeva uzorkuje se sediment poplavne ravnice, tlo, humus i vodotočni sediment. Sedimenti poplavne ravnice uzorkuju se u području ušća izdvojenog vodotoka, a tlo u području jednog manjeg sljeva unutar tog drenažnog bazena. Radi boljeg definiranja geokemijskih osobina sedimenti poplavne ravnice i tlo uzorkuju se bušenjem do dubine od 1 metra, a kompozitni uzorci uzimaju se na osam dubina (0–5 cm, 5–10 cm, 10–20 cm, 20–30 cm, 30–40 cm, 40–50 cm, 50–70 cm i 70–100 cm). Takođe, metodom uzorkovanja pokrivena su područja: Hrvatsko zagorje, Banovina, centralni dio Istre, centralni dio Dalmacije te područje oko ušća Neretve (oko 40% teritorija države). Na žalost, krajem 2013. godine MZOS je ukinulo financiranje temeljnih projekata tako da od tada nema dostatnih sredstava za nastavak ovih istraživanja. Na temelju analitičkih podataka dobivenih dosadašnjim ispitivanjima napravljen je nacrt geokemijskog atlasa drenažnog bazena rijeke Krapine u Hrvatskom zagorju. Osim toga, taj veliki broj podataka bit će, u suradnji s kolegama iz Europe, a posebno iz susjednih država, upotrijebljen za izradu znanstvenih radova u narednom razdoblju.

Tijekom proteklih deset godina članovi geokemijske istraživačke skupine sudjelovali su u nekoliko međunarodnih i domaćih znanstvenih projekata te objavili desetke znanstvenih radova u CC časopisima. Dvoje znanstvenika obranilo je i doktorske disertacije, a još je jedna u završnoj fazi izrade.

After the sampling of surface soil for the entire territory of the Republic of Croatia (RH) and the publishing of the Geochemical atlas according to the research programme of the fundamental project, the Basic Geochemical Map of the RH, the country's entire territory has been divided into ~200 individual catchments of uniform size. The research methodology has been adapted to the production of the Geochemical atlas of Europe – FOREGS (2005 and 2006). Within an isolated catchment, the floodplain sediment, soil, topsoil, and stream sediment were sampled. Floodplain sediments were sampled in the confluence area of the selected watercourse, and the soil in the area of a smaller catchment within that drainage basin. In order to better define geochemical properties, the floodplain sediments and soil are sampled by drilling to 1 m depth, with composite samples collected at eight depths (0–5 cm, 5–10 cm, 10–20 cm, 20–30 cm, 30–40 cm, 40–50 cm, 50–70 cm, and 70–100 cm). The following areas have been covered by this method: Hrvatsko zagorje, Banovina, Central Istria, Central Dalmatia, and the area around the Neretva River delta (ca. 40% of the country's territory). Unfortunately, at the end of 2013, the Ministry of Science, Education and Sports terminated the financing of fundamental projects. Since then, there have not been sufficient funds to continue this research. With regard to analytical data acquired through the testing performed up to date, an outline of the geochemical atlas of the Krapina River drainage basin in Hrvatsko zagorje has been made. This large amount of data will also be used in the production of scientific papers in the following period in co-operation with colleagues from Europe, especially those from neighbouring countries.

During the last ten years, the members of the geochemical research group have participated in several international and national scientific projects, and published dozens of scientific papers in eminent journals. Two scientists have also defended their PhD dissertations, with another one currently in the final stage of completion.



Uzorkovana područja RH  
Sampled areas of the RH

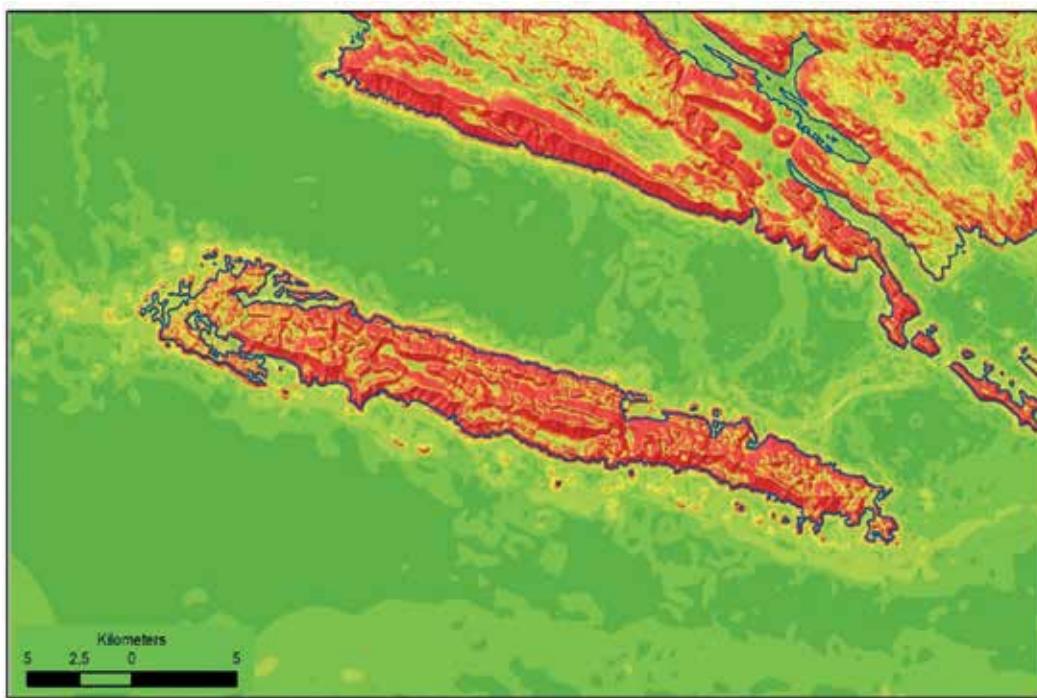
# Geološke karte podmorja

## Geological Maps of the Croatian Adriatic Sea

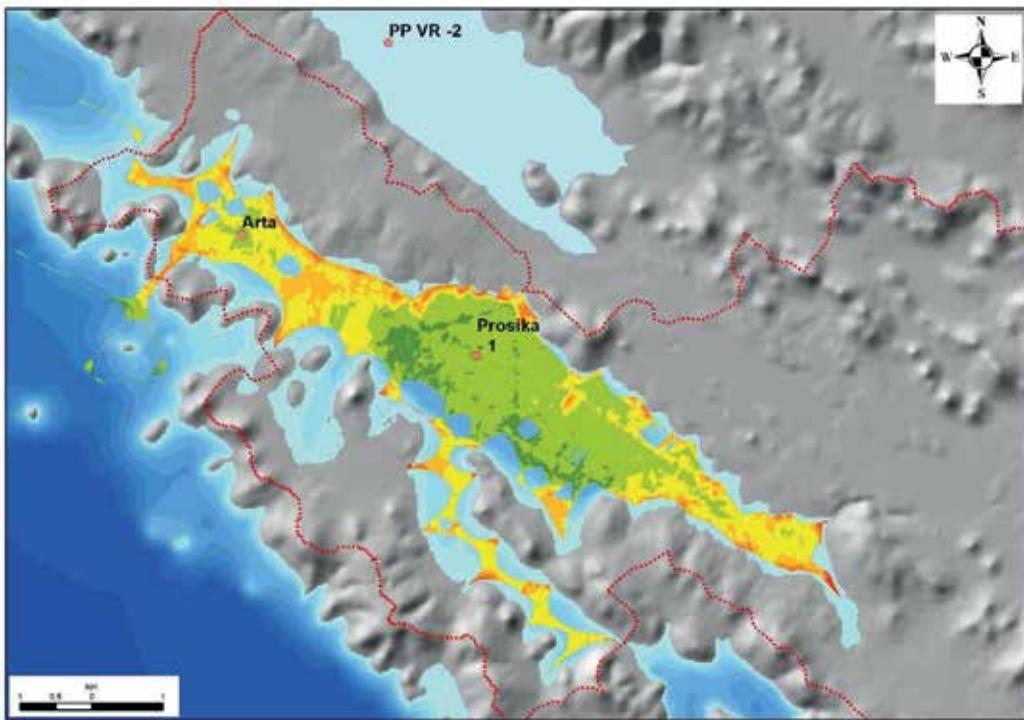
Glavni istraživač / Principal investigator: dr. sc. **Slobodan MIKO**

Istraživanja i aktivnosti vezane za pilot projekt "Geološke karte podmorja" počela su se provoditi 2014. godine kroz projekt EMODnet Geology II i III. Obavljena su geofizička istraživanja geološkim i panoramskim dubinomjerima na području Lošinjskog kanala, Novigradskog mora, Pirovačkog zaljeva i Koločepskog kanala. Ukupno je snimljeno više od 500 km seizmičkih profila. Geofizička istraživanja provedena su u suradnji s kolegama sa Sveučilišta u Patrasu, Grčka (Laboratorij za marinsku geologiju i fizičku oceanografiju te poduzećem Innomar (Njemačka) koja je ustupila geološki dubinomjer za potrebe projekta LoLADRIA. Na istim lokacijama provedena su istražna bušenja, pri čemu je izvađeno više od 20 jezgara na kojima su načinjena datiranja, mikropaleontološke, sedimentološke i

Research and activities related to the pilot project "Geological Maps of the Croatian Adriatic Sea" have initiated in 2014 within the EMODnet Geology II and III projects. Geophysical explorations by subbottom profiler and side-scan sonar have been carried out in the areas of the Lošinj Channel, the Novigrad Sea, the Pirovac Bay, and the Koločep Bay. A total of more than 500 seismic profiles have been recorded. Geophysical explorations were carried out in co-operation with colleagues from the University of Patras, Greece (Laboratory of Marine Geology and Physical Oceanography), and with the Innomar company (Germany), which provided a subbottom profiler for the project Submerged Holocene karst environments: in search for the missing link between the Vrana Lake, the largest lake in Croatia, and the sea. Sediment corings



Geomorfometrijska analiza podmorja oko otoka Mljet  
Geomorphometrical slope analysis of sea bottom surrounding the island of Mljet



Karta morskog dna Pirovačkog zaljeva klasificiranog na temelju pozadinskog odziva panoramskog dubinomjera  
Sea bottom map of Pirovac Bay classified on the basis of background response of the side-scan sonar

geokemijske analize. Time su utvrđeni datumi ingressije mora u pojedine zaljeve i depresije. Nabavkom višesnognog dubinomjera 2018. godine omogućena je izrada geoloških karta navedenih područja u mjerilu 1:25.000, čija se izrada planira do kraja 2023. Upotrebom i analizom seizmičkih profila jadranskog podmorja krenulo se u pripremu geološke karte podmorja (predkvartarnih naslaga) u mjerilu 1:500.000, u suradnji s Agencijom za ugljikovodike. Kako bi se harmonizirala geologija podmorja Jadrana, zemlje koje imaju izlaz na Jadransko more pripremile su sporazum o razumijevanju (EMODnet Adriatic Sea Group) putem kojeg se planira uspostaviti čvršća suradnja između Italije, koja je otisla najdalje u kartiranju podmorja, sa zemljama istočne jadranske obale u kojima je razvoj geološkog kartiranja podmorja u povojima. Provedeno je i regionalno uzorkovanje sedimenata Jadranskog mora u sklopu znanstveno-istraživačkog krstarenja na istraživačkom brodu RV „Poseidon“, tijekom svibnja i lipnja 2017. godine. Znanstveno-istraživačko krstarenje je dio projekta „Mikropaleontologija, aktuopaleontologija i istraživanje okolišne osnovice holocene to i najmlađeg pleistocena u bazenu sjevernog i istočnog Jadranskog mora“

were performed in these locations with more than 20 cores extracted, and dating, micropaleontological, sedimentological, and geochemical analyses were performed. This determined the timing of the marine ingressions into certain bays and depressions. The purchase of a multibeam sonar in 2018 enabled the production of geological maps of these areas at the scale of 1 : 25,000, which is a project to be finished by the end of 2023. With the use and analysis of seismic profiles of the Adriatic Sea, the preparation of a geological map of the sea floor (pre-Quaternary sediments) at the scale of 1 : 500,000 has begun, in co-operation with the Croatian Hydrocarbon Agency. In order to harmonise the geology of the Adriatic Sea, the countries with access to the Adriatic Sea have prepared an understanding treaty (EMODnet Adriatic Sea Group), through which the establishment of stronger cooperation is planned with Italy, which has gone farthest in sea floor mapping, and the eastern Adriatic countries, where geological submarine mapping is in its initial stages. Regional sampling of Adriatic Sea sediments has also been conducted within the scientific-research cruise on the research ship RV "Poseidon", during the period May – June 2017. The scientific-research cruise is part of the project "Micropaleontology, Actuopaleontology, and Environmental Baseline Study of the Holocene to latest Pleistocene in the northern and eastern Adriatic Sea basin".

# Strukturno-geomorfološka karta Republike Hrvatske

## Structural-Geomorphological Map of the Republic of Croatia

Glavni istraživač / Principal investigator: dr. sc. **Ivan HEĆIMOVIĆ**

Autorica teksta / Author of the text: dr. sc. **Koraljka BAKRAĆ**

Glavni cilj strukturno-geomorfoloških istraživanja je utvrđivanje recentnog strukturnog sklopa, izdvajanje i klasificiranje rasjeda i tektonski aktivnih zona te definiranje recentnih struktura i njihovih odnosa. Dolazi se do novih spoznaja o geološkoj građi i neotektonskoj aktivnosti i to ponajprije u terenima u kojima se geološkim kartiranjem ili nekom drugom geološkom metodom ne mogu dobiti adekvatni podatci o strukturnim odnosima. Stoga čine izravnu dopunu OGK RH pa se i dinamika izrade u potpunosti poklapa s planom i programom istraživanja na OGK.

Tako su se u području Slavonije uspjele utvrditi dvije veće morfostrukture te rasjedi duž kojih su ustanovljena i desna horizontalna kretanja. Ustanovljeno je kako Karlovačka depresija predstavlja složenu spuštenu morfostrukturnu jedinicu. U području Istre dobiveni su također vrijedni podaci od kojih su neki do sada bili nepoznati. U reljefu se ističu izdignute morfostrukturne

The main goal of structural-geomorphological research is to determine the recent structural assembly, isolate and classify faults and tectonically active zones, and define recent structures and their relations. New findings on geological material and neotectonical activity are attained, primarily in terrains where geological mapping or other geological methods cannot provide adequate data on structural relations. They thus provide an addition to the BGM of the RH, such that the creation dynamics is completely in line with the plan of research on the BGM.

In Slavonia, two larger morpho-structures have been determined, as well as faults along which dextral horizontal movements have been ascertained. The Karlovac depression was found to represent a complex lowered morpho-structural unit. In Istria, valuable data have also been acquired. Uplifted morpho-structural units and faults stand out in the terrain, indicating their recent activity.

Among the particularly distinguished faults are those of kilometres dimensions, especially those that separate morpho-structural units (e.g. the reverse faults along the Ćićarija Mt.), longitudinal faults with dextral horizontal movements (the Mirna river valley), and the transverse faults with a significant sinistral movement (the Dragonja river valley). The recent structural fabric of the wider Medvednica area is characterised in turn by uplifted and lowered morpho-structures and faults. Eight reversely uplifted morpho-structures and three tectonic grabens have been isolated. Faults of the recent structural assembly are delineated according to type as normal and reverse, along which vertical, but also horizontal tectonic transport occurred. Fault zones along which morpho-structure deformations occurred in the form of sinking, vertical and horizontal movements or rotations of their parts, have also been determined. Fault zones are characterised by numerous geomorphological features, which



Pogled s prapornog strmca na Vukovarsku adu i Dunav (foto L. Wacha)  
View from the loess escarpment toward the Vukovarska ada island and the Danube river (photo by L. Wacha)

jinice i rasjedi, što ukazuje na njihovu recentnu aktivnost. Od rasjeda posebice se iskazuju oni koji su kilometarskih dimenzijsa, osobito oni koji odvajaju morfostrukturne jedinice (npr. reversni rasjedi duž Čićarije), uzdužni rasjedi s desnim horizontalnim kretanjima (dolina Mirne) i poprečni rasjedi sa zamjetnim lijevim kretanjem (dolina Dragonje). Recentni strukturni sklop šireg područja Medvednice obilježavaju pak izdignute i spuštene morfostrukture i rasjedi. Izdvojeno je osam reverzno izdignutih morfostrukura i tri tektonske grabe. Rasjedi recentnog strukturnog sklopa se prema tipu očrtavaju kao normalni i reverzni, duž kojih se odvijao vertikalni, ali i horizontalni tektonski transport. Ustanovljene su i rasjedne zone duž kojih je došlo do deformacija morfostrukura i to u obliku tonjenja, vertikalnih i horizontalnih pomaka ili rotacija pojedinih njihovih dijelova. Rasjedne zone su obilježene brojnim geomorfološkim oblicima, čime je istaknuta njihova recentna tektonska aktivnost, na što upućuju i učestali potresi u tom području.

Projekt je bio financiran od strane MZOŠ-a do 2013. godine, kada je provedba prekinuta zbog prestanka finansiranja Projekata.

highlights their recent tectonic activity, indicated also by frequent earthquakes in that area.

This project was funded by the Ministry of Science, Education and Sports until 2013, when it ceased due to the termination of project financing.



Strukturno – geomorfološka karta Medvednice (I. Hećimović – radni materijal)  
Structural – geomorphological map of Medvednica Mt. (I. Hećimović – work in progress)

# Tektonska karta Republike Hrvatske

## Tectonic Map of the Republic of Croatia

Glavni istraživač / Principal investigator: dr. sc. **Domagoj JAMIČIĆ**

Autorica teksta / Author of the text: dr. sc. **Koraljka BAKRAČ**

Cilj istraživanja na projektu je definiranje strukturno-tektonskih odnosa u području RH, a posebice u dodirnom području panonskih struktura i Dinarida. Dinamika istraživanja vezana je uz dinamiku i obim istraživanja na OGK RH. Tijekom terenskih istraživanja obavljaju se strukturolaška mjerjenja dostupnih elemenata mehaničkih ploha diskontinuiteta i orientacije linearnih i plikativnih elemenata. Najveća pažnja pridaje se strukturnim oblicima nastalim u posljednjim deformacijskim fazama, na temelju čega se određuje geneza njihovog formiranja. Tektonska slika, te međusobni odnosi strukturnih planova, završno se određuju na temelju značajki struktura i vremenskog definiranja njihovog postanka.

Tako je za područje Panonskog bazena ustavljeno da je to područje formirano tijekom pet deformacijskih događaja.



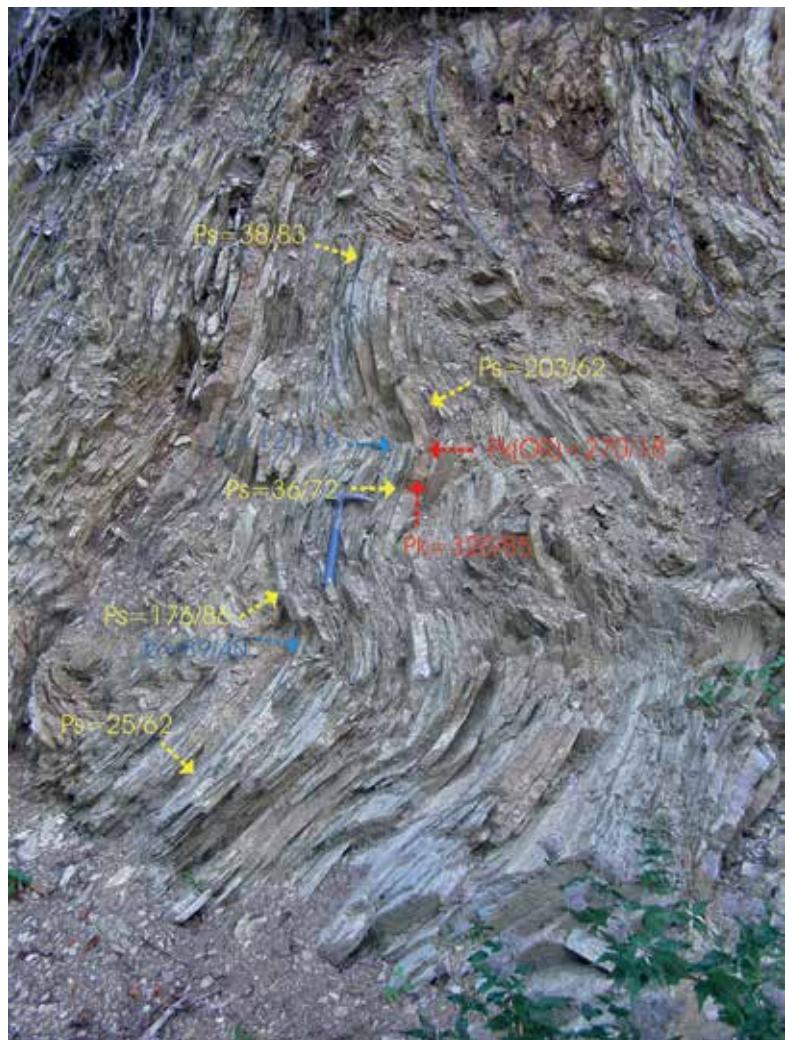
Bore u jurskim vapnencima, Donje Pazarište (priredio R. Filjak)  
Folds in Jurassic limestones, Donje Pazarište (prepared by R. Filjak)

The aim of the research on the project is the definition of structural-tectonic relations on the territory of the Republic of Croatia (RH), particularly in the contact area of Pannonian Basin and the Dinarides. The research is tied to the dynamics and scope of research of the BGM of the RH. During the field research, structural measurements of available elements at mechanical discontinuity surfaces and the orientation of linear and plicative elements are performed. The largest amount of attention is paid to structural shapes created in the last deformational phases to determine the genesis of their formation. The tectonic image and the mutual relations of structural plans are finally determined based on structure characteristics and the temporal definition of their genesis.

Findings showed that the Pannonian Basin area was formed during five deformational events. Research carried out on Žumberak Mt., in Gorski kotar, partly in Istria, and on some Adriatic islands determined three deformational events whose orientations of the principal stress axis are mutually inclined. The oldest determined stress acted in the approximate E-W direction at the time of Upper Cretaceous and the Paleogene period, and the results of its effect are significantly conjugated systems of strike-slip faults and rare folded structures of eastern vergence. The youngest event is related to the Pyrenean phase of Alpine orogeny, when significant folded structures of NW-SE strike and SW vergence appear under the influence of regional stress from the NE-SW direction. The transpression and NE-SW contraction of the Adriatic carbonate platform (ACP) are followed by strike-slip faults of sinistral and dextral movements with reverse faults of NW-SE strike. The NE area is characterised by slightly

Provedenim istraživanjima na Žumberku, u Gorskem kotaru, dijelom u Istri, te na nekim jadran-skim otocima, ustanovljena su tri deformacijska događaja čije orientacije glavne osi stresa stoje međusobno pod kutom. Najstariji ustanovljeni stres je djelovao na približnom pravcu I-Z u vrijeme gornje krede i paleogena, a rezultat njegovog djelovanja su značajni konjugirani sustavi strike-slip rasjeda i rijetke borane strukture istočne vergencije. Mlađi događaj je vezan za pirenejsku fazu alpinske orogeneze kada nastaju, pod utjecajem regionalnog stresa iz smjera SI-JZ, značajne borane strukture pružanja SZ-JI i JZ vergencije. Transpresiju i SI-JZ kontrakciju Jadranse karbonatne platforme (JKP) prate strike-slip rasjedi lijevih i desnih pomaka uz reverzne rasjede pružanja SZ-JI. SI područje karakterizira blago borane strukture, a JZ dijelove jače izdignuti i snažnije borani oblici. Treći deformacijski događaj djeluje na pravcu S-J, uz lokalna manja odstupanja, u vrijeme neotektonskе faze alpinske orogeneze. Stres karakteriziraju pomaci uz desne rasjede koji koriste povoljno orientirane starije rasjedne plohe reverznih rasjeda pružanja SZ-JI. Rijetko se javljaju borane strukture i one su uglavnom južne vergencije.

Projekt je bio financiran od strane MZOŠ-a do 2013. godine, kada je provedba prekinuta zbog prestanka financiranja zProjekata.



Borani siliti, donja kreda, Selce Žumberačko (priredio R. Filjak)  
Folded siltite, Lower Cretaceous, Selce Žumberačko (prepared by R. Filjak)

folded structures, and the SW parts by more uplifted and more strongly folded shapes. The third deformational event acts on the N-S strike, with minor local deviations, at the time of the neotectonic phase of Alpine orogeny. The stress is characterised by movements along dextral faults that reactivated favourably oriented older fault surfaces of reverse faults of the NW-SE strike. Folded structures rarely appear and are mostly of southern vergence.

This project was funded by the Ministry of Science, Education and Sports until 2013, when it ceased due to the termination of zProject financing.

# Stratigrafska naslaga krede u okviru geodinamike jadranskog područja Hrvatske

## Stratigraphy of Cretaceous Deposits in the Framework of the Geodynamics of the Croatian Adriatic Area

Glavni istraživač / Principal investigator: dr. sc. **Tvrko KORBAR**

Ovaj znanstveni projekt financiralo je Ministarstvo znanosti, obrazovanja i športa od 2007. do 2014. godine (MZOS br. 181-1191152-2697), a prijavljen je u okviru programa "Geološka evolucija krške i jadranske Hrvatske" (voditelj prof. dr. sc. Mladen Juračić, PMF-GPZ). U projektu su sudjelovali sljedeći istraživači: Tvrko Korbar (HGI-CGS), Blanka Cvetko-Tešović (PMF), Bosiljka Glumac (SAD), Vladimir Jelaska (Zagreb), Thomas Ste-

This scientific project was financed by the Ministry of Science, Education, and Sports (MSES) in the period 2007–2014 (no. 181-1191152-2697), and it was implemented within the programme "Geological evolution of karst and Adriatic Croatia" (with prof. Mladen Juračić, PhD, PMF-GPZ as the principal investigator). The following researchers participated in the project: Tvrko Korbar (HGI-CGS), Blanka Cvetko-Tešović (PMF), Bosiljka Glumac (USA),



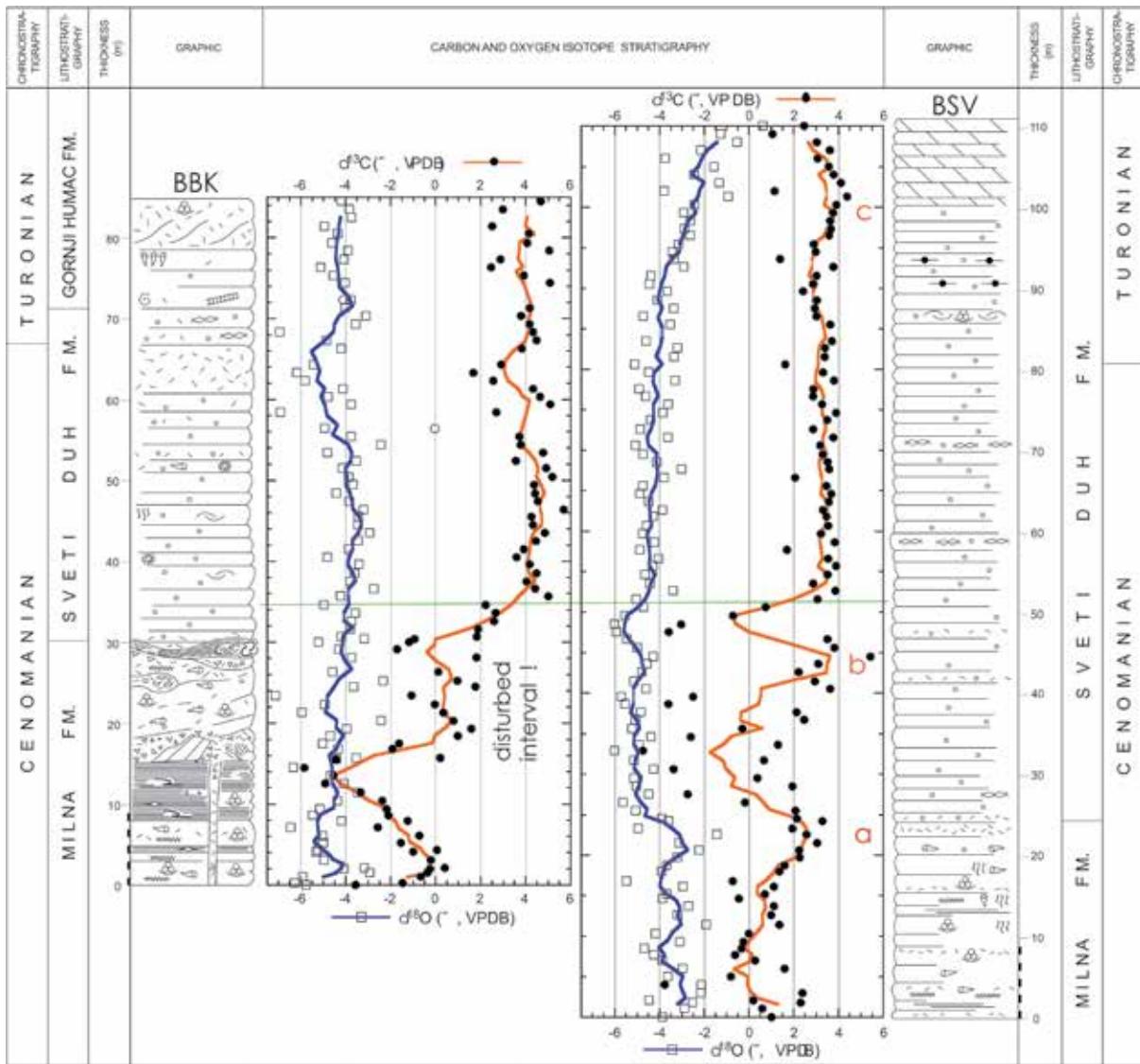
Suradnici tijekom terenskih istraživanja  
Associates during fieldwork

uber (UAE), Mihovil Brlek (HGI-CGS), stručni savjetnici Ladislav Fuček (HGI-CGS) i Nenad Oštrić (HGI-CGS) te crtači i laboratorijski tehničari Zavoda za geologiju (HGI-CGS).

Ukupno je realizirano 255 dana terenskih istraživanja, a suradnici su aktivno sudjelovali na 17 znanstvenih skupova i objavili 16 znanstvenih radova u WoS časopisima. Potvrđeno je da su neki regionalni i globalni geološki događaji ostavili zapise u krednim naslagama na području istraživanja pa su isti upotrebljivi za stratigrafsku korelaciju i korekciju kronostratigrafi-

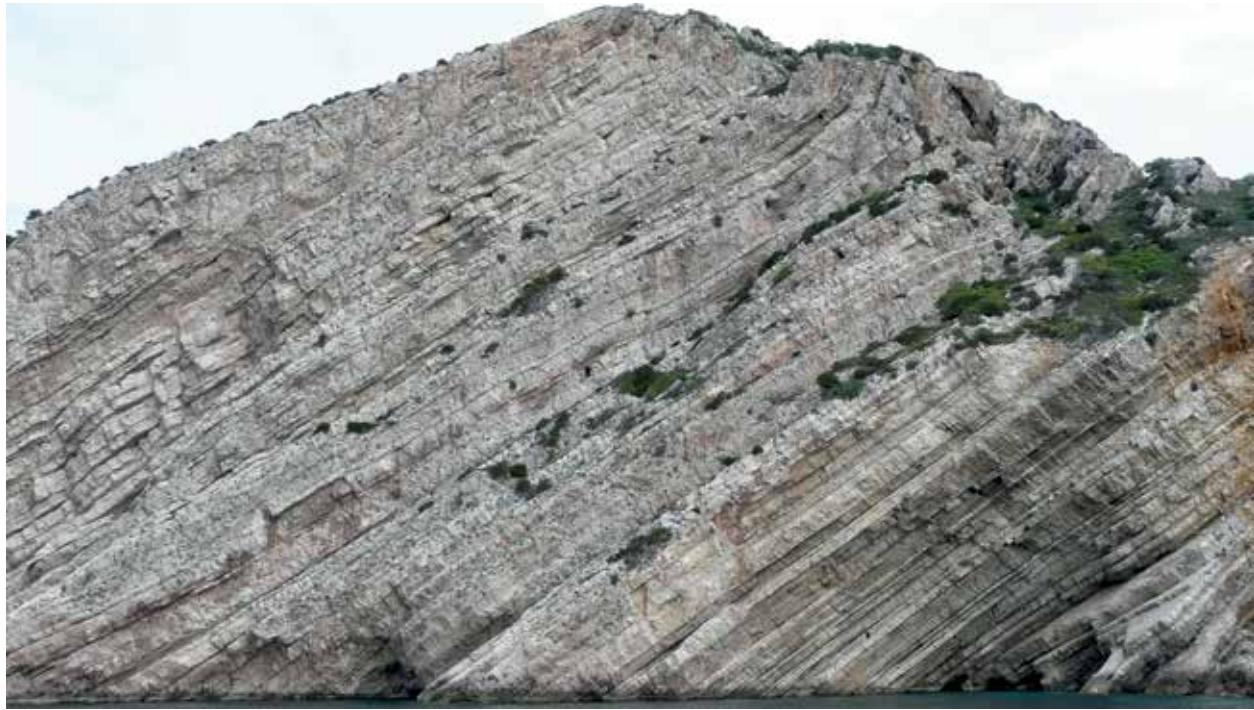
Vladimir Jelaska (Zagreb), Thomas Steuber (UAE), Mihovil Brlek (HGI-CGS), professional advisors Ladislav Fuček (HGI-CGS) and Nenad Oštrić (HGI-CGS), and technical staff of the Department of Geology (HGI-CGS).

A total of 255 fieldwork days were realised, and the associates actively participated in 17 scientific conferences and published 16 scientific papers in WoS journals. Some regional and global geological events were confirmed to have left traces in Cretaceous sediments within the research area that can be used for

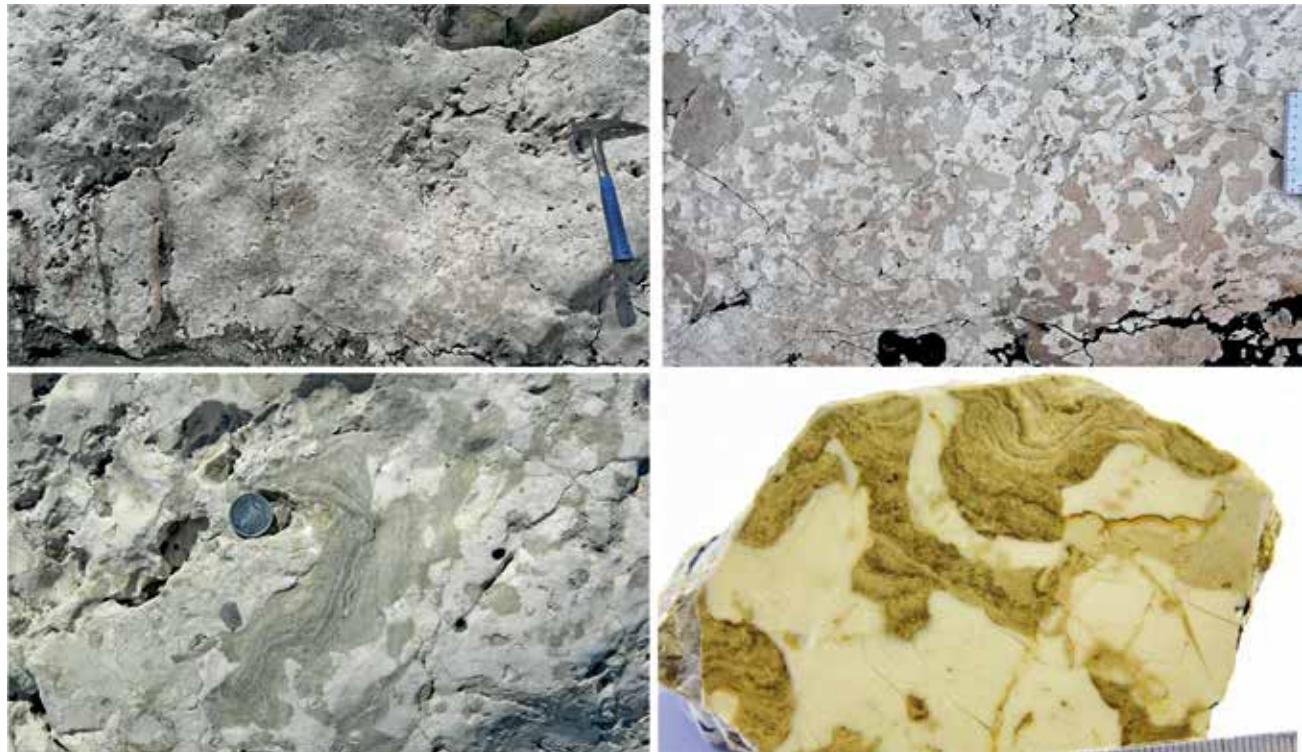


Kemostratigrafska korelacija karbonatnih naslaga cenomana i turona otoka Brača (iz Korbar et al., 2012)

Chemostratigraphical correlation of Cenomanian and Turonian carbonate deposits of the island of Brač (from Korbar et al., 2012)



Slijed plitkovodnih karbonata donje krede na otoku Svecu (Sveti Andrija)  
Sequence of shallow-marine Lower Cretaceous sediments on the island of Svetac (Sveti Andrija) (photo by T. Korbar)



Fotografije kompozitnih površina diskontinuiteta unutar naslaga formacije Gornji Humac kod Šibenika (Brlek et al., 2014)  
Photographs of composite discontinuity surfaces within deposits of the Gornji Humac formation near Šibenik (from Brlek et al., 2014)



Panoramska fotografija uvale Majerovica i punte Kovač (grad Hvar, vidi Korbar et al., 2015) (foto G. Bruce)

Panoramic photographs of the Majerovica Bay and Cape Kovač (the town of Hvar, see Korbar et al., 2015) (photo by G. Bruce)

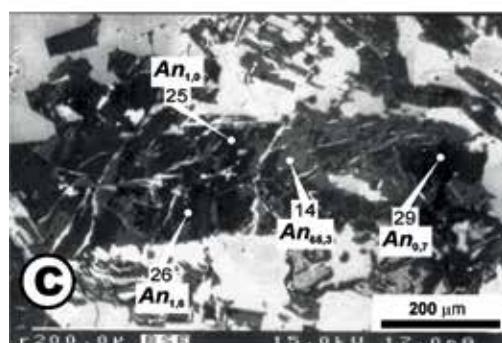
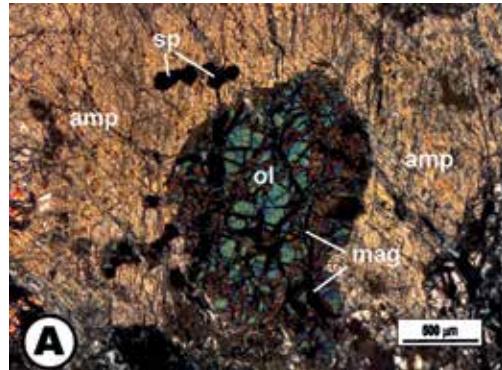
je. Unaprijeđena stratigrafska korelacija omogućuje regionalnu analizu geodinamike s većom rezolucijom, što dodatno rasvjetljava povezanost lateralnih facijesnih razlika i pojačane geodinamike tijekom gornje krede. Prikaz regionalne rasprostranjenosti pojedinih gornjokrednih formacija iznimno je važan za rekonstrukciju orogeneze Dinarida. Definirane su i nove litostratigrafske jedinice, čime se izravno pridonijelo pripremi za izradu litostratigrafske karte u okviru izrade OGK RH 1:50.000. Naglašen je i značaj različitih vrsta površina diskontinuiteta koji se pojavljuju u karbonatnim naslagama za genetske, paleookolišne i stratigrafske interpretacije. Istražen je i neuobičajeni zapis globalnog impaktnog događaja na granici krede i paleogen u slijedu plitkovodnih naslaga otoka Hvara, koji ima dalekosežne implikacije na rekonstrukciju paleogeografije JZ ruba Jadranse karbonatne platforme, a moguće i zapadnog Tetisa.

stratigraphical correlation and correction of chronostratigraphy. Improved stratigraphical correlation enables regional analysis of geodynamics at higher resolution, which additionally clarifies the connection of lateral facies differences and intensified geodynamics during the Upper Cretaceous. The display of regional distribution of certain Upper Cretaceous formations is extremely important for the reconstruction of the Dinarides' orogeny. New lithostratigraphical units have also been defined, thus directly contributing to the preparation for the creation of the lithostratigraphical map within the production of the Basic geological map of the Republic of Croatia (RH) at the scale of 1 : 50,000. Moreover, the importance of different types of discontinuity surfaces that appear in carbonate sediments for genetic, paleoenvironmental, and stratigraphical interpretations is underlined. An unusual record of a global impact events at the turn of the Cretaceous and the Paleogene period has also been explored in the sequences of shallow-marine sediments of the island of Hvar. This has far-reaching implications for the reconstruction of paleogeography of the SW edge of the Adriatic carbonate platform, possibly also of the western Tethys.

# Mezozojske magmatske, plaštne i piroklastične stijene sjeverozapadne Hrvatske

## Mesozoic Magmatic, Mantle and Pyroclastic Rocks of the NW Croatia

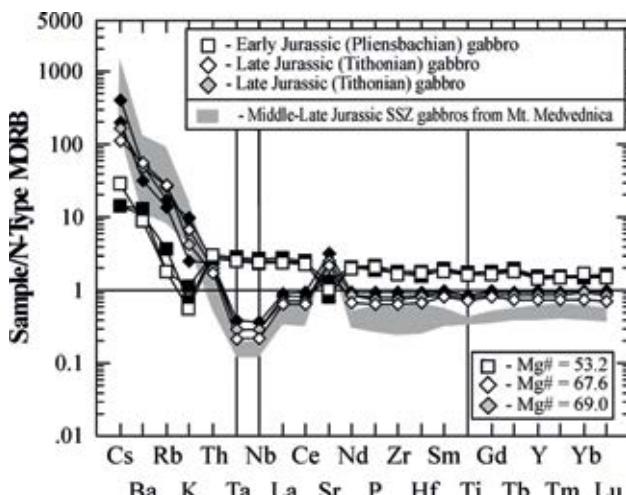
Glavni istraživač / Principal investigator: dr. sc. **Damir SLOVENEC**



This project explored mantle, magmatic, and pyroclastic rocks of the Mesozoic age outcropping in the areas of Medvednica, Šimonska gora, Kalnik, Ivančica, Strahinjčica, Desinić, Kuna gora, and Ravna gora mountains. They represent parts of magmatic-sedimentary successions and complexes belonging to various phases of the Alpine orogenic cycle. Research was based on mineralogical-petrological-geochemical and isotope data from magmatic and pyroclastic rocks, and on sedimentological and biostratigraphical analyses of sediments associated with them. Research results enable the description of their genesis and the timings of magma genesis, as well as recognition of the primordial geotectonic regime and the provenances of magma genesis and positions. Finally, this data can provide the reconstruction of geodynamic evolution of the research area as an integral part of the NW Mesozoic Tethys. This includes records of volcanic activity connected with subduction of Paleotethys lithosphere beneath the active European continental margin during the Middle Triassic, and the approximately contemporary magmatic activity connected with the initial intracontinental rifting in the NW Tethys area. From the late Middle Triassic until the middle of the Jurassic, the research area was characterised by oceanisation

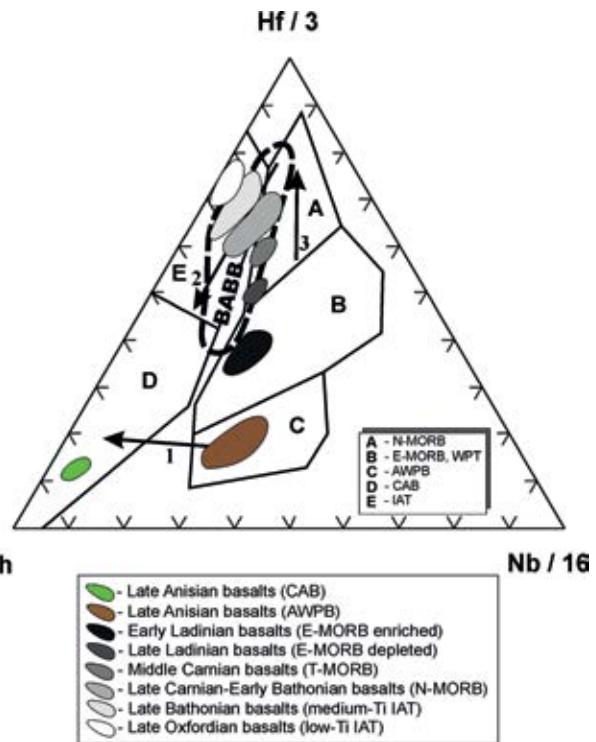
Mikrofotografije (A) kumulativnog amfibolskog lercolita (Kamešnica potok, Kalnik); N+; (B) ofitnog bazalta (Kraljev vrh, Medvednica); N+. Legenda: amp – amfibol, cpx – klinopiroksen, mag – magnetit, ol – olivin, pl – plagioklas, sp – spinel. (C) Slika bazalta snimljena pomoću povratno raspršenih elektrona (BSE) pokazuje albitizirane dijelove (crno obojeno) zrna bazičnog plagioklaza (sivo obojeno); (Bistra potok, Medvednica)

Microphotography of the (A) amphibole cumulate lherzolite (Kamešnica creek, Kalnik Mt.); N+; (B) ophitic basalt (Kraljev vrh, Medvednica Mt.); N+. Legend: amp – amphibole, cpx – clinopyroxene, mag – magnetite, ol – olivine, pl – plagioclase, sp – spinel; (C) Back-scattered electron (BSE) image of the basalt showing albitized parts (black coloured) of basic plagioclase grain (grey coloured) (Bistra creek; Medvednica Mt.)



Spider dijagram normaliziran na N-MORB (Sun & McDonough, 1989) za gabroide stijene Kalnika

N-MORB normalized (Sun & McDonough, 1989) multielement patterns (spider diagram) for the Kalnik Mt. gabbroic rocks



Diskriminacijski dijagram za ekstruzivne i piroklastične stijene Kalnika i Ivanščice. Th – Nb/1– Hf/diagram (Wood, 1980). A – normalni bazalți srednjooceanskog hrpta (N-MORB); B – obogaćeni MORB (E-MORB) i toleiti unutar ploče (WPT); C – alkalinski bazalți unutar ploče (AWPB); D – kalc-alkalinski bazalți (CAB); E – toleiti otočnog luka (IAT); – kontaminacija korom; – trend ofiolita iz suprasubdukcione zone; – trend MORB ofiolita

Discrimination diagram for the extrusive and pyroclastic rocks from the Mts. Kalnik and Ivanščica. Th – Nb/1– Hf/diagram (Wood, 1980). A – normal mid-ocean ridge basalts (N-MORB); B – enriched MORB (E-MORB) and within-plate tholeites (WPT); C – alkaline within-plate basalts (AWPB); D – calc-alkali basalts (CAB); E – island-arc tholeites (IAT); – crustal contamination; – SSZ ophiolites trend; – MORB ophiolites trend

Projektom su istraživane plaštne, magmatske i piroklastične stijene mezozojske starosti koje izdanjuju na području Medvednice, Samoborske gore, Kalnika, Ivanščice, Strahinjščice, Desinić i Kuna gore, te Ravne gore. One predstavljaju dijelove magmatsko-sedimentnih sukcesija i kompleksa koji pripadaju različitim fazama alpinskog orogenskog ciklusa. Istraživanja su temeljena na mineraloško-petrološko-geokemijskim i izotopnim podatcima magmatskih i piroklastičnih stijena, te sedimentološkim i biostratigrafskim analizama s njima udruženih sedimenata. Rezultati istraživanja omogućuju definiranje njihove geneze i vremena generiranja magmi, kao i prepoznavanje iskonskog geotektonskog režima i provenijencija nastanka i smještanja magmi, te u konačnici rekonstrukciju geodinamske evolucije istraživanog područja, kao sastavnog dijela SZ mezozojskog Tetisa. Navedeno uključuje zapise o vulkanskoj aktivnosti povezanoj sa subdukcijom paleotetiske litosfere ispod aktivnog europskog kontinentalnog ruba tijekom srednjeg trijasa, te približno istovremenu magmatsku aktivnost vezanu za inicijalno intrakontinentalno riftovanje u području SZ Tetisa. Od kasnog srednjeg trijasa do sredine jure istraživani prostor karakterizira oceanizacija uz generiranje oceanske litosfere ofiolitnog tipa. U kasnoj srednjoj juri započinje intraoceanska subdukcija i formiranje zalučnog bazena u kojem se kontinuirano generira kora oceanskog tipa čiji nastanak traje i u donjoj kredi. Istraživani oceanski prostor tijekom srednjojurskog-do-

with the generation of an oceanic lithosphere of the ophiolitic type. In the late Middle Jurassic, the intraoceanic subduction commenced and the formation of a back-arc basin, where the oceanic type crust, whose formation lasted also throughout the Lower Cretaceous, was continually generated. During the Middle Jurassic-Lower Cretaceous period, the explored oceanic area was characterised by contraction and the consequent formation of ophiolitic melanges. The correlation of obtained results with the results of similar magmatic complexes in the area of the Pannonian Basin, the Dinarides, and the Alps provides a wider regional significance of the Mesozoic mantle, magmatic, and pyroclastic rocks of NW Croatia. The research results are presented within

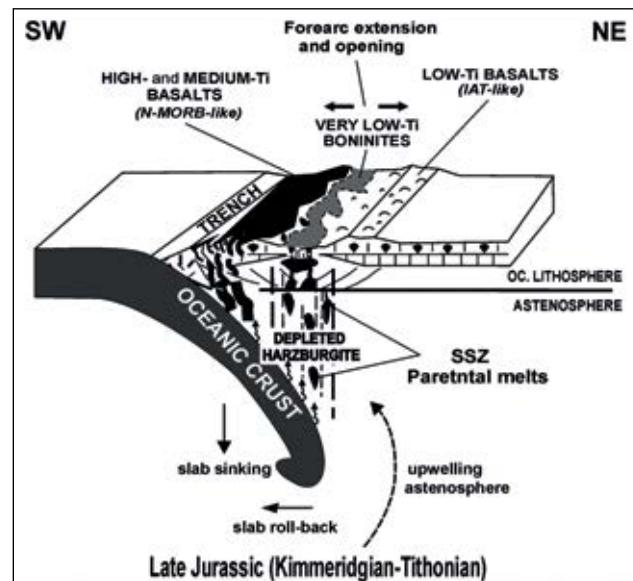
njokrednog razdoblja obilježen je sažimanjem i posljedično formiranjem ofiolitnih melanža. Koreliranjem dobivenih rezultata s rezultatima sličnih magmatskih kompleksa na području Panonskog bazena, Dinarida i Alpa dobiven je širi regionalni značaj mezozojskih plaštnih, magmatskih i piroklastičnih stijena sjeverozapadne Hrvatske. Rezultati istraživanja prikazani su kroz niz znanstvenih publikacija: [https://www.bib.irb.hr/pregled/projekti/181-1951126-1141?order\\_by=year\\_desc&page=1](https://www.bib.irb.hr/pregled/projekti/181-1951126-1141?order_by=year_desc&page=1).

Shematski geodinamski model razvoja suprasubdukcjske oceanske litosfere u sjeverozapadnom dijelu

Dinaridsko-vardarskog Tetisa

Schematic geodynamic model of suprasubduction oceanic lithosphere development in the north-western branch of Dinaric-Vardar Tethys

a number of scientific publications: [https://www.bib.irb.hr/pregled/projekti/181-1951126-1141?order\\_by=year\\_desc&page=1](https://www.bib.irb.hr/pregled/projekti/181-1951126-1141?order_by=year_desc&page=1).



# Holocenski sedimenti kao zapis promjena u okolišu jadranskih sljevova

## Holocene Sediments as a Record of Environmental Changes in Adriatic Catchments

Glavni istraživač / Principal investigator: dr. sc. **Georg KOCH**

Autor teksta / Author of the text: dr. sc. **Slobodan MIKO**

Temeljni cilj istraživanja u sklopu projekta je razumijevanje složene geneze i svih varijacija u procesu nastanka recentnih i subrecentnih sedimenata na temelju višedisciplinarnih znanstvenih istraživanja uz korištenje modernog metodološkog pristupa. Zapis zbivanja u holocenskim jezerskim sedimentima je izvor podataka o prošlim reakcijama okoliša na promjene klime i upotrebe zemljišta, a dobiveni podatci mogu bitno doprinijeti modeliranju budućih promjena u okolišu. U sklopu ovog multidisciplinarnog projekta zajedno su se pri interpretaciji koristili rezultati mikropaleontologije, mineralogije i geokemije sedimenata (marinskih, jezerskih i aluvijalnih). Kako bi se doš-

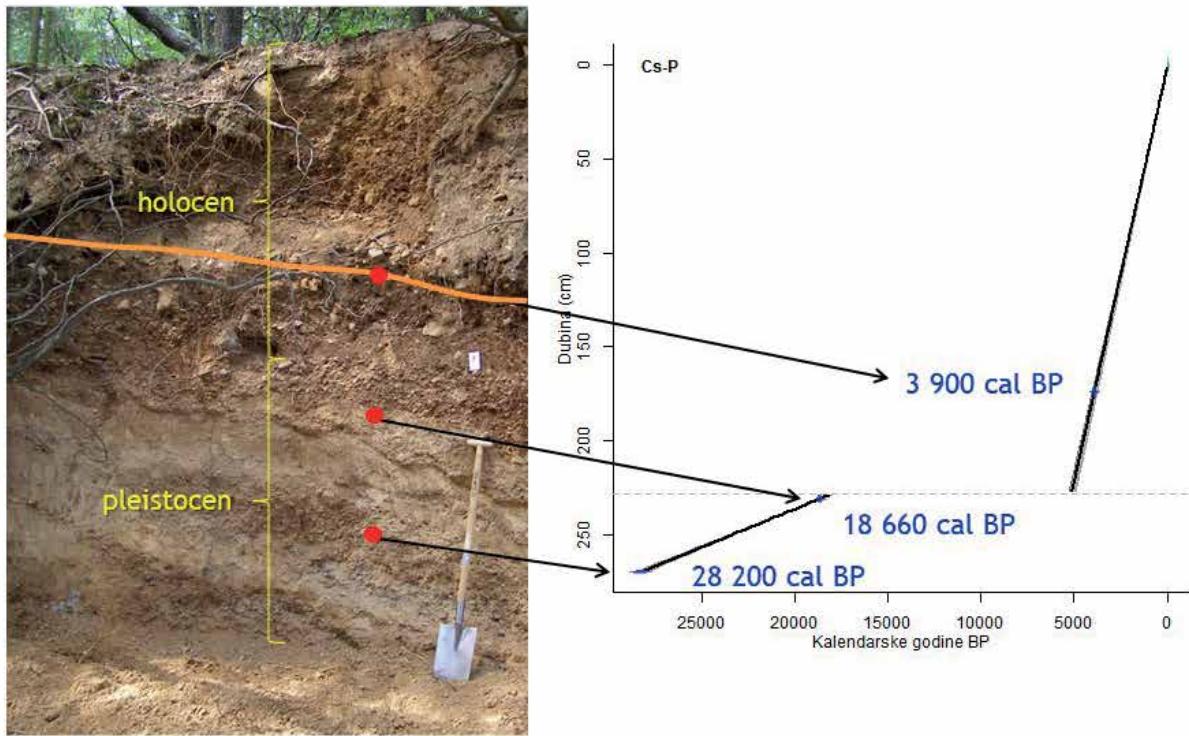
The basic research aim of the project is the understanding of the complex genesis and variations in the formation processes of recent and sub-recent sediments based on multidisciplinary scientific research using a modern methodological approach. Records of events in Holocene lake sediments provide a source of data on past environmental reactions to climate and land use changes, and the acquired data can significantly contribute to the modelling of future changes in the environment. The results of micro-paleontology, mineralogy, and geochemistry of sediments (marine, lake, and alluvial) were used jointly for interpretation within this multidisciplinary project. In order to obtain usable samples



Vransko jezero na Cresu, pogled s južne strane (foto I. Razum)  
Vrana Lake on the island of Cres, the view from the south (photo by I. Razum)



Uzorkovanje kopnenih sedimenata uzorkovanih pomoću udarne bušilice Cobre, u aluvijalnoj ravnici na južnom dijelu Vranskog jezera (foto N. Ilijanić)  
Sampling of the terrestrial sediments from the alluvial fan on the southern shores of the Vrana Lake, cored by Cobra drilling equipment (photo by N. Ilijanić)



Profil tla u koritu povremenog potoka na južnim obalama Vranskog jezera, s utvrđenim starostima po dubini profila (izradila N. Ilijanić)  
Soil profile from the periodical stream on the southern shores of the Vrana Lake, with determined ages and time span throughout the profile (prepared by N. Ilijanić)

lo do upotrebljivih uzoraka za ovakve rekonstrukcije, nužno je obaviti uzorkovanje na lokacijama koje zadovoljavaju okolišne uvjete sačuvanja akumulacije polena u anoksičnim uvjetima te mali ili nikakav prinos sedimenata kroz sredinu (akumulacijski prostori bez površinskog otjecanja). Takvi uvjeti zadovoljeni su na 15-ak lokacija u jadraskom dijelu RH. U različitim fazama projekta istraživane su sljedeće lokacije: 1. Čepić polje, 2. Vransko jezero na Cresu, 3. Kolansko blato na Pagu, 4. Veliko blato na Pagu, 5. Novigradsko more, 6. Bokanjačko blato, 7. Pirovački zaljev, 8. Morinjski zaljev, 9. Blatsko polje na Korčuli, 10. Baćinska jezera, i 11. Prološko blato.

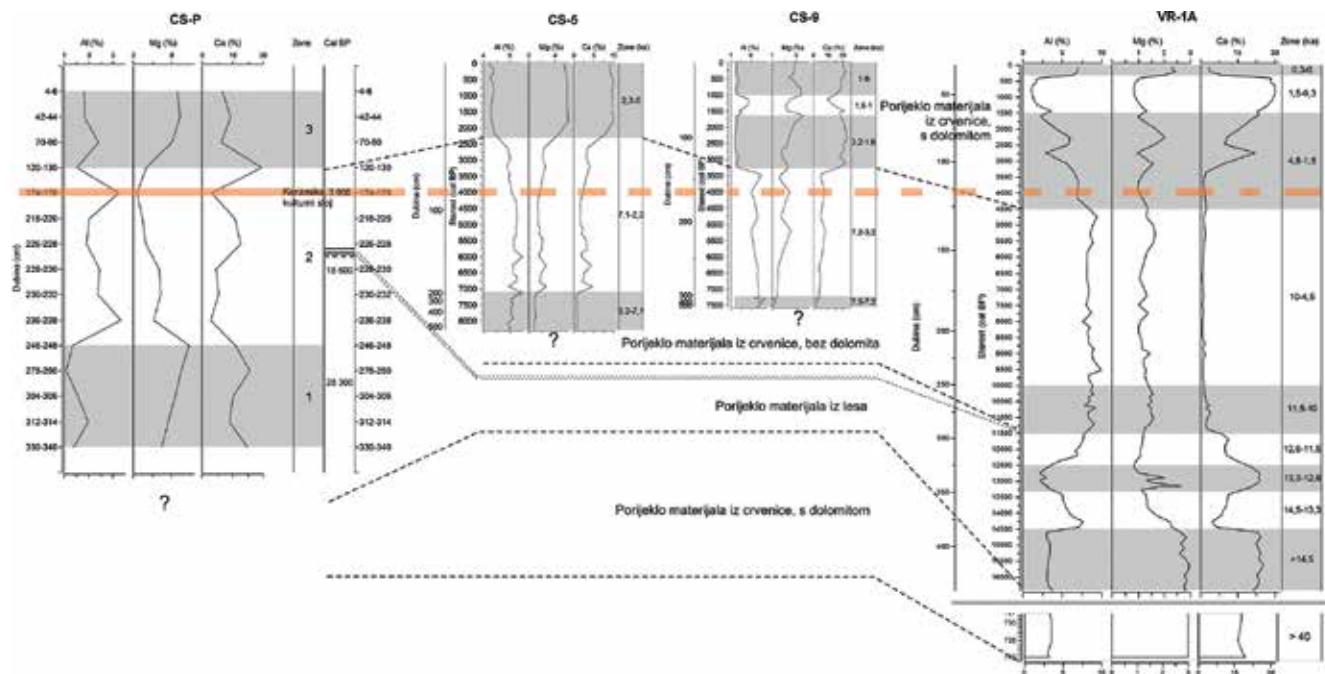
Lokaliteti koji su dobri dijelom uzorkovani su prostori Čepić polja, Vranskog jezera na Cresu, poplavno/ponorne zone Ličkog polja, Bokanjačko blato i Blatsko polje na Korčuli. Od navedenih područja obrađena su Vransko jezero na Cresu te ponorna zone Ličkog polja, a naknadno je uvršten prostor Kolanskog blata na Pagu. Tijekom 2009. godine nabavljen je platforma za uzimanje nepormećenih uoraka sedimenata pomoću klipnog jezgrila „NIEDERREITER 60“ dužine 3 m, s

for such reconstructions, it is necessary to perform sampling in locations that satisfy environmental conditions of pollen accumulation preservation in anoxic conditions and a small or no transport of sediment through the environment (accumulation areas without surface runoff). Such conditions were met in around 15 locations in the Adriatic part of Croatia. In various phases of the project, the following locations were explored: 1. Čepić polje, 2. Vrana Lake on the island of Cres, 3. Kolansko blato on the island of Pag, 4. Veliko blato (Pag), 5. the Novigrad Sea, 6. Bokanjačko blato, 7. Pirovac Bay, 8. Morinj Bay, 9. Blatsko polje on the island of Korčula, 10. Baćina Lakes, and 11. Prološko blato.

The sites sampled to a larger extent were the areas of Čepić polje, the Vrana Lake on Cres, the flood/sinkhole zone of Ličko polje, Bokanjačko blato, and Blatsko polje on Korčula. Among these areas, the Vrana Lake on Cres and the sinkhole zone of Ličko polje were analysed, and subsequently the area of Kolansko blato on Pag. In 2009, the platform for extracting undisturbed sediment samples using the "NIEDERREITER 60" 3 m long piston corer was purchased, with the possibility of sampling a 12 m sediment pro-

mogućnošću uzorkovanja 12 m profila sedimenta. Uz to je provedena i obuka za upotrebu gravitacijskog korera dužine 60 cm. Rezultati ovog projekta korišteni su u disertaciji N. Ilijanić (2014) kojom je obrađen nastanak Vranskog jezera na Cresu, Bokanjačkog blata, Vranskog jezera kod Biograda i Baćinskih jezera.

The training for the use of a 60 cm gravity corer was also completed. The results of these projects were used in the PhD thesis of N. Ilijanić (2014), in which the genesis of the Vrana Lake on Cres, Bokanjačko blato, the Vrana lake near Biograd, and Baćina lakes was analysed.



Usporedba profila tla (CS-P) i jezgri iz aluvijalne ravnice (CS-i 9) s jezgrom sedimenata iz središnjeg dijela Vranskog jezera s utvrđenim geokemijskim karakteristikama i mogućim izvorom materijala (izradila N. Ilijanić)

Comparison of the soil profile (CS-P) and cores from the alluvial fan (CS-and 9) in the southern part of the Vrana Lake with lake sediments from the central part of the lake with geochemical characteristics and proposed source material (prepared by N. Ilijanić)

# Stratigrafska evolucija trijasa Hrvatske

## Stratigraphic Evolution of the Triassic in Croatia

Glavni istraživač / Principal investigator: dr. sc. **Tonći GRGASOVIĆ**

Cilj ovog projekta bilo je multidisciplinarno istraživanje trijaskih naslaga Hrvatske, posebno naslaga srednjeg trijasa, doba velikih geoloških promjena. Istraživanja lokaliteta u sjevernoj Hrvatskoj (Žumberak, Medvednica, Ivanščica) pokazala su vulkanogeno-sedimentni slijed spuštenih blokova kontinentalnog ruba te razbijene nekompletne ophiolitne bazenske sekvencije, no zbog složenih tektonskih odnosa u tom području težište istraživanja je premješteno u Liku, gdje se kao najintere-

The aim of this project was multidisciplinary research of the Triassic deposits in Croatia, especially of the Middle Triassic, the time of significant geological changes. The research conducted on sites in northern Croatia (Žumberak, Medvednica and Ivanščica Mts.) has shown volcanogenic-sedimentary sequences of lowered continental margin blocks and broken incomplete ophiolite basin sequences. However, because of complex tectonic relations within the area, the research focus was moved to Lika, where the Donje Pazarište region was found to be the most interesting. The Middle Triassic deposits in that region display the facies development of an intra-platform basin, a slope, and a platform margin. Several zones of pyroclastic rocks are present, and in the lower part of the sediments a basalt zone with appearances of pyroclastic breccia was isolated. Ten lithostratigraphic units, characteristic for certain facies, were isolated. Along with the recording of geological columns and profiles, geological mapping of the entire area was also performed with the purpose of analyses of paleoenvironments and their lateral and vertical relations. Rich



Gornjotrijaski stromatolitni dolomiti – Velika Plana, Donje Pazarište  
Upper Triassic stromatolithic dolomites – Velika Plana, Donje Pazarište



Ladinički pločasti i nodulasti vapnenac s proslojcima piroklastita  
– Donje Pazarište  
Ladinian platy and nodular limestone interbedded with pyroclastite  
– Donje Pazarište



*Cymoplia barbata* (San Salvador, Bahami), živući srodnik fosilnih dazikladalnih algi  
*Cymoplia barbata* (San Salvador, Bahamas), a living relative of fossil dasyclad algae



Gornjotrijaski "Glavni dolomit" Žumberka  
Upper Triassic "Main Dolomite" of Žumberak Mt.

santnije pokazalo područje Donjeg Pazarišta. Naslage srednjeg trijasa na ovom području pokazuju razvoj facijesa intraplatformnog bazena, padine i ruba platforme. Prisutno je nekoliko zona piroklastičnih stijena, a u donjem dijelu naslaga izdvojena je zona bazalta s pojавama piroklastičnih breča. Izdvojeno je deset litostratigrafskih jedinica koje su karakteristične za pojedine facijese. Uz snimanje geoloških stupova i profila, obavljen je geološko kartiranje čitavog područja u svrhu analize paleookoliša i njihovih bočnih i vertikalnih odnosa. Prikupljen je bogat paleontološki materijal (vapnenačke alge, foraminifere, palinomorfe, konodonti, radiolarije) koji omogućuje preciznu korelaciju istraživanih naslaga. Obavljena su i detaljna geokemijska istraživanja.

Sredstva planirana za putovanja u inozemstvo iskorištena su posjetom otoku San Salvador (Bahami) gdje su istraživane recentne vapnenačke alge u cilju usporedbe s fosilnim srodnicima, naročito sa stanovišta produkcije sedimenta i njihovog životnog okoliša.

Do sada objavljeni radovi obrađuju uglavnom biostratigrafiju istraženog područja, vapnenačke alge i radiolarite.

paleontological material (calcareous algae, foraminifera, palynomorphs, conodonts, and radiolaria) that enables precise correlation of investigated sediments, was acquired. Detailed geochemical research was also performed.

Funds allocated for travel abroad were used to visit the island of San Salvador (Bahamas), where recent calcareous algae were studied in order to compare them with their fossil relatives, particularly in terms of sediment production and their living environments.

The published papers mostly deal with biostratigraphy of the studied area, calcareous algae, and radiolaria.

# Građa facijesa i sekvencijalna stratigrafija promina formacije u Dalmaciji

## Facies Architecture and Sequence Stratigraphy of the Promina Formation in Dalmatia

Glavni istraživač / Principal investigator: dr. sc. **Dubravko MATIČEC**

Autorica teksta / Author of the text: dr. sc. **Koraljka BAKRAČ**

Istraživanja su potvrdila očekivanu vertikalnu i lateralnu varijabilnost facijesa. U jugoistočnom dijelu Prominskog bazena tj. u području kanjona Krke utvrđeno je 5 lithostratigrafskih jedinica, a u sjeverozapadnom dijelu bazena 7 lithostratigrafskih jedinica. Slijed naslaga u području kanjona Čikole je najvećim dijelom izgrađen od sedimenata nastalih taloženjem iz debrinih tokova i gustih turbiditnih tokova. U području kanjona Krke i sjeverozapadnom dijelu bazena utvrđeno je nekoliko transgresivnih i regresivnih sistemskih traktova. Regresivni traktovi se sastoje od facijesa šljunčanih delta, plaže i prepletenih rijeka dok transgresivne traktove karakteriziraju pješčani i muljni facijesi obalnog lica i vanjskog šelfa. Jedinicu *Benkovački kamen* karakterizira prisutnost izuzetno brojnih i dobro očuvanih tipova ihnofosila. Iako su naslage taložene na plitkom šelfu, značajan dio ihnotragova pripada dubokomorskoj zajednici *Nereites*, što dovodi u sumnju ihnozajednice kao pouzdani batimetrijski in-

Research has confirmed the expected vertical and lateral facies variability. In the south-eastern part of the Promina basin, i.e. in the Krka canyon area, five lithostratigraphic units have been identified, and in the north-western part of the basin there were seven lithostratigraphic units. The sediment sequence in the Čikola canyon area is mostly built of sediments created by deposition from debris flows and dense turbidite flows. In the Krka canyon area and the north-western part of the basin, several transgressive and regressive system tracts have been confirmed. The regressive tracts consist of gravel delta facies, beaches, and braided rivers, while transgressive tracts are characterised by sand and mud facies of coastal face and outer shelf. The *Benkovac stone* unit is characterised by the presence of exceptionally numerous and well-preserved types of ichnofossils. Although the deposits were deposited on a shallow shelf, a significant number of ichnotraces belongs to the *Nereites* deep sea community, which brings



Panoramski pogled na kanjon Čikole (foto E. Mrnjek)

Panoramic view of Čikola canyon (photo by E. Mrnjek)



Izdanak Promina naslaga – izmjena tankih do srednje debelih slojeva karbonatnih siltita i pješčenjaka s debeloslojevitim, matriks-potpornim, normalno gradiranim konglomeratima u krovini (foto E. Mrinjek)

Outcrop of Promina deposits – alternation of thin to medium beds of carbonate siltstone and sandstone overlayed by thick bedded, matrix-rich, normally graded conglomerates (photo by E. Mrinjek)

dikator. Osim ihnofosila, analizirani su i makrofossili i mikrofossili. Analize nanofosila upućuju da su Prominske naslage mlađe nego što se mislilo – najstarije naslage su taložene krajem eocena i početkom oligocena, dok se glavna sedimentacija odigravala u oligocenu. Nije isključeno da su najmlađe naslage taložene i u donjem miocenu. Na području Lišana i Ostrovice, unutar lithostratigrafske jedinice Ostrovica koja je poznata po bogatoj i raznovrsnoj makrofauni i mikrofauni, utvrđene su brojne pojave lećastih muljnih humaka formiranih na vanjskim dijelovima rampe, odnosno na dubljem šelfu. Svi navedeni rezultati istraživanja interpretiraju paleogenske klastite sjeverne Dalmacije kao ispune dugačkog i relativno uskog *foreland* bazena, koji se zbog razvoja sljepih reversnih rasjeda (rastuće antiklinale) već u gornjem eocenu definitivno diferencirao u distalno fliško korito s dubokomorskim (fliškim) naslagama i proksimalne *piggyback* bazene s plitkomorskим obalnim, deltnim i aluvijalnim (prominskim) naslagama.

doubt to ichnocommunities as a reliable bathymetric indicator. Besides ichnofossils, macrofossils and microfossils were also analysed. Nanofossil analyses indicate that the Promina deposits are younger than previously thought – the oldest deposits were deposited at the end of the Eocene and the beginning of the Oligocene period, with the predominant sedimentation occurring during the latter. The deposition of youngest deposits also in the Lower Miocene period is not excluded. In the area of Lišane and Ostrovica, particularly within the lithostratigraphic unit *Ostrovica*, known by its rich and diverse macrofauna, numerous appearances of lenticular mud mounds formed on the external parts of the ramp, i.e. on the deepest shelf, have been discovered. All of the listed research results interpret the Northern Dalmatian Paleogene clastic rocks as infills of a long and relatively narrow foreland basin, which had, because of the development of blind reverse faults (rising anticline), already in the Upper Eocene period definitely differentiated into a distal flysch bed with deep sea (flysch) deposits and proximal piggyback basins with shallow sea coastal, delta, and alluvial (Promina) deposits.

# Odraz paleoklimatskih promjena u jursko-krednim sedimentima krških Dinarida

## Reflection of Paleoclimatic Changes in Jurassic-Cretaceous Sediments of the Karst Dinarides

Glavni istraživači / Principal investigators: dr. sc. **Antun HUSINEC**, dr. sc. **Valentina HAJEK-TADESSE**



Panorama Blatine kod Blata na otoku Mljetu. U pozadini se jasno ističu slojevi donjokrednih vapnenaca

Panorama of Blatina near Blato on the island of Mljet. Layers of Lower Cretaceous limestones are clearly visible in the background

Cilj projekta bio je istražiti je li odraz paleoklima, promjena morske razine i oceanskoga kemizma očuvan u gornjojursko-donjokrednoj sukcesiji plitkomorskih naslaga krških Dinarida, odnosno, može li dati odgovore na pitanja o tome koja su razdoblja u evoluciji krških Dinarida bila obilježena *greenhouse*, a koja globalno hladnjim, tzv. prijelaznim (*greenhouse / icehouse*) uvjetima. Metode istraživanja uključile su: (a) snimanje detaljnih geoloških stupova u obalnom području krških Dinarida; (b) mikropaleontološke i sedimentno-petrografske analize s ciljem određivanja starosti te bio-i litofacijesa istraživanih sukcesija; (c) analizu stabilnih izotopa (C i O) karbonatnog matriksa; (d) detaljno istraživanje peritajdalnih facijesa u cilju pronalaženja dokaza aridnih, odnosno humidnih, signala tijekom evolucije krških Dinarida; i (e) detaljno istraživanje sedimentoloških dokaza mogućih promjena u kemizmu mora te

The aim of this project was to examine whether the reflection of paleoclimate, sea level changes, and oceanic chemistry is preserved in the Upper Jurassic – Lower Cretaceous succession of Dinaric karst shallow marine deposits. This investigation would determine which periods in the evolution of karst Dinarides were characterised by greenhouse conditions and which by globally colder, so-called transitional greenhouse / icehouse conditions. Research methods included: (a) recording of detailed geological columns in the coastal area of karst Dinarides; (b) micropaleontological and sediment-petrographical analyses with the goal of determining the age and the bio- and lithofacies of examined successions; (c) stable isotope (C and O) analyses of carbonate matrix; (d) detailed research of peritidal facies with the aim of finding evidence of arid or humid signals during the evolution of karst Dinarides; and (e) detailed research of sedimentological evidence

relativnu brojnost onkoida i ooida, kako bi se odredio stupanj zasićenosti karbonatom jursko-krednog platformnog mora.

Ovaj projekt predstavlja prva sekvensijsko i ciklostratigrafska istraživanja visoke rezolucije u području krških Dinarida, a postignuti rezultati upućuju da je kemostratigrafija (stabilni izotopi ugljika) primjenjiva u korelaciji jursko-krednih plitkomorskikh naslaga Jadranske platforme i istodobnih dubokomorskikh naslaga Tethysa. Ekskurzije stabilnih izotopa ugljika povezane s krednim oceanskim anoksičnim događajima (OAE1a, b, i c) jasno su izražene unutar istraživanog slijeda naslaga, pri čemu je glavni anoksični događaj (OAE1a) rezultirao i lokalnim taloženjem disoksičnih vapnenaca.

U istraživanjima su sudjelovali Valentina Hajek-Tadesse, Božo Prtoljan i Damir Palenik iz Hrvatskog geološkog instituta, Antun Husinec (Sveučilište St. Lawrence) te suradnici iz SAD-a koji su provodili geokemijske analize. Rezultati istraživanja do sada su predstavljeni kroz devet znanstvenih radova te brojna kongresna priopćenja (Njemačka, Austrija, Velika Britanija, Italija, Španjolska, Francuska, Maroko, Tunis, SAD, Kanada, Meksiko i Argentina).

of possible changes in sea chemistry and the relative number of oncoids and ooids, in order to determine the level of carbonate saturation of the Jurassic-Triassic platform sea.

This project represents the first high resolution sequence- and cyclostratigraphic examinations in the area of karst Dinarides, and the obtained results indicate that the chemostratigraphy (stable carbon isotope analysis) is applicable for the correlation of shallow marine deposits of the Jurassic-Cretaceous Adriatic platform and the contemporary Tethyan deep marine sediments. Excursions of stable carbon isotopes connected with Cretaceous anoxic events (OAE1a, b, and c) are clearly expressed within the examined sedimentary sequence, where the main anoxic event (OAE1a) also resulted in local deposition of dysoxic limestones.

The participating researchers were Valentina Hajek-Tadesse, Božo Prtoljan, and Damir Palenik from the HGI-CGS, Antun Husinec (University of St. Lawrence) and associates from the USA who performed the geochemical analyses. Research results have so far been presented in nine scientific papers and at numerous congresses (Germany, Austria, Great Britain, Italy, Spain, France, Morocco, Tunisia, USA, Canada, Mexico, and Argentina).



Terensko istraživanje donjokrednog slijeda naslaga na poluotoku Pelješcu  
Fieldwork research of Lower Cretaceous sedimentary sequence on the Pelješac peninsula

# Geološka karta Konavala 1:50.000 – nužna pretpostavka održivog razvoja

## Geological Map of Konavle 1:50,000 – a Necessary Prerequisite of Sustainable Development

Glavni istraživači / Principal investigators: dr. sc. **Božo PRTOLJAN**

Autorica teksta / Author of the text: dr. sc. **Koraljka BAKRAČ**

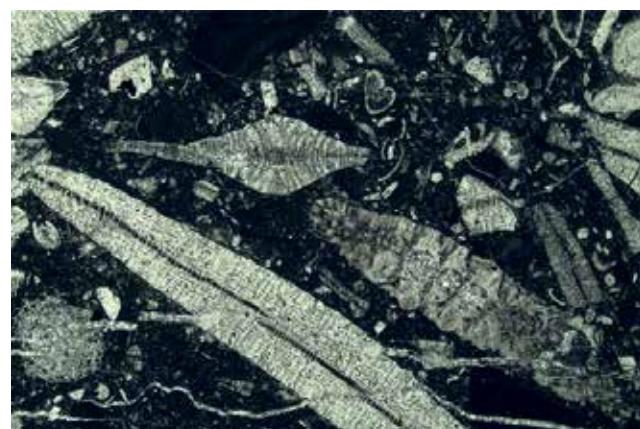
Izrađena je nova geološka karta Konavala M 1:50.000 u GIS okruženju. Karta je izrađena lithostratigrafskim principom. Na taj način, kroz sljedove mezozojskih i tercijarnih naslaga, snimljeno je preko 3000 metara stupova. Sedimentološke, biostratigrafске, petrografske i druge uže specijalističke analize obavljene su na više od 1770 uzoraka. Unutar karbonatnih naslaga izdvojeno je ukupno 19 lithostratigrafiskih jedinica, od čega jedna u trijaskim, 9 u jurskim, 6 jedinica u kredno-paleogenskim naslagama i 3 u tercijarnim klastitima. Područje Konavala geomorfološki je strukturirano polifaznim tektonskim procesima, kao i šire područje Dinarida. Međutim, stratigrafski podatci dobiveni iz tercijarnih klastita ukazuju na produljenu tektonsku aktivnost ovog dijela Dinarida, što se odrazilo i u bit-

A new geological map of Konavle, at the scale of 1 : 50,000, has been constructed in the GIS environment. The map was produced following the lithostratigraphic principles. In this manner, using Mesozoic and Tertiary deposit sequences, over 3000 m of columns were recorded. Sedimentological, biostratigraphical, petrographical, and other narrow specialist analyses were performed on over 1770 samples. A total of 19 lithostratigraphic units were identified within carbonate deposits, one in Triassic, nine in Jurassic, six in Cretaceous-Paleogene deposits, and three in Tertiary clastic rocks. The Konavle area is geomorphologically structured by polyphase tectonic processes, as is the wider Dinaric area. However, stratigraphic data acquired from Tertiary clastic rocks indicate prolonged tectonic activity in this part of the Di-



Izdanak fliša – izmjena siliciklastično-karbonatnih silita/pješčenjaka i laporanja (foto S. Bergant)

Flysch outcrop – alternation of siliciclastic-carbonate siltstone / sandstone and marlstone (photo by S. Bergant)



Mikrofotografija biomikritnog foraminiferskog (discociklinskog) vapnenca (foto S. Bergant)

Microphotography of biomicrite foraminiferal (*Discocyclina*) limestone (photo by S. Bergant)

no kompleksnijim strukturno-tektonskim, mikroseizmičkim i hidrogeološkim odnosima.

Osim toga, litostratigrafska karta poslužila je kao podloga u planiranju zahvata i aktivnosti u sklopu izrade prostornog plana općine, posebno u planiranju razvojnih projekata koji iziskuju veće standarde u zaštiti prirodne i kulturne baštine. Sagledane su podzemne i površinske vode, odnosno brojni kopneni i priobalni izvori koji su do tada tek manjim dijelom bili uključeni u vodoopskrbu. Litostratigrafska karta ponudila je i temelj za procjenu regenerativnog kapaciteta prostora, jer precizno definirana podloga nudi cjelovit uvid u strukturu geoloških čimbenika koji, uz klimu, velikim dijelom uvjetuju i izvorene biološke odnose. Na takav način utvrđeni biološko-geološki potencijali u prostorno-planskim i strateškim studijama razvoja daju mjeru dopustivog antropogenog utjecaja na okoliš. Provedena je i geoturistička valorizacija, jer geoturističke atrakcije u ponudi Općine Konavle predstavljaju značajno osvježenje i obogaćenje turističke ponude. U skladu s time, nova geološka karta poslužila je kao baza za razradu prijedloga izmjena metodologije izrade Prostornog plana uređenja Općine Konavle.

narides, which is also reflected in the significantly more complex structural-tectonic, micro-seismic, and hydrogeological relations.

Furthermore, the lithostratigraphic map served as the basis in planning of operations in the scope of the preparation of the municipal spatial plan, especially in the planning of developments requiring higher standards in natural and cultural heritage protection. Groundwater and surface water were investigated, i.e. the numerous inland and coastal springs that have previously been included in the water supply only to a small extent. The lithostratigraphic map has also offered the basis for the assessment of regenerative capacity of the area, because the precisely described basis offers complete insight into the structure of geological factors which, together with the climate, predominantly condition the original biological relations. In this way, the discovered biological-geological potentials in spatial planning and strategical development studies provide a measure of permissible anthropogenic influence on the environment. Geotouristical evaluation has also been performed, since geotouristic attractions present significant refreshment and enrichment of the touristic attributes within the Konavle Municipality. Accordingly, the new geological map has served as the basis for elaboration of the proposal for changes in the methodology of creating the Konavle Municipality Spatial plan.

# Greenhouse i tranzicijske klime unutar 50 milijuna godina gornjojursko – donjokrednog karbonatnog slijeda Jadranske platforme u Hrvatskoj

## Greenhouse and Transitional Climates Within 50 Million Years of the Upper Jurassic – Lower Cretaceous Carbonate Succession of the Adriatic Carbonate Platform in Croatia

Glavni istraživači / Principal investigators: dr. sc. **Antun HUSINEC**, dr. sc. **Valentina HAJEK-TADESSE**

Projekt je imao za cilj istražiti pretpostavku da unutar gornjojursko – donjokrednog slijeda Jadranske platforme, istaloženog tijekom klasičnog greenhouse klimatskog razdoblja, postoje dokazi o kraćim razdobljima zahlađenja, tijekom kojih je dominirala glacioeustazija umjerenih amplituda, što bi u konačnici upućivalo na postojanje leda na visokim zemljopisnim širinama. U ostvarivanju ciljeva i potvrđivanja hipoteze projekta snimljeno je više kontinuiranih geoloških stupova kroz srednjojur-

The aim of the project was to investigate the hypothesis that within the Upper Jurassic – Lower Cretaceous sequence of the Adriatic platform, deposited during the typical greenhouse climatic period, there is evidence of shorter cooling periods dominated by moderate-amplitude glacioeustasy, ultimately indicating the existence of ice at high geographic latitudes. To confirm the hypothesis of this project, several continuous geologic columns were investigated in the Middle Jurassic – Middle Creta-



Združeni hrvatsko-američki tim u pauzi istraživanja gornjojurskih vapnenaca u Konavlima. Slijeva nadesno: Amelia Oates, Bonnie Govani, Antun Husinec, Božo Prtoljan i Fred Read

A joint Croatian-American team at break time during the investigation of the Upper Jurassic limestone in Konavle. From left to right: Amelia Oates, Bonnie Govani, Antun Husinec, Božo Prtoljan, and Fred Read



**Snimanje litostratigrafskog stupa kroz donjokredne naslage otoka Mljeta kod Sobre. Slijeva nadesno: Dave Mosher, Fred Read i Sean Regan**

Investigating a lithostratigraphic column in Lower Cretaceous deposits of the island of Mljet near Sobra. From left to right: Dave Mosher, Fred Read, and Sean Regan

sko – srednjokredne naslage, čija ukupna analizirana debljina nadmašuje planiranu. Istraživani lokaliteti uključuju: (1) Otok Hvar – detaljni litostratigrafski stup kroz aptsko – starjealbske naslage snimljen je u blizini naselja Jelsa; (2) Otok Korčula – na području Čare i Pupnata snimljeno je pet litostratigrafskih stupova koji obuhvaćaju raspon od barema do gornjeg alba; (3) Poluotok Pelješac – snimljen je kraći slijed berijaskih dolomita, te duži profil kroz baremsko – aptske naslage; (4) Otok Mljet – četiri litostratigrafska stupa snimljena su na području Sobre, Kozarice i Babinog Polja; (5) Dubrovačko zaleđe – sedam kontinuiranih profila detaljno je istraženo na širem prostoru Jasenica, Brotnica i Veljeg Dola. Usporedno sa snimanjem, detaljno su bili prikupljeni uzorci vapnenaca za mikropaleontološko – biostratigrafske i sedimentološko – petrografske analize (uključujući katodoluminescenciju), te vapnenaca i dolomita za analizu stabilnih izotopa i elemenata u tragovima. Rezultati spektralne analize ciklo- i kemostratigrafije upućuju na dominantan utjecaj ekscentričnosti Zemljine orbite (ciklusi od 100.000 i 400.000 godina) na oscilacije morske razine tijekom donje krede. Rezultati također upućuju da unutar istraživanog slijeda Jadranse platforme kemostratigrafski signal nije u potpunosti očuvan.

U istraživanjima su sudjelovali Valentina Hajek-Tadesse i Božo Prtoljan iz Hrvatskog geološkog instituta, Antun Husinec (Sveučilište St. Lawrence), te suradnici iz Kanade i SAD-a koji su izvođili terensko istraživanje.

ceous deposits, whose total analysed thickness was larger than anticipated. The investigated sites include: (1) the island of Hvar – a detailed lithostratigraphic column was investigated in the Aptian -late Albian deposits near the town of Jelsa; (2) the island of Korčula – in the Čara and Pupnat area, five lithostratigraphic columns were investigated, spanning from Barremian to Upper Albian; (3) Pelješac peninsula – a shorter sequence of Berriasian dolomites was investigated, as well as a longer profile through the Barremian – Aptian deposits; (4) the island of Mljet – four lithostratigraphic columns were investigated in the area of Sobra, Kozarica and Babino Polje; (5) the Dubrovnik hinterland – seven continuous sections were investigated in detail in the wider area of Jasenice, Brotnice and Velji Do. Along with the investigation, limestone samples were collected in detail for micropaleontological – biostratigraphic and sedimentological-petrographic analyses (including cathodoluminescence), as well as limestone and dolomite samples for stable isotope and trace element analyses. The results of spectral, cyclo- and chemo-stratigraphic analyses indicate the dominant influence of the Earth's orbital eccentricity (cycles of 100,000 and 400,000 years) on sea level oscillations during the Lower Cretaceous period. The results also show that within the investigated sequence of the Adriatic platform, the chemo-stratigraphic signal is not entirely preserved.

Scientists that participated in the research were Valentina Hajek-Tadesse and Božo Prtoljan from the HGI-CGS, Antun Husinec from St. Lawrence University, and associates from Canada and the USA, who conducted field research.

# Usklađivanje i korelacija rezultata kartiranja kvartarnih naslaga u dravskoj depresiji

## Harmonization and Correlation of Quaternary Mapping Results in the Drava Basin

Glavni istraživač / Principal investigator: dr. sc. **Ivan HEĆIMOVIĆ**

Autorica teksta / Author of the text: dr. sc. **Anita GRIZELJ**

Bilateralni projekt, financiran od strane MZOŠ-a, koji je za cilj imao usklađivanje geoloških podataka dravskog područja s obje strane granice Hrvatske i Mađarske bio je aktivan u periodu od 2007 – 2009. godine. U provedbi projekta su sudjelovali istraživači iz Mađarskog geološkog instituta iz Budimpešte: István Marsi, Géza Chikán, László Koloszár i Árpád Magyari te iz Hrvatskog geološkog instituta: Ivan Hećimović, Anita Grizelj, Adriano Banak i Marija Horvat. Rezultat projekta je geološka karta dravskog područja, list Sellye-Slatina M 1:100.000, na čijoj izradi su sudjelovali i Ajka Šorša, Pavle Ferić i Josip Halamić, a predstavljen je na 4. hrvatskom geološkom kongresu u Šibeniku.

The bilateral project was conducted from 2007 to 2009, funded by the Ministry of Science and Education (MSE). The project aimed at harmonising geological data of the Drava basin on both sides of the border between Croatia and Hungary. Researchers who participated in the implementation of the project were István Marsi, Géza Chikán, László Koloszár and Árpád Magyari from the Mining and Geological Survey of Hungary and Ivan Hećimović, Anita Grizelj, Adriano Banak and Marija Horvat from the HGI-CGS. The project resulted in the construction of the geological map of the Drava basin, sheet Sellye-Slatina, at the scale 1 : 100,000. Ajka Šorša, Pavle Ferić, and Josip Halamić worked on



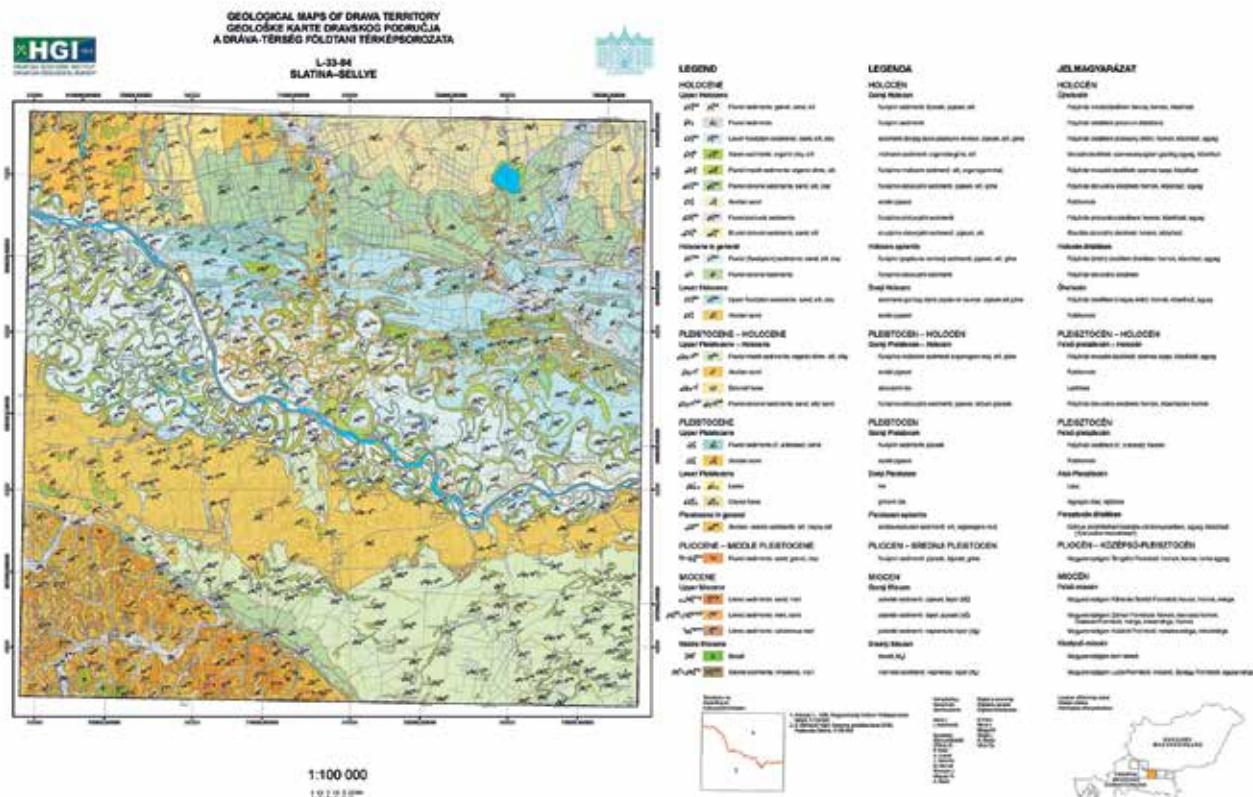
Diskusija geologa na izdanku s naslagama Tengelic formacije (Mađarska)  
Discussion at the outcrop of Tengelic formation deposits (Hungary)

ku 2010. godine. Nastavak projekta, također financiran od strane MZOŠ-a, potписан je 2009. godine pod nazivom „Usklađivanje rezultata geološkog kartiranja u Baranji“ u sklopu kojeg su započeli radovi na usklađivanju listova Mohač – Mohács i Donji Miholjac – Siklos M 1:100.000. Projekt je završen 2010. godine.

the finalization of the sheet. The sheet was presented in 2010 at the 4<sup>th</sup> Croatian Geological Congress in Šibenik. Continuation of the project, which was also funded by the MSE, was approved in 2009 under the title “Harmonisation of geological mapping results from Baranja”, within which work began on the harmonisation of the sheets Mohač – Mohács and Donji Miholjac – Siklos at the scale 1 : 100,000. The project ended in 2010.



Radni sastanak – Bátaapáti (Mađarska)  
Work group meeting in Bátaapáti (Hungary)



Geološka karta dravskog područja, list Slatina-Sellye M 1:100.000  
Geological map of the Drava basin, sheet Slatina – Sellye, at the scale of 1: 100,000

# Korelacija prapor / paleotlo sekvencija jugoistočne Transdanubije s istočnim i jadranskim dijelom Hrvatske

## Correlation of Loess / Paleosol Sequences of Southeastern Transdanubia with Eastern and Adriatic Part of Croatia

Glavna istraživačica / Principal investigator: dr. sc. **Lidija GALOVIĆ**

Ovaj bilateralni projekt s Republikom Mađarskom, financiran od strane MZOŠ-a, nastavak je bilateralnog projekta „Korelacija prapor/paleotlo sekvencija na hrvatskom i mađarskom dijelu Baranje“. Oba projekta bila su povezana sa znanstvenim istraživačkim projektom Osnovna geološka karta Republike Hrvatske, mjerila 1:50 000.

Budući da je tijekom prvog bilateralnog projekta unutar prapor-a pronađena tefra u jugoistočnom dijelu Mađarske, a na sve-

This bilateral Croatian – Hungarian project, funded by the MSE, was a continuation of the bilateral project "Correlation of the loess / paleosoil sequences in Croatian and Hungarian part of Baranja". Both projects were linked to the scientific research project Basic geological map of the Republic of Croatia at the scale of 1 : 50,000.

During the first bilateral project, tephra was found within the loess horizon in the south-western part of Hungary, and only at



Praporni profil u Šarengradu  
Loess section in Šarengrad



Zaštićeni geološki spomenik prirode  
„GORJANOVIĆEV PRAPORNI PROFIL U VUKOVARU“  
Protected geological natural heritage "Gorjanović  
Loess Section in Vukovar"

ga jednom mjestu u istočnoj Hrvatskoj, korelirali smo ih s već pronađenim proslojcima tefre na sjevernojadranskim otocima.

Slične klimatske oscilacije korelirali smo usporedbom paleota-la razvijenih na praporu Suska s paleotlima razvijenim na praporu u Panonskom bazenu. Uspoređivali smo i mineraloške i sedimentološke karakteristike prapora na području današnjeg sjevernog Jadrana, gdje je rijeka Po donosila materijal, s praprom Podunavlja. Povezivanje ovih dvaju sedimentacijskih ba-zena nužno je za razumijevanje klimatskih promjena koje se događaju u ovom dijelu Europe.

S mađarske strane projekt je vodio László Koloszár. Sudjelovali su Štefánko Lugović, Zoran Peh, Marta Crnjaković, Danica Miletić, Lara Wacha, Pavle Ferić, Snježana Mikulčić Pavlaković, Géza Chikán, István Marsi, Árpád Magyari, Pál Sümegi i Erzsébet Horváth.

Rezultati su objavljeni u pet originalnih znanstvenih radova, de-vet sažetaka na znanstvenim skupovima i jednom poglavljju u knjizi. Pri Ministarstvu kulture pokrenut je postupak zaštite geološkog lokaliteta „GORJANOVIĆEV PRAPORNI PROFIL U VUKO-VARU“ u kategoriji geološkog spomenika prirode.

one location in eastern Croatia. Hence, we correlated those tephra interlayers with the ones on the northern Adriatic islands.

Similar climatic oscillations were correlated, and the paleosoil developed from loess on the island of Susak was compared with one in the Pannonian Basin. We also compared the mineralogical and sedimentological properties of loess in today's northern Adriatic area, where the Po River was depositing material, with loess in the Danube area. Connecting these two sedimentation basins is essential for understanding the effects of climate change taking place in this part of Europe.

The project was led by László Koloszár from the Hungarian team. Other participants in the project were Štefánko Lugović, Zoran Peh, Marta Crnjaković, Danica Miletić, Lara Wacha, Pavle Ferić, Snježana Mikulčić Pavlaković, Géza Chikán, István Marsi, Árpád Magyari, Pál Sümegi, and Erzsébet Horváth.

The results were published in five original scientific papers, nine abstracts at scientific conferences, and one book chapter. In addition, the Ministry of Culture initiated the process of protecting the geological site "Gorjanović Loess Section in Vukovar" in the category of geological natural heritage.

# Standardizacija i primjenjena istraživanja kvartarnih sedimenata Hrvatske

## Standardisation and Applied Investigation of Quaternary Sediments in Croatia

Glavna istraživačica / Principal investigator: dr. sc. **Lidija GALOVIĆ**

Uspostavljeni istraživački projekt SAPIQ bio je financijski poduprijet od strane Hrvatske zaklade za znanost, a voditeljica projekta bila je Lidija Galović. Započeo je 1. rujna 2014., a završio 31. prosinca 2017. godine. Na projektu je surađivala velika međunarodna skupina znanstvenika iz Hrvatske, Srbije, Njemačke i Francuske (†Hrvoje Posilović, Koraljka Bakrač, Manfred Frechen, Ingeborg Soulié-Marsche, Lara Wacha, Adriano Banak, Anita Grizelj, Jadranka Mauch Lenardić, Danijel Ivanišević, Petar Stejić, Mihovil Brlek, Rodoljub Gajić i Mihajlo Pandurov).

Cilj ovog uspostavnog istraživačkog projekta bio je formiranje grupe znanstvenika Zavoda za geologiju, te njihova izobrazba i dodatno osposobljavanje, kako bi mogli standardizirati istraživanje kvartarnih naslaga RH, primjenjujući nove analitičke metode i znanstvene spoznaje. Dobiveni rezultati omogućili su korelaciju s rezultatima iz ostalih europskih država, posebno s rezultatima s područja srednje i južne Europe. Istraživana su područja Slavonije i Baranje, Vrgoraca, Bilogore, Suske, Velebita

The SAPIQ installation research project was financially supported by the Croatian Science Foundation, with Lidija Galović as the project leader. The project commenced on the 1<sup>st</sup> of September 2014 and ended on the 31<sup>st</sup> of December 2017. A large group of scientists from Croatia, Serbia, Germany, and France collaborated on the project (†Hrvoje Posilović, Koraljka Bakrač, Manfred Frechen, Ingeborg Soulié-Marsche, Lara Wacha, Adriano Banak, Anita Grizelj, Jadranka Mauch Lenardić, Danijel Ivanišević, Petar Stejić, Mihovil Brlek, Rodoljub Gajić, and Mihajlo Pandurov).

The aim of this installation research project was the establishment of a group of scientists at the Department of Geology, and their education and additional training, which would enable standardised research of Quaternary deposits in the Republic of Croatia, applying new analytical methods and scientific findings. The obtained results enabled correlation with results from other European countries, especially the results from the area of Central and Southern Europe. Areas of Slavonia and Baranja, Vrgorac, Bi-



Diskusija na svježe otvorenom prapornom profilu u Zmajevcu (foto H. Posilović)  
Discussion on the freshly opened loess profile in Zmajevac (photo by H. Posilović)



Estavele u Vrgoračkom polju  
Estavelles in the Vrgorac polje



Donje do srednje pleistocenska dravska terasa i sedimenti poplavne ravnice na lokaciji Sv. Ana / Lower to Middle Pleistocene Drava terrace and floodplain sediments at the Sv. Ana location (foto L. Wacha)  
Lower to Middle Pleistocene Drava terrace and floodplain sediments at the Sv. Ana locality (photo by L. Wacha)



Izlaganje prof. Georges Stoops tijekom Intenzivne radionice iz mikromorfologije tla  
The lecture of prof. Georges Stoops during the Intensive workshop in soil micromorphology

i Đurđevca, a rezultati istraživanja su publicirani u 13 originalnih znanstvenih radova i predstavljeni na brojnim kongresima.

Sredstvima projekta kupljen je TGA/DSC2 HT MODUL METTLER-TOLEDO, polarizacijski mikroskop Carl ZEISS Axio Lab.A1 POL, dva mikroskopa Loupe XTJ-4400D, polirka za pripremu mikroskopskih preparata, X-rite kolorimetar, 3 računala, 3 GPS-a, 3 tableta i druga sitna oprema, za ukopno više od 400.000 kuna.

U sklopu projekta od 17. do 28. kolovoza 2015. godine u HGI-CGS-u je organizirana Intenzivna radionica iz mikromorfologije tla. Pozvani predavači bili su Rosa M. Poch (Španjolska), Georges Stoops (Belgija) i Vera Marcelino (Belgija), a svojim predavanjima doprinijeli su i Lidija Galović, Hrvoje Posilović i Mihovil Brlek. Na radionici je sudjelovalo 20 polaznika s tri kontinenta. U sklopu radionice organizirana je terenska ekskurzija u Muzej Kraneamus-Krapina, dvorac Trakošćan i Aquae Iasae-Varaždinske toplice.



Prof. Georges Stoops i sudionici Intenzivne radionice iz mikromorfologije tla. (foto D. Ivanišević)

Prof. Georges Stoops and participants of the Intensive workshop in soil micromorphology (photo by D. Ivanišević)

logora, Susak, Velebit, and Đurđevac have been studied, and the research results were published in 13 original scientific papers and presented at numerous congresses.

The TGA/DSC2 HT MODUL METTLER-TOLEDO, a Carl ZEISS Axio Lab.A1 POL polarised light microscope, two Loupe XTJ-4400D microscopes, a polisher for preparation of microscopic thin sections, an X-rite colorimeter, three computers, three GPSs, three tablets, and other small equipment was purchased by project funds, for a total of more than 400,000 HRK.

As part of the project, an intensive workshop in soil micromorphology was organised at the HGI-CGS from the 17<sup>th</sup> to the 28<sup>th</sup> of August 2015. The invited lecturers were Rosa M. Poch (Spain), Georges Stoops (Belgium), and Vera Marcelino (Belgium), with Lidija Galović, Hrvoje Posilović, and Mihovil Brlek also contributing with their lectures. Twenty participants from three continents attended the workshop. The workshop included a fieldwork excursion to Kraneamus Museum in Krapina, Trakošćan castle, and Aquae Iasae – Varaždinske Toplice.



Banner projekta SAPIQ (izradio D. Ivanišević)

The SAPIQ project banner (prepared by D. Ivanišević)

# Nestali jezerski krajobrazi istočnog dijela šelfa Jadranskog mora

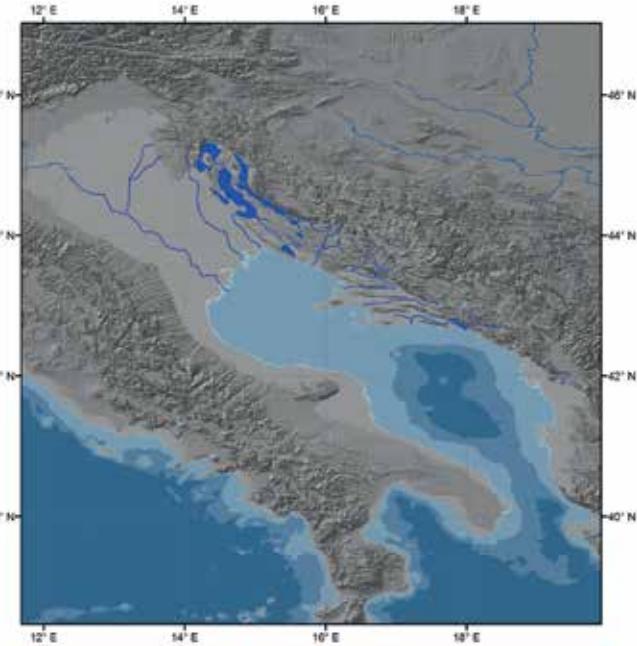
## Lost Lake Landscapes of the Eastern Adriatic Shelf

Glavni istraživač / Principal investigator: dr. sc. **Slobodan MIKO**

<https://loladria.wordpress.com/>

Projekt akronima LoLADRIA financiran je od strane HRZZ-a od 2014. do 2018. godine. Zbog specifične geološke građe koja se odlikuje krškom geomorfolojijom malo je postglacijalnih zapisa u terestičkim okolišima jadranske Hrvatske. Zapis ovih događaja zbog izraženih erozijskih procesa i postglacijalne transgresije mora nalaze u današnjem podmorju Jadrana. Upotreba multidisciplinarnih analitičkih tehnika (ostrakoda, polena, kemijskog i mineraloškog sastava sedimenata, fizičkih karakteristika sedimenata, te geoloških i geomorfoloških svojstava istraživanog prostora) omogućit će rekonstrukciju postglacijalnih okoliša istočne obale Jadrana. Istraživanja su koncipirana na način da se rekonstrukcija holocenskih paleookoliša, koja se temelji na jezerskim sedimentima postojećih jezera (Vransko jezero na Cresu, Vransko jezero kod Biograda,

The LoLADRIA project was funded by the Croatian Science Foundation from 2014 until 2018. Due to specific geological setting characterized by karst geomorphology, there are few postglacial records in the terrestrial environments of the Croatian Adriatic coast. Records of these events are left by marked erosion processes and postglacial marine transgression found in the present-day Adriatic Sea. The use of multidisciplinary analytical techniques (ostracods, pollen, chemical and mineralogical composition of sediments, physical characteristics of sediments, and geological and geomorphological properties of the studied area) will enable the reconstruction of postglacial environments of the eastern Adriatic coast. The research is conceived so that the reconstruction of Holocene paleoenvironments, based on lake sediments of existing lakes (Vrana Lake on the island of Cres, Vrana Lake near Biograd, Baćina lakes), is extended to the LGM (ca. 25,000 years) with the help of analysis of environments in the Lošinj Channel, the Novigrad Sea, the Pirovac Bay, Veliko jezero on the island of Mljet, and the Koločep Channel, which existed during the Pleistocene period, when sea levels were up to 120 m lower. During this project, geophysical research was carried out using a subbottom profiler in the areas of the Lošinj Channel, the Novigrad Sea, the Karin Sea and the Pirovac Bay, the Koločep Channel, Telašćica Bay, a part of the Brač Channel, and the Cetina River estuary. More than 600 km of seismic profiles was recorded. The existence of lacustrine / alluvial deposits beneath the Holocene marine sediments has been determined at all locations.

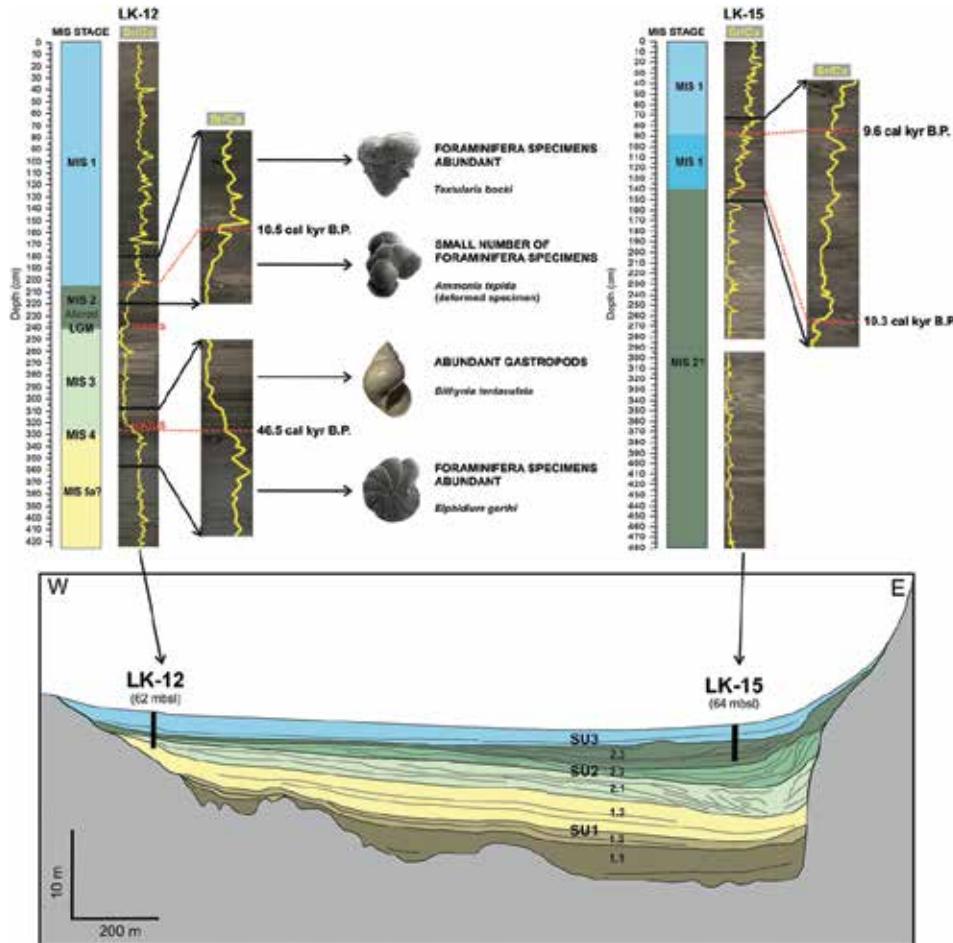


Rekonstrukcija paleookoliša Jadranskog mora tijekom posljednjeg glacijalnog maksimuma prije 18.000 godina

Reconstruction of the LGM (18 ka BP) landscape of the Adriatic Basin based on LoLADRIA project data

Baćinska jezera) produlji do LGM-a (oko 25.000 godina) uz pomoć analize okoliša potopljenih jezera u Lošinjskom kanalu, Novigradskom moru, Pirovačkom zaljevu, Velikom jezeru na Mljetu te Koločepskom kanalu, koja su postojala u pleistocenu kada su razine mora bile i do 120 m niže. Tijekom projekta provedena su geofizička istraživanja geološkim dubinomjerom na prostoru Lošinjskog kanala, Novigradskog mora, Karinskog mora i Pirovačkog zaljeva, Koločepskog kanala, uvale Telašćica, dijela Bračkog kanala i estuarija rijeke Cetine. Ukupno je snimljeno više od 600 km seizmičkih profila. Na svim lokacijama utvrđeno je postojanje jezerskih/aluvijalnih naslaga ispod holocenskih marinskih sedimenta. U Lošinjskom kanalu debljina jezerskih sedimenta doseže 10 m, a u Karinskem moru svega 1 m. Ukupno je s navedenih lokacija analizirano dvadesetak jezgrí neporemećenih sljedova sedimentata. Neka jezera su postojala svega 2-3 tisuće godina, a

u Lošinjskom kanalu vjerojatno i više od 10.000 godina, prije potapanja morem. Osim novootkrivenih paleojezera otkrivene su pojave do sada nezabilježenih slojeva mikrotefri vezanih za erupcije Vezuva i Flegrejskih polja u Italiji. U sklopu projekta LoLADRIA izrađene su tri doktorske disertacije (O. Hasan, I. Razum, D. Brunović) i 7 diplomskih radova, a izrada jedne disertacije je u tijeku (D. Šolaja). Uspostavljene su i kolaboracije sa 5 istraživačkih grupa diljem Europe te u Izraelu. Istraživanja će poslužiti za objavljivanje radova u časopisima s visokim faktorom odjeka te kao podloga za izradu geoloških karata podmorja.



Potpopljeni okoliši Lošinskog kanala (izradila D. Brunović)  
Submerged landscapes of Lošinj Channel (prepared by D. Brunović)

In the Lošinj Channel, the thickness of lake sediments reaches 10 m, while in the Karin Sea only 1 m. A total of around 20 cores of undisturbed sediment sequences has been analysed from these locations. Some lakes existed for only 2–3 thousand years, and in the Lošinj Channel probably for more than 10,000 years, before being flooded by the sea. Besides the newly discovered paleolakes, appearances of previously unrecorded layers of microtephra related to the eruptions of Vesuvius and Phlegraean Fields in Italy have been discovered. Within the LoLADRIA project, three PhD dissertations were completed (O. Hasan, I. Razum, D. Brunović) and seven master theses, while a further PhD dissertation (D. Šolaja) is in progress. Collaborations with five research groups from Europe and Israel have also been established. The project results will be used for publishing papers in journals with high impact factors, and as a basis for production of submarine geological maps.

# Međunarodni projekti GEMAS, URGE i Bottled Water

## International Projects GEMAS, URGE and Bottled Water

Autori teksta / Authors of the text: dr. sc. **Josip HALAMIĆ**, dr. sc. **Ajka ŠORŠA**

<http://gemas.geolba.ac.at/>; <http://www.geochemistryineurope.org/projects/urge-project/>

Od 2009. do 2014. godine potpisani autori, kao članovi Geokemijske ekspertne skupine EuroGeoSurveys-a, sudjelovali su u tri paneuropska projekta.

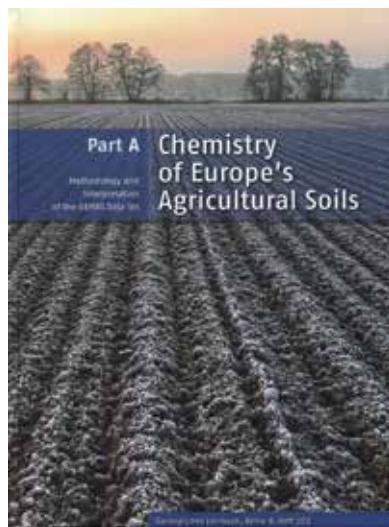
U sklopu projekta „Geochemistry of European Bottled Water“ analizirano je 14 uzoraka komercijalnih flaširanih voda i 15 uzoraka voda iz javne vodovodne mreže RH. Rezultati projekta objavljeni su u knjizi „Geochemistry of European Bottled Water“ i posebnom izdanju međunarodnoga CC časopisa „Journal of Geochemical Exploration – Mineral Waters of Europe“.

U projektu „Geochemical Mapping of Agricultural and Grazing Land Soils – GEMAS“ geokemijski su kartirana poljoprivredna tla i permanentne travnate površine na području Europe. Mreža uzorkovanja bila je 50x50 km (Lambertova ekvivalentna projekcija) i, nakon usuglašavanja metodologije uzorkovanja, na području RH uzeto je ukupno 58 uzoraka (29 s oraničnih tala i 29 s travnatih površina). Nakon standardizirane pripreme,

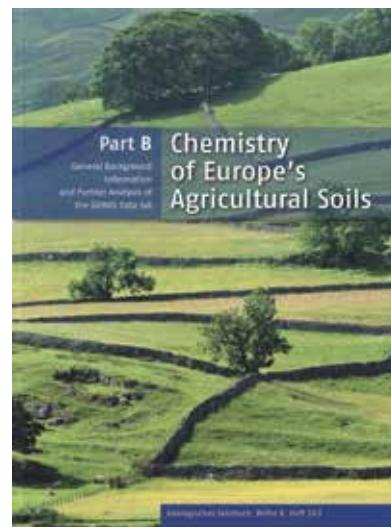
From 2009 to 2014, the signed authors, members of the EuroGeoSurveys Geochemical Expert Group, participated in three pan-European projects.

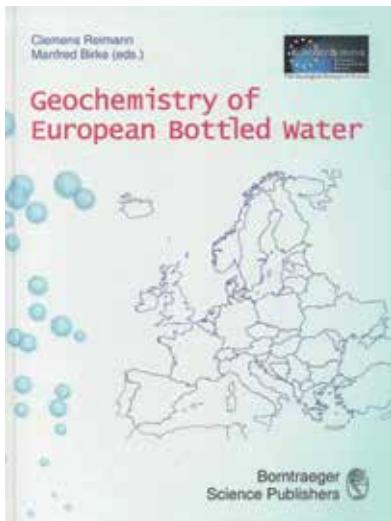
Within the project “Geochemistry of European Bottled Water”, 14 samples of commercial bottled water and 15 samples of water from the public water supply were analysed in the Republic of Croatia (RH). The results of the project were published in the book “Geochemistry of European Bottled Water” and in a special edition of the international CC “Journal of Geochemical Exploration – Mineral Waters of Europe”.

Within the project “Geochemical Mapping of Agricultural and Grazing Land Soils – GEMAS”, agricultural soils and permanent grasslands were mapped across Europe. The sampling network consisted of 50 x 50 km squares (Lambert equal-area projection) and after the sampling methodology was standardised, a total of 58 soil samples were collected (29 of agricultural and 29 of grassland soil) on the territory of the RH. After standardised prepa-

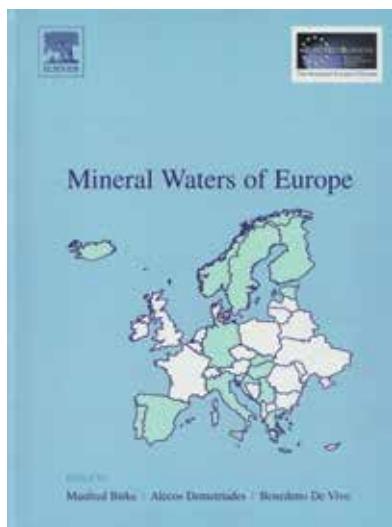


Naslovnice publikacija projekta GEMAS  
Covers of the GEMAS project publications





Naslovna publikacije projekta Geochemistry of European Bottled Water  
Cover of the "Geochemistry of European Bottled Water" project publication



Naslovna posebnog izdanja časopisa „Journal of Geochemical Exploration“ – „Mineral Waters of Europe“

Cover of the special edition of the "Journal of Geochemical Exploration – Mineral Waters of Europe"

uzorci su analizirani metodama ICP-AES, ICP-MS, XRF i MMI na set od 53 kemijska elementa. Rezultati istraživanja prezentirani su u dva toma geokemijskog atlasa „Kemija europskih poljoprivrednih tala – Dio A: metodologija i interpretacija podataka projekta GEMAS“ i „Kemija europskih poljoprivrednih tala – Dio B: opća pozadina, informacije i daljnje analize podataka projekta GEMAS“, te u tridesetak članaka publiciranih u međunarodnim znanstvenim časopisima. Službena ceremonija završetka projekta organizirana je 2013. godine u Rimu na svjetski Dan tla od strane Organizacije za hranu i poljoprivredu Ujedjenih naroda (FAO).

Grad Sisak i njegova ruralna okolica izabrani su kao područje za sudjelovanje u projektu „Urban Geochemistry in Europe (URGE) – Soil, children, health“. Na istraživanom području uzeta su 144 površinska uzorka tla i 26 uzoraka iz 5 pedoloških jama. Dobiveni rezultati upotrijebljeni su za izradu jedne doktorske disertacije, dvaju diplomskih radova te za izdavanje knjige „Geokemijski atlas Siska“ te više znanstvenih radova. U posebnom izdanju časopisa „Journal of Geochemical Exploration“ objavljeni su znanstveni članci iz svih gradova EU koji su sudjelovali u projektu.

Vezano na ovaj projekt, u proteklom je razdoblju završen i jedan bilateralni projekt u suradnji s Tehnološkim fakultetom Sveučilišta u Novom Sadu na temu „Inorganic and organic pollutants in urban areas“, čiji su rezultati također publicirani u više članaka u znanstvenim časopisima.

ration, the samples were analysed by ICP-AES, ICP-MS, XRF, and MMI methods for a set of 53 chemical elements. The results of the research were presented in the geochemical atlas in two parts: "Chemistry of Europe's Agricultural Soils – Part A: Methodology and Interpretation of the GEMAS Data Set" and "Chemistry of Europe's Agricultural Soils – Part B: General Background and Information and Further Analysis of the GEMAS Data Set", and in about thirty articles published in international scientific journals. The official ceremony for the completion of the project was held in 2013 in Rome, on the World Soil Day organised by the UN Food and Agriculture Organisation (FAO).

The City of Sisak and its rural surrounding were selected for participation in the project "Urban Geochemistry in Europe (URGE) – Soil, Children, Health". 144 surface soil samples and 26 samples from five pedological pits were collected in the investigated area. The obtained results were used in one PhD dissertation, two graduate theses, a book "Geochemical Atlas of Sisak" and more a number of scientific papers. Scientific articles on investigations from all European cities that participated in the project were published in a special edition of the "Journal of Geochemical Exploration".

In connection with this project and over the past period, a bilateral Croatian – Serbian project was completed on "Inorganic and Organic Pollutants in Urban Areas" in cooperation with the Faculty of Technical Sciences of the University of Novi Sad, the results of which were likewise published in several articles in scientific journals.

# Geološka istraživanja arhitektonsko-građevnog i pločastog vapnenca duž jadranskog krškog pojasa Hrvatske

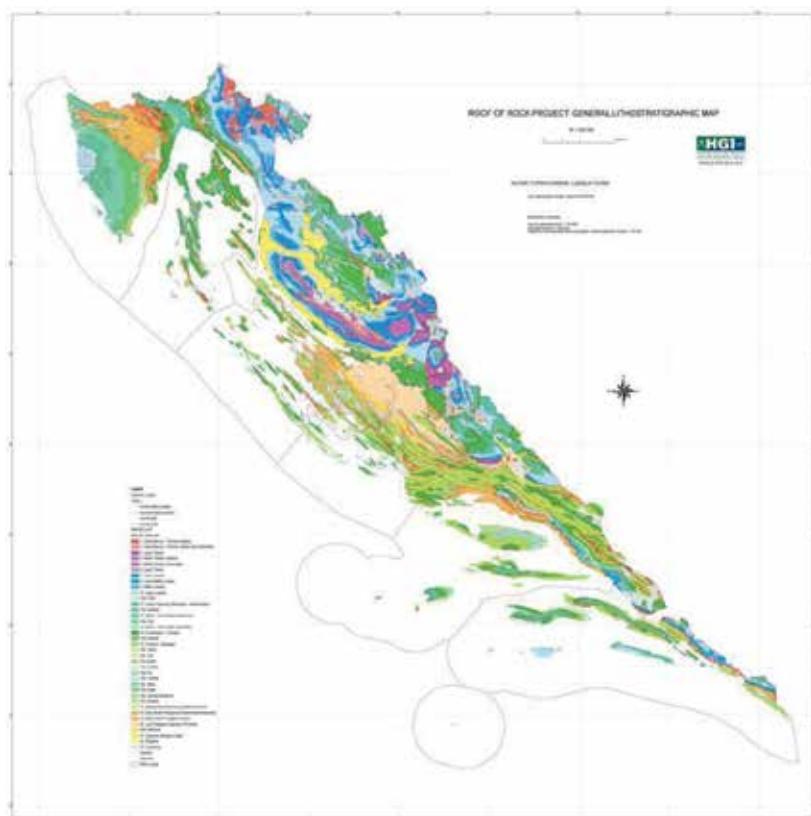
## Geological Survey on Building and Platy Limestone in the Adriatic Karst Region of Croatia

Koordinator za HGI-CGS / Coordinator for HGI-CGS: dr. sc. **Tvrtko KORBAR**

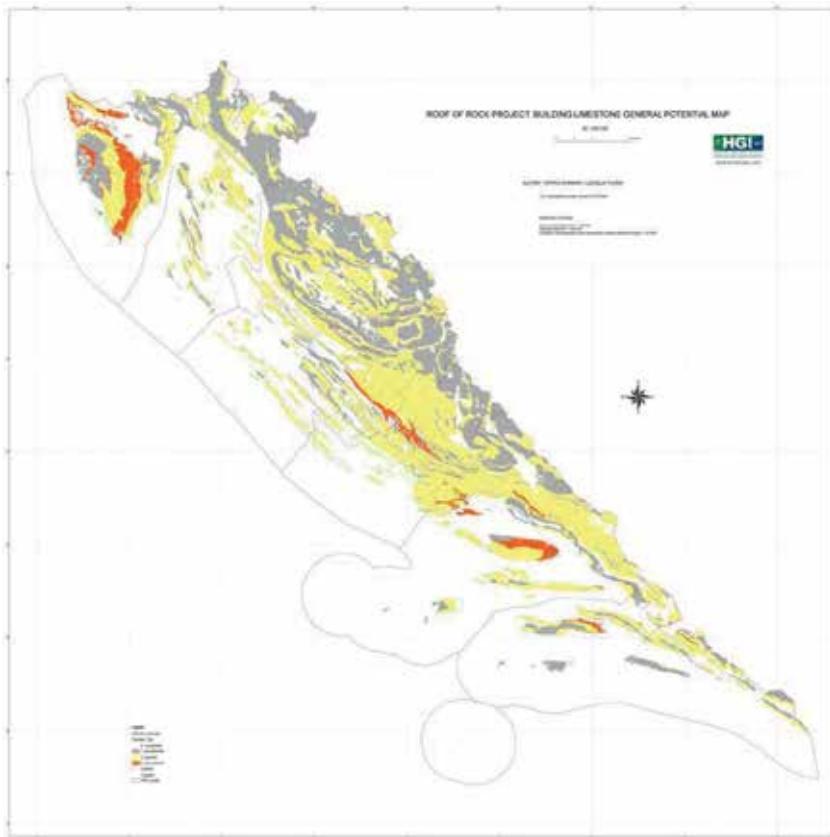
[www.roofofrock.eu](http://www.roofofrock.eu)

Od 2013. do 2015. godine HGI-CGS je obavljao poslove vezane uz geološki dio projekta RoofOfRock na području Republike Hrvatske. Projekt RoofOfRock bio je financiran kroz Adriatic IPA prekogranični program EU, a vodeći partner bio je Geološ-

From 2013 to 2015, HGI-CGS carried out activities related to the geological part of the "RoofOfRock" project on the territory of RH. The "RoofOfRock" project was funded through the IPA Adriatic Cross Border Cooperation Programme, and the lead partner



Prikaz pregledne geološke karte izrađene za potrebe projekta RoofOfRock u projektnom području RH  
Overview geological map of the project area in the RH, constructed within the "RoofOfRock" project



Prikaz pregledne karte potencijalnosti ag-kamena vapnenca u projektnom području RH  
(orančasto = visokopotencijalno, žuto = potencijalno)

Overview map of the architectural construction limestone potential of the project area in the RH (orange – high potential, yellow – moderate potential)

ki zavod Slovenije. Prema ugovorima s hrvatskim projektnim partnerima – županijskim razvojnim agencijama Zadarske (ZADRA), Splitsko-dalmatinske (RERA SD), Dubrovačko-neretvanske (DUNEA) i Istarske županije (IDA), tim HGI-CGS-a je izvodio geološka istraživanja i izradivao bazu podataka u GIS okruženju. Glavni cilj geološkog dijela projekta bio je definiranje općeg potencijala vapnenca kao arhitektonsko-građevnog (ag) kamena (za sve priobalne županije RH) te detaljniji prikaz područja pojavljivanja odabralih tipova vapnenca s posebnim naglaskom na pločaste vapnence, uz procjenu njihova potencijala kao ag materijala za promociju i zaštitu zajedničke prirodne i kulturne baštine (na odabranim područjima četiri županije RH – projektnih partnera na projektu RoofOfRock). Tim HGI-CGS-a činilo je dvadesetak znanstvenih, stručnih i tehničkih suradnika iz Zavoda za geologiju.

U okviru projekta izrađena je kompilacijska pregledna geološka karta projektnog područja u RH mjerila 1:250.000 i na teme-

was the Geological Survey of Slovenia. According to the agreements with the Croatian project partners – the Zadar (ZADRA), Split-Dalmatia (RERA SD), Dubrovnik-Neretva (DUNEA), and Istria (IDA) Counties' development agencies, the HGI-CGS team conducted geological surveys and created a database in GIS environment. The main goal of the geological part of the project was to define the general potential of limestone as an architectural and construction (AC) stone (for all coastal counties of the RH) and to provide a more detailed overview of the appearance of the selected types of limestone. Particular emphasis was on platy limestone, as well as on the estimation of its potential as the AC material that promotes and protects the common natural and cultural heritage (in the selected four counties of the RH – partners in the "RoofOfRock" project). The HGI-CGS team consisted of some 20 scientific, expert, and technical associates from the Department of Geology.

Within the project, the overview geological map at the scale 1 : 250,000 was compiled, which covers the project area in the



Izdanak pločastog vapnenca unutar karbonatnih naslaga formacije Gornji Humac na otoku Braču  
Platy limestone outcrop within carbonate deposits of the Gornji Humac formation on the island of Brač

Iju nje pregledna karta potencijalnosti ag kameva vapnenca s prikazom odabranih kamenoloma. Pločasti vapnenci detaljno su istraživani u Istri, širem području Benkovca i Trogira te dijelovima otoka Brača, Hvara, Šolte, Visa, Korčule i poluotoka Pelješca. Na temelju geološkog kartiranja izrađene su detaljne geološke (litostratigrafske) karte odabranih područja te geološke baze podataka u GIS okruženju. Tijekom istraživanja definirane su temeljne stratigrafske, sedimentološke i paleontološke značajke raznih tipova pločastih vapnenaca, koji se unutar slijeda naslaga mogu izdvojiti kao litostratigrafske jedinice lateralnog pružanja od 100 m do 20-ak km.

Kulturna i prirodna baština te nalazište pločastih vapnenaca – otok Šolta  
Cultural and natural heritage and platy limestone sites – the island of Šolta

RH. In addition, an overview map of limestone potential was constructed from its basis, with marked selected quarries. Platy limestone was explored in detail in Istria, in the wider areas of Benkovac and Trogir and in parts of the islands of Brač, Hvar, Šolta, Vis, and Korčula, and on the Pelješac peninsula. Based on geological mapping, detailed geological (lithostratigraphic) maps of selected areas were constructed, as well as geological databases in GIS environment. During the research, the basic stratigraphic, sedimentological, and paleontological properties of various types of platy limestones were defined, which can be classified as lithostratigraphic units of 100 m to ~20 km lateral continuity.



Napušteni kamenolom pločastog vapnenca unutar bazenskih karbonata predgorskog bazena u okolini Benkovca  
Abandoned platy limestone quarry within basin carbonates of the foreland basin in the surroundings of Benkovac



# Istraživanja paleorazina Vranskog jezera na Cresu

## Research of Paleolevels of Vrana Lake on the Island of Cres

Voditeljica projekta / Project Manager: dr. sc. **Saša MESIĆ**

Autorica teksta / Author of the text: dr. sc. **Nikolina ILLJANIĆ**

Suradnici / Collaborators: dr. sc. Slobodan MIKO, dr. sc. Ozren HASAN, dr. sc. Nikolina ILLJANIĆ, Martina ŠPARICA MIKO, Helena ĆUĆUZOVIĆ, dr. sc. Koraljka BAKRAČ, dr. sc. Valentina HAJEK-TADESSE, dr. sc. Ines GALOVIĆ, dr. sc. Katarina CAPUT MIHALIĆ

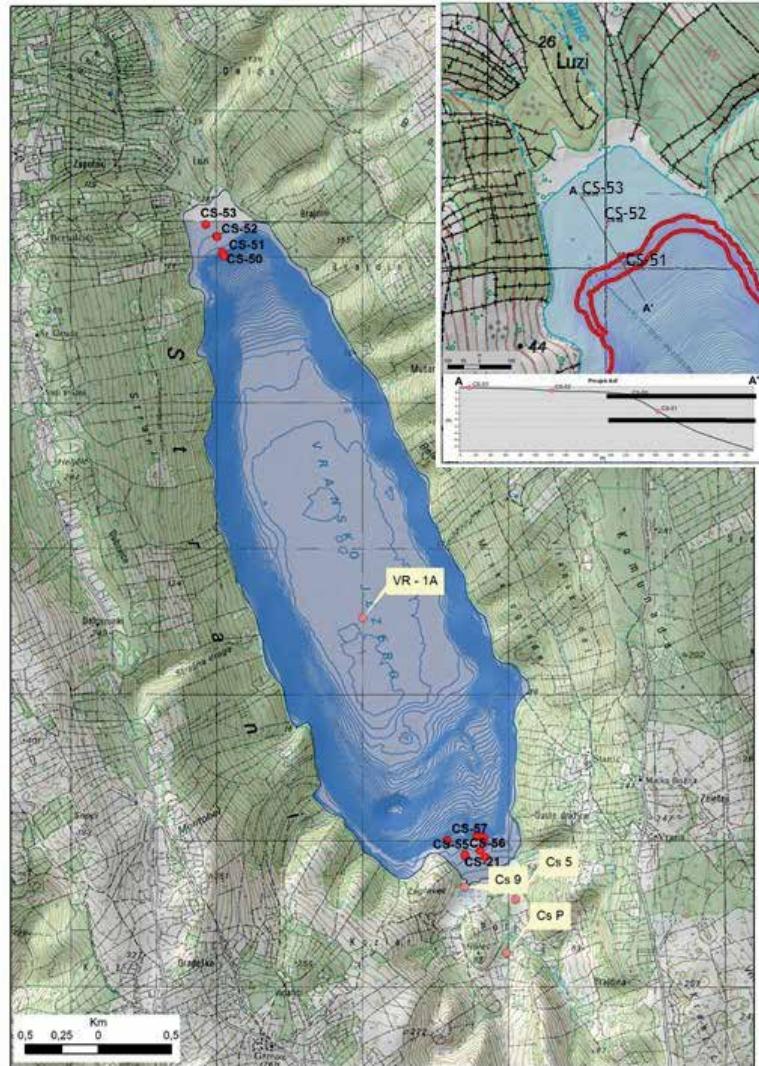
Projekt je financiran od strane Hrvatskih voda, a istraživanja su trajala od rujna 2013. do travnja 2015. godine. U sklopu projekta provedena su paleolimnološka istraživanja Vranskog jezera na Cresu, na temelju čega su rekonstruirane paleorazine jezera. Vransko jezero je duboko krško jezero u središnjem dijelu otoka. Jezero je kriptodepresija te je srednja razina vode u jezeru 13,13 m n. m., a maksimalna izmjerena dubina je 61,3 m ispod razine mora (depresija u JZ dijelu jezera). Dno jezera je većim dijelom ravno, oko 40 m ispod razine mora, što znači da je prosječna dubina vode oko 50 m. Paleolimnologija obuhvaća multidisciplinarni pristup istraživanja slijeda jezerskih sedimenata, te su napravljene analize boje i magnetskog suscep-

This project was financed by Hrvatske vode (Croatian water management authority), and the research lasted from September 2013 to April 2015. As part of the project, paleolimnological investigations of Vrana Lake were carried out on the island of Cres and used as a basis for the reconstruction of its paleo-levels. Vrana Lake is a deep karst lake in the central part of the island. The mean water level in the lake is 13.13 m a.s.l., while the maximum measured depth is 61.3 m b.s.l. (depression in the SW part of the lake), representing a cryptodepression. The bottom of the lake is mostly flat, at about 40 m b.s.l., which means the average depth is about 50 m b.s.l. Paleo-limnology includes a multidisciplinary approach to the investigation of the lacustrine sediment sequences. Hence, different analyses were carried out on several sediment cores from the lake: colour and magnetic susceptibility analyses, granulometric, mineral and geochemical analyses, palynological analyses and the analyses of ostracods and diatoms. One sediment core was collected in the central part of the lake, from a depth of 55 m. Paleo-environmental conditions of late Pleistocene and Ho-



Vransko jezero na Cresu i istraživačka platforma za uzorkovanje jezerskih sedimenata (foto S. Miko)

Vrana Lake on the island of Cres and the research platform for lake sediment sampling (photo by S. Miko)



Lokacije bušenja jezgri sedimenta u Vranskom jezeru na Cresu (priredio S. Miko)

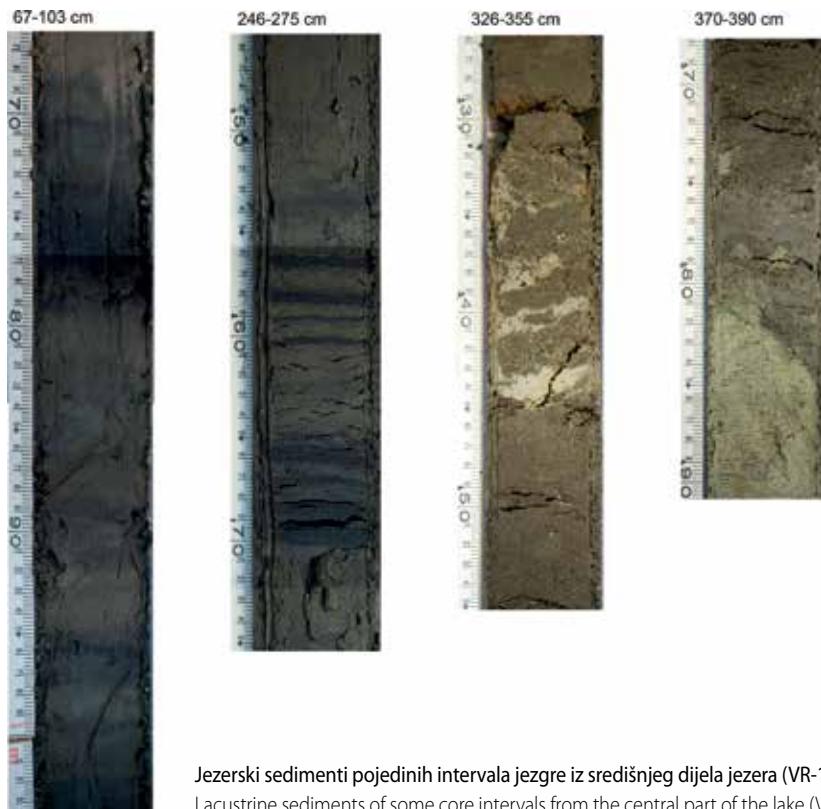
Locations of sediment sampling in Vranskom Lake na on the island of Cres (prepared by S. Miko)

tibiliteta, granulometrijske, mineraloške i geokemijske analize, palinološke analize te analize ostrakoda i dijatomeja, na nekoliko jezgri sedimenata iz jezera: jednoj iz središnjeg dijela jezera, s dubine od 55 m, prema kojoj su se utvrdili paleookolišni uvjeti od kasnog pleistocena i tijekom holocena, te 3 jezgre sedimenata iz plićeg sjevernog dijela jezera, s dubina od 2 do 10 m, pomoću kojih su se identificirale promjene u razinama jezera. Kraj pleistocena karakteriziran je prijelazom iz sedimentacije erozijskog materijala koji sadrži kalcit i dolomit (>14.500 godina) u plićem okolišu, u taloženje siliciklastičnog materijala, u kojem se uočava period intenzivne erozije od 11.700 do 4.500 godina, te se on pripisuje vlažnom periodu.

Nakon toga se udio siliciklastične komponente smanjuje i započinje dominantno taloženje endogenog karbonata, s či-

locene period were determined according to this sample. Three sediment cores, which provided data on lake water level changes, were collected in the shallower, northern part of the lake, from depths of 2–10 m. The end of Pleistocene is characterised by a transition from sedimentation of eroded material containing calcite and dolomite in shallow environment (> 14,500 years) to the sedimentation of siliciclastic material. The latter shows a period of intense erosion from 11,700 to 4,500 years BCE, attributed to the humidity of the period.

Subsequently, the fraction of the siliciclastic component decreases, and precipitation of the endogenous carbonate becomes dominant, which can be related to the current lake water levels. Geochemical and sedimentary analyses of sediments, distribution of ostracod and diatom communities, as well as distribu-



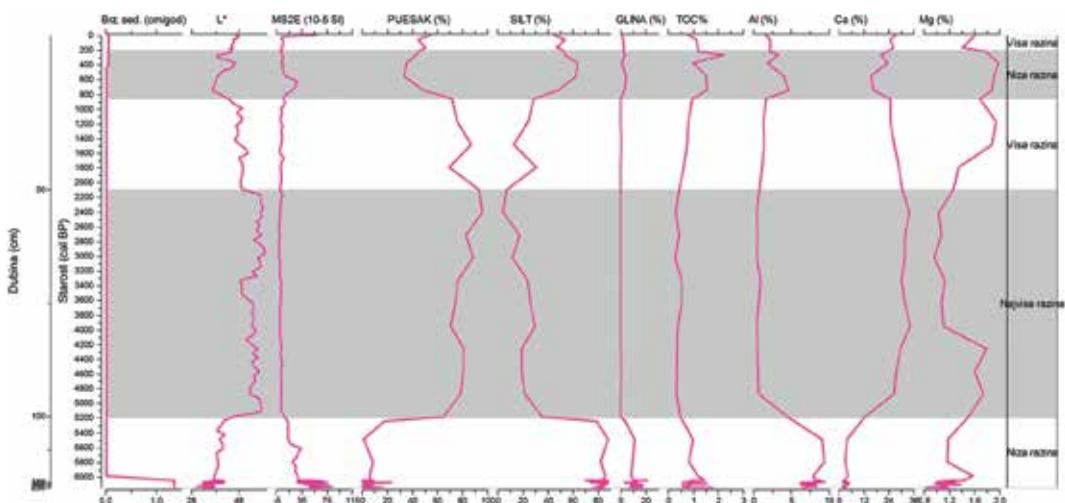
Jezerski sedimenti pojedinih intervala jezgre iz središnjeg dijela jezera (VR-1A)  
Lacustrine sediments of some core intervals from the central part of the lake (VR-1A)

me se povezuje uspostavljanje sadašnjih razina jezera. Geokemijska i sedimentološka analiza sedimenata, distribucija ostrakodnih i dijatomskih zajednica te peludi i palinomorfa u rubnim jezgrama sedimenata, omogućile su utvrđivanje fluktuacije u razini jezera, odnosno dubljih i plićih perioda razvoja jezera u posljednjih 7.000 godina.

tion of pollen and palynomorphs in marginal sediment cores, allowed the determination of variations in the water levels of the lake, i.e. deeper and shallower periods of the lake's evolution in the last 7,000 years.

Distribucija sedimentoloških i geokemijskih parametara po dubini jezgre sedimenata iz rubnog dijela jezera, s interpretiranim fluktuacijom razine jezerske vode

Distribution of sedimentological and geochemical parameters by core depth from the marginal part of the lake, with interpreted water levels in the lake



# Promjene zalihe ugljika u tlu i izračun trendova ukupnog dušika i organskog ugljika u tlu

## Changes in Carbon Stocks and Calculation of Trends of Total Nitrogen and Organic Carbon in Soil and Carbon-to-Nitrogen Ratios

Glavni istraživač / Principal investigator: dr. sc. **Slobodan MIKO**

Suradnici / Collaborators: dr. sc. Ozren HASAN, dr. sc. Nikolina ILIJANIĆ, mr. sc. Martina ŠPARICA MIKO, dr. sc. Ajka ŠORŠA, Ana Marija ĐUMBIR, Danijel IVANIŠEVIĆ, Ivo SUŠA

Istraživanje je izrađeno za potrebe Hrvatske agencije za okoliš i prirodu u sklopu programa „Dogradnja i razvoj Informacijskog sustava zaštite okoliša i unaprjeđenje sustava praćenja i izvješćivanja o stanju okoliša u RH“ u skladu sa smjernicama UNFCCC konvencije i protokola iz Kyota. Projekt je izrađen u suradnji s Hrvatskim šumarskim institutom i Agencijom za poljoprivredno zemljište.

Istraživanje je uključivalo uzorkovanje tala u intervalima 0-10, 10-20 i 20-30 cm, analize uzoraka te izračun organskog ugljika ( $C_{org}$ ) u tlu, rekalkulaciju zaliha ugljika u tlu izračunatih 2012. godine s novim podatcima za ugljik i fizikalnim parametrima, izračun ukupnog dušika i omjera ugljika i dušika (C/N), defini-

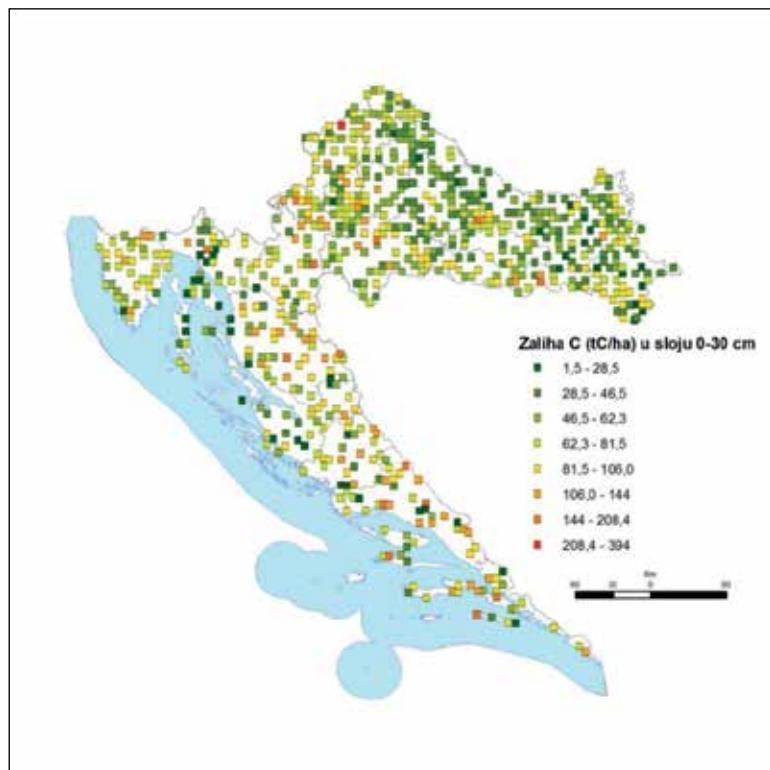
This research was carried out according to the requirements of the Croatian Agency for the Environment and Nature within the programme "Upgrade and development of the information system for the protection of environment and improvement of the system of monitoring and reporting on the condition of environment in the Republic of Croatia" in accordance with the UNFCCC convention and the Kyoto Protocol. The project was conducted in collaboration with the Croatian Forest Research Institute and the Agricultural Land Agency.

The research included soil sampling in intervals of 0–10 cm, 10–20 cm, and 20–30 cm, the subsequent sample analyses, calculation of organic carbon ( $C_{org}$ ) in the soil, recalculation of carbon stocks

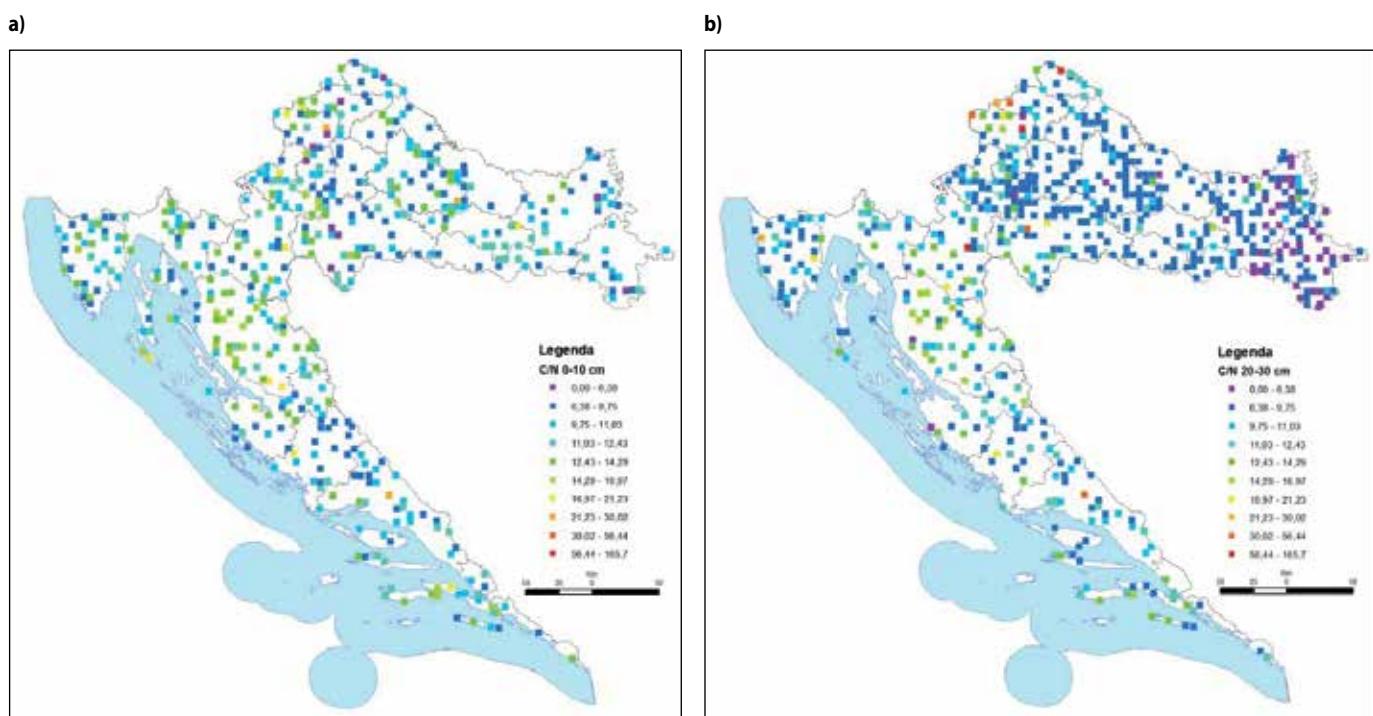
Srednja vrijednost masenog udjela organskog ugljika, dušika i omjera C/N u sloju od 0-3cm u tlima uzorkovanim 2015.-2016. po CORINE Land Cover kategorijama

Average values of organic carbon, nitrogen and C/N ratio in the 0–3cm layer of soil mass fraction in soils sampled during 2015 and 2016, according to the CORINE Land Cover categories

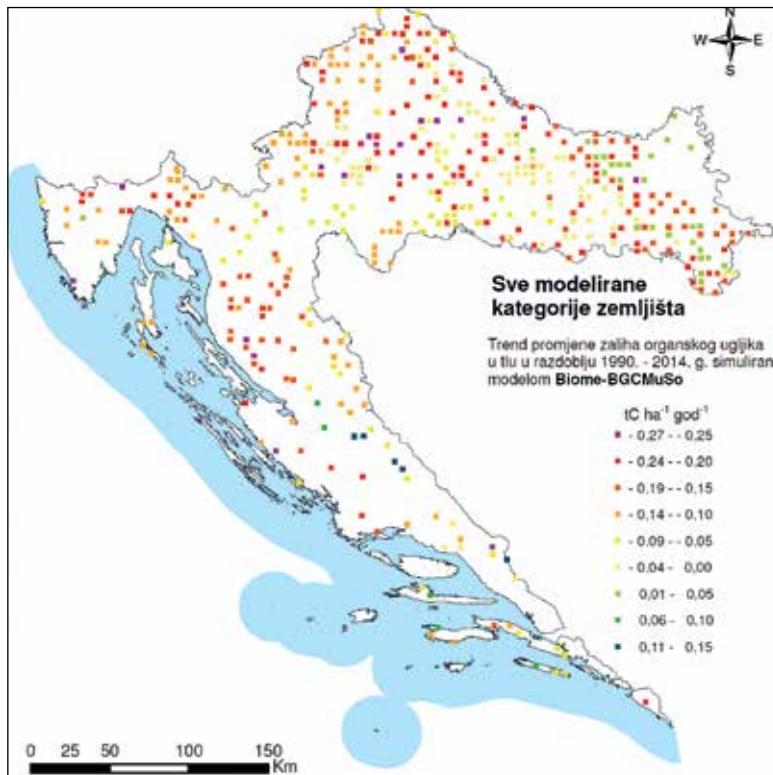
LULUCF kategorije zemljišta	Organski ugljik (SOC %)	Ukupni dušik (N %)	C/N
Šume bjelogorice (Deciduous forest)	2.67	0.239	11.27
Šume crnogorice (Coniferous forest)	4.43	0.348	13.02
Makije i šikare (Forest out of yield)	4.84	0.443	11.27
Jednogodišnji usjevi (Annual cropland)	1.33	0.155	7.96
Višegodišnji nasadi (Perennial cropland)	1.92	0.154	10.81
Travnjaci (Grassland)	2.37	0.259	9.25
Močvare (Wetlands)	3.34	0.342	10.33
Naseljena područja (Settlements)	2.54	0.254	10.46
Ostalo zemljište (Other land)	4.25	0.471	9.02
Prosječno	2.53	0.247	10.13



in the soil calculated in 2012 with new data for carbon and physical parameters, calculation of total nitrogen and the carbon to nitrogen ratios (C/N), definition and mitigation of the most common sources of error during the assessment of  $C_{org}$  stocks in the soil (such as insecurity in assessment of soil density and rockiness or soil skeleton), and calculation of  $C_{org}$  in the organic layer of forest soil. Further, regional pedo-transfer functions were formed and evaluated, enabling better estimation and control of the soil density and skeleton from other available data. Moreover, research analyses of potentially toxic elements were also carried out, as well as calculations of mass and tension balance for heavy metals, and selection and validation of models for estimating carbon stock changes in soils and the assessment of carbon stock changes in soils using the Biome-BG-CMuSo model. Determination of total carbon and nitrogen was carried out simultaneously, using the method of dry combustion in the geochemical laboratory of the HGI-CGS. The results are displayed by individual intervals, and for the total layer thickness of 30 cm.



Karta omjera C:N u analiziranom sloju tla od 0–10 cm (a) odnosno 20–30 cm (b)  
Map of C:N ratio in the analysed soil layer of 0–10 cm (a) and 20–30 cm (b)



Trend promjene zaliha organskog ugljika u tlu (0–3 cm) za razdoblje 1990.–2014. g. skupno za sve LULUCF kategorije koje su modelirane (*Šume bjelogorice / crnogorice, Jednogodišnji usjevi i Travnjaci*)

Trends in organic carbon stocks in the soil (0–3 cm) for the period 1990–2014, total for all modelled LULUCF categories (*Deciduous / coniferous forests, Annual crops, and Lawns*)

ranje i smanjenje najčešćih izvora nesigurnosti pri procjeni zaliha  $C_{org}$  u tlu (kao što su nesigurnost kod procjene gustoće tla i kamenitosti odnosno skeleta u tlu) te izračun  $C_{org}$  u organskom sloju za šumska tla i izrada i valorizacija regionalnih pedotransfernih funkcija koje bi omogućile bolju procjenu i kontrolu gustoće tla i skeleta iz ostalih dostupnih podataka. U sklopu istraživanja izrađene su i analize potencijalno toksičnih elemenata te izračun bilance masa i napetosti za teške metale te odabir i validacija modela za procjenu promjena zaliha ugljika u tlima i procjena promjena zaliha ugljika u tlima pomoću modela Biome-BGCMuSo. Određivanje ukupnog ugljika i dušika provedeno je simultano, metodom suhog spaljivanja u Geokemijskom laboratoriju HGI-CGS-a. Rezultati su prikazani po pojedinim intervalima, te u ukupnom sloju od 30 cm.

Za potrebe ovog projekta analizirano je 1880 uzorka sa 720 lokacija, od kojih je za 21 lokaciju ponovljeno uzorkovanje i analiza radi kontrole rezultata. Utvrđeno je kako tla u RH u sloju 0–30 cm prosječno sadrže 66,9 t C/ha i 6,8 t N/ha, dok je prosječan omjer C/N 10,1. Jednogodišnji i višegodišnji nasadi (poljoprivredna zemljišta) imaju niže količine C i N u odnosu na šumska tla i močvare.

A total of 1880 samples from 720 locations were analysed for the requirements of this project, among which 21 samples were re-sampled and re-analysed for the purposes of quality control. Results show that a 0–30 cm layer of soil in Croatia contains an average of 66.9 t C/ha and 6.8 t N/ha, while the average C/N ratio is 10.1. Annual and multi-annual crop land (agricultural land) has lower amounts of C and N than forest soil and wetlands.

# Ispitivanje tla u površinskom dijelu i po dubini na teške metale i organska onečišćiva na prostoru tvornice HERBOS d.d. u Sisku

## Testing the Soils in the Superficial Part and by Depth for Heavy Metals and Organic Pollutants at the Location of HERBOS Plc Factory in Sisak

Autori teksta / Authors of the text: dr. sc. **Ajka ŠORŠA**, dr. sc. **Josip HALAMIĆ**

U krugu tvornice HERBOS d.d. u Sisku, temeljem ugovora između Hypo Alpe-Adria banke i HGI-CGS-a napravljena su istraživanja onečišćenja tla teškim metalima u 2012. godini, a organskim onečišćivačima 2015. godine.

Kemijska tvornica u Sisku osnovana je 1946. godine i u njoj su se tijekom dugogodišnjeg rada proizvodila sredstava za zaštitu bilja na bazi organo-živinih proizvoda i organo-sumporni fungicidi. Posebno je značajan patent za sintezu atrazina u proizvodnji herbicida koji se izvozio u cijeli svijet. Na području tvornice izgrađena je 1988. godine i spalionica opasnog otpada. Stečajni postupak poduzeća pokrenut je krajem 2011. godine.

Tvornica je smještena uz rijeku Savu u sjeveroistočnom dijelu grada Siska. Aluvijalne naslage su sitnozrnaste i dobre međuzrske propusnosti. Nivo podzemne vode je na oko 4 m. Analiza sadržaja teških metala u tlu provedena je na površinskim uzorcima tla (0-10 cm). Prema preporuci HGI-CGS-a napravljena je i analiza onečišćenja organskim onečišćivalima, koja je, osim uzorkovanja površinskog sloja tla, uključivala i bušenje sondažnih jama do 1 m dubine.

U oba istraživanja obrada podataka i preporuke za daljnje postupanje date su prema Pravilniku o zaštiti poljoprivrednog zemljišta od onečišćenja. Naime, u RH se postojeći zakonski propisi o dopuštenim graničnim koncentracijama teških metala odnose samo na poljoprivredna zemljišta. Upotreba zemljišta na istraživanoj lokaciji je industrijska, a ne poljoprivredna. Zato su dodatno uspoređeni dobiveni analitički rezultati s preporu-

Soil contamination was investigated in the city of Sisak at the property of the HERBOS plc company, with regard to heavy metals in 2012, and with regard to organic compounds in 2015. The investigation was based on a contract between the Hypo Alpe-Adria Bank and the HGI-CGS.

The chemical factory in Sisak was founded in 1946, and during its long-term operation it has been producing plant protection products based on organic-mercury compounds, as well as organic sulphur fungicides. The patent for atrazine synthesis is particularly significant in the production of herbicides exported worldwide. Moreover, a hazardous waste incinerator was built at the property of the factory in 1988. The company's bankruptcy procedure was initiated at the end of 2011.

The factory is located along the Sava river in the north-eastern part of the city of Sisak. Alluvial deposits are fine-grained and of good intergranular permeability. The groundwater level is at about 4 m depth. The analysis of heavy metals content in the soil was carried out on surface soil samples (0–10 cm). Following the recommendation of the HGI-CGS, a contamination analysis of organic compounds was also carried out, which included, besides the sampling of the surface layer of soil, drilling soil pits up to 1 m deep.

The data were processed and recommendations for further treatment were provided under the regulations on the protection of agricultural land from contamination. Specifically, in the RH the existing legislation on threshold concentrations of heavy metals



Pogled na kemijsku tvornicu HERBOS iz zraka (foto Ž. Rakarić)

Aerial photography of HERBOS plant (photo by Ž. Rakarić)

čenim vrijednostima iz Prijedloga za granične vrijednosti teških metala u područjima za industrijske i komercijalne svrhe, kao i sa zakonskim propisima za granične vrijednosti teških metala u područjima za industrijske i komercijalne svrhe u SR Njemačkoj. Dobiveni rezultati za koncentracije teških metala uspoređeni su i s onima iz Geokemijskog atlasa Grada Siska.

only includes agricultural land. The use of land at the investigated location is industrial, rather than agricultural. Therefore, the obtained analytical results were additionally compared to the recommended values from the proposal for threshold concentrations of heavy metals in the areas for industrial and commercial purposes, as well as to the German regulations on threshold concentrations of heavy metals in the areas for industrial and commercial purposes. Moreover, the concentrations of heavy metals were compared with those from the Geochemical Atlas of the City of Sisak.

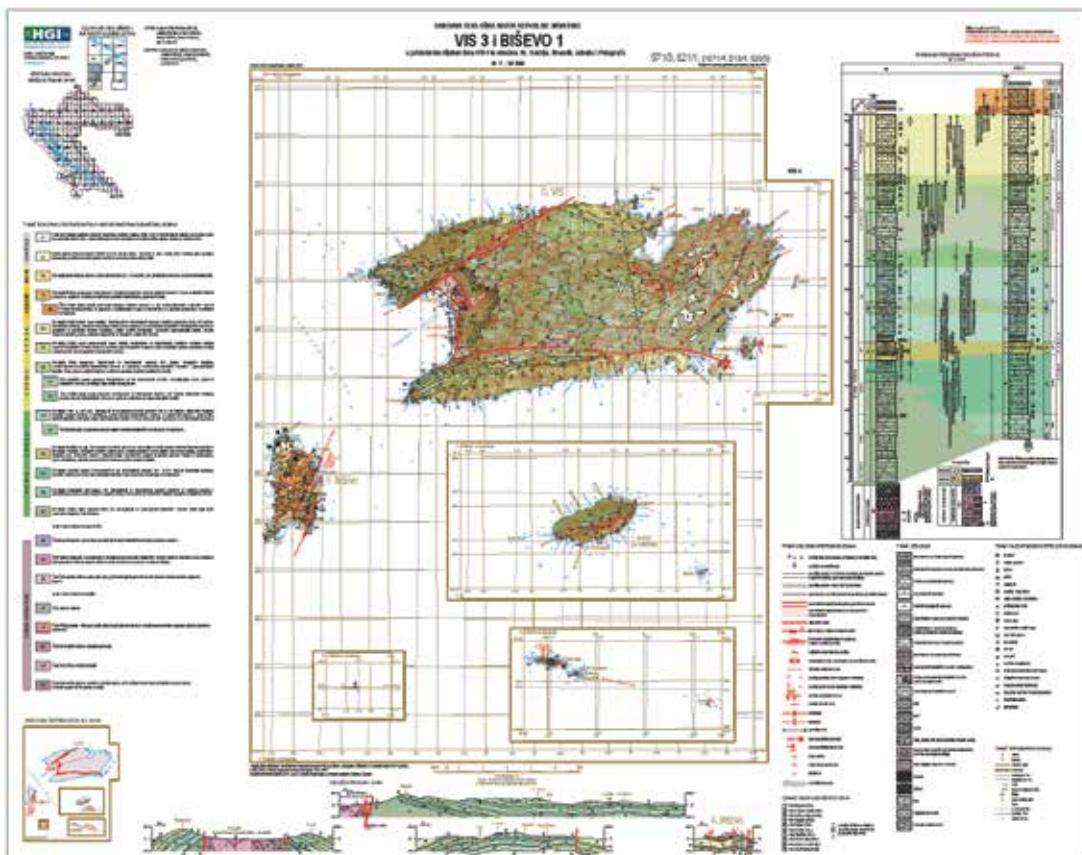
# Geopark Viški arhipelag i geostaze na području gradova Komiže i Visa

## Geopark Vis Archipelago and Geotrails in the Towns of Komiža and Vis

Autor teksta / Author of the text: dr. sc. **Tvrtko KORBAR**

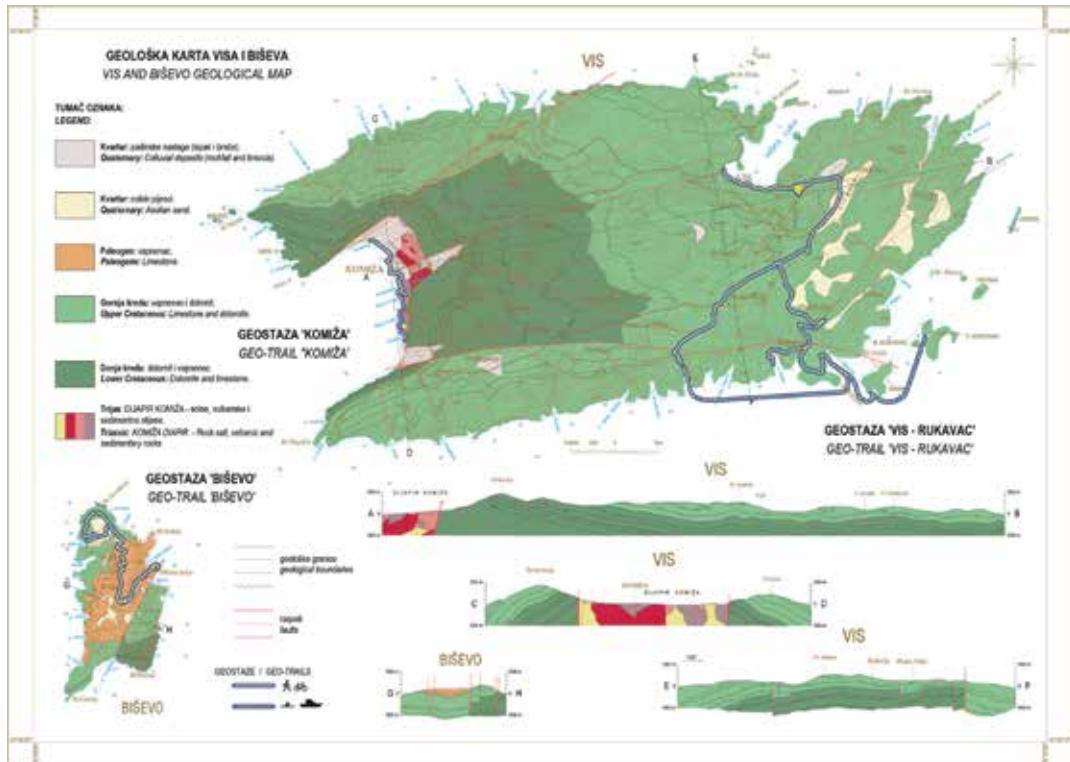
Viški arhipelag je najstariji, ali ujedno i najmlađi na Jadranu, a raznolike geološke pojave lokalnoj zajednici nude nove mogućnosti za razvoj turizma. Brojni zaštićeni spomenici prirode

The Vis archipelago is characterised by both the oldest and the youngest rocks on the Adriatic. These diverse geological phenomena provide the local community with new possibilities for

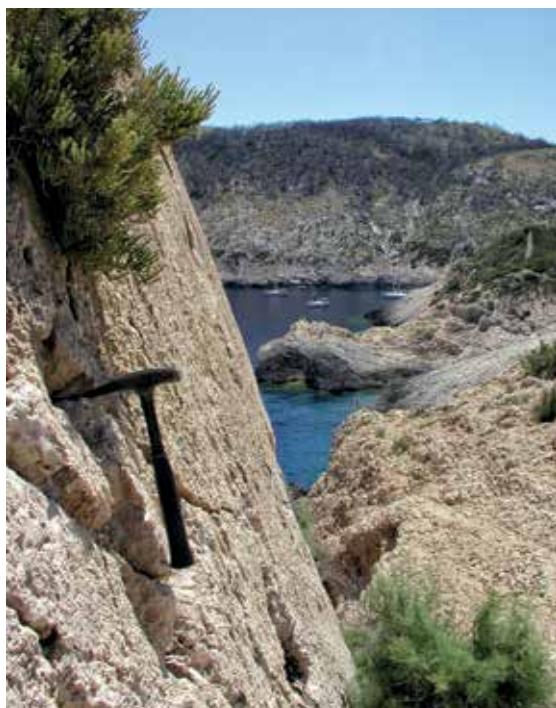


Prikaz lista OGK RH u mjerilu 1:50.000 (Korbar et al., 2012) koji obuhvaća područje geoparka Viški arhipelag

Overview of the BGM RH sheet at the scale of 1:50,000, which comprises the area of the proposed Vis archipelago geopark



Prikaz pregledne geološke karte i prvih geostaza na području otoka Visa i Biševa  
Overview geological map and the first geo-trails in the area of the islands of Vis and Biševo



Paraklaza iznad Modre špilje (otok Biševo)  
Fault plane above the Blue cave (the island of Biševo)

tourism development. Numerous protected natural monuments and landscapes of Dalmatia are located in the area of the Vis archipelago – geological (Brusnik and Jabuka), geomorphological (Stiniva, the cave on the island of Ravnik, Medvidina and Blue caves) and the protected landscapes (small island of Ravnik). It is the most concentrated area of natural monuments on the ter-



Koso uslojeni eolski pijesci (Zlopolje, otok Vis)  
Cross-bedded aeolian sands (Zlopolje, the island of Vis)



Uvala Stiniva (otok Vis)  
Stiniva cove (the island of Vis)

i krajobrazi Dalmacije nalaze se upravo na području Viškog arhipelaga: geološki (Brusnik i Jabuka), geomorfološki (Stiniva, špilja na otoku Ravniku, Medvidina i Modra špilja) te zaštićeni krajobrazi (otočić Ravnik), što je najveća koncentracija spomenika prirode na području Hrvatske, pa i šire. Pored njih, postoji još na desetke geološki i geomorfološki zanimljivih pojava koje također zaslužuju neki oblik zaštite, odnosno promocije. Zbog svega toga, na inicijativu koja je došla od HGI-CGS-a još 2013. godine, nakon prezentacije novog lista OGK RH koji prikazuje geologiju otoka Viškog arhipelaga, lokalna zajednica odlučila je prijaviti se za stjecanje statusa UNESCO Global Geopark.

Temelji za stjecanje statusa UNESCO geoparka nalaze se u geološkoj građi Viškog arhipelaga, koja je sustavno istraživana tijekom izrade nove OGK RH (Korbar i sur., 2012). Tijekom 2017. godine gradovi Komiža i Vis prihvatali su ponudu HGI-CGS-a da izradi materijale nužne za prijavu te za obilježavanje triju geostaza na području budućeg geoparka: "Komiža", "Biševo" i "Vis-Rukavac". Djelatnici Zavoda za geologiju HGI-CGS-a (T. Korbar, M. Belak, N. Belić, K. Petrinjak i M. Horvat) pripremili su popularno-geološke tekstove i grafike nužne za obilježavanja geostaza, koji su iskorišteni za izradu informativnih ploča i pripremu aplikacije. Međunarodno povjerenstvo ocjenjivalo je aplikaciju i obišlo geostaze tijekom ljeta 2018., a odluka UNESCO-a o prihvaćanju prijave očekuje se u proljeće 2019. godine.

ritory of Croatia and beyond. In addition, the local community decided to apply for UNESCO Global Geopark status, as there are still dozens of geologically and geomorphologically interesting phenomena in the area, which deserve protection and promotion. This occurred at the initiative of the HGI-CGS in 2013, after the presentation of a new sheet of the BGM of the RH, illustrating the geology of the islands of Vis archipelago.

The premise for obtaining the UNESCO geopark status is the geological structure of the Vis archipelago, which was systematically investigated during the construction of the new BGM of the RH (Korbar et al., 2012). In 2017, the towns of Komiža and Vis accepted the offer from the HGI-CGS to prepare the necessary materials for registration and to mark three geo-trails in the area of the future geopark: "Komiža", "Biševo", and "Vis-Rukavac". The employees of the Department of Geology of the HGI-CGS (T. Korbar, M. Belak, N. Belić, K. Petrinjak and M. Horvat) prepared the popular-geological texts and graphics necessary for marking the geo-trails. These were used in information boards and for preparation of the application. The international commission evaluated the application and visited geo-trails during the summer of 2018. UNESCO's decision on the application is expected in spring 2019.

# Geološka procjena potencijalnih nekonvencionalnih naftnih i plinskih resursa u Europi

## Geological Evaluation of Potential Unconventional Oil and Gas Resources in Europe

Koordinator za HGI-CGS / Coordinator for HGI-CGS: dr. sc. **Tonći GRGASOVIĆ**

Suradnici / Collaborators: dr. sc. Vlatko BRČIĆ, dr. sc. Georg KOCH, Pavle FERIĆ

U okviru programa Horizon 2020 poziva B.2.9. "Podrška energetskoj politici na nekonvencionalnim izvorima plina i nafte" iz Europske komisije, GEUS (Geological Survey of Denmark and Greenland) je dobio projekt "Geološka procjena potencijalnih nekonvencionalnih naftnih i plinskih resursa u Europi", skraćeno EUOGA.

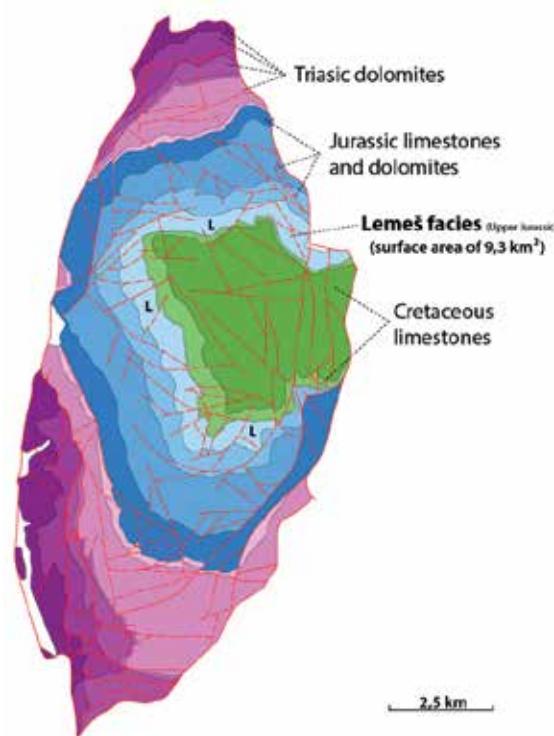
Cilj projekta je bio prikupljanje postojećih publiciranih saznanja o naslagama šejlova u Europi, relevantnim za primjenu nekonvencionalnih metoda pridobivanja nafte i plina, uz sudjelovanje podugovaratelja članova EuroGeoSurveys-a. Fokus je bio na definiranju zajedničke metodologije procjene resursa i javnosti rezultata kroz GIS bazu podataka. Također su se prikupljali javno dostupni podatci o aktivnostima vezanim za nekonvencionalne naftne i plinske resurse, kao i službenim političkim stavovima o ovom pitanju.

U konačnici su izdvojene 74 lokacije naslaga šejla u Europi, raspoređene u 30 bazena, koje su zadovoljile postavljene kriterije.

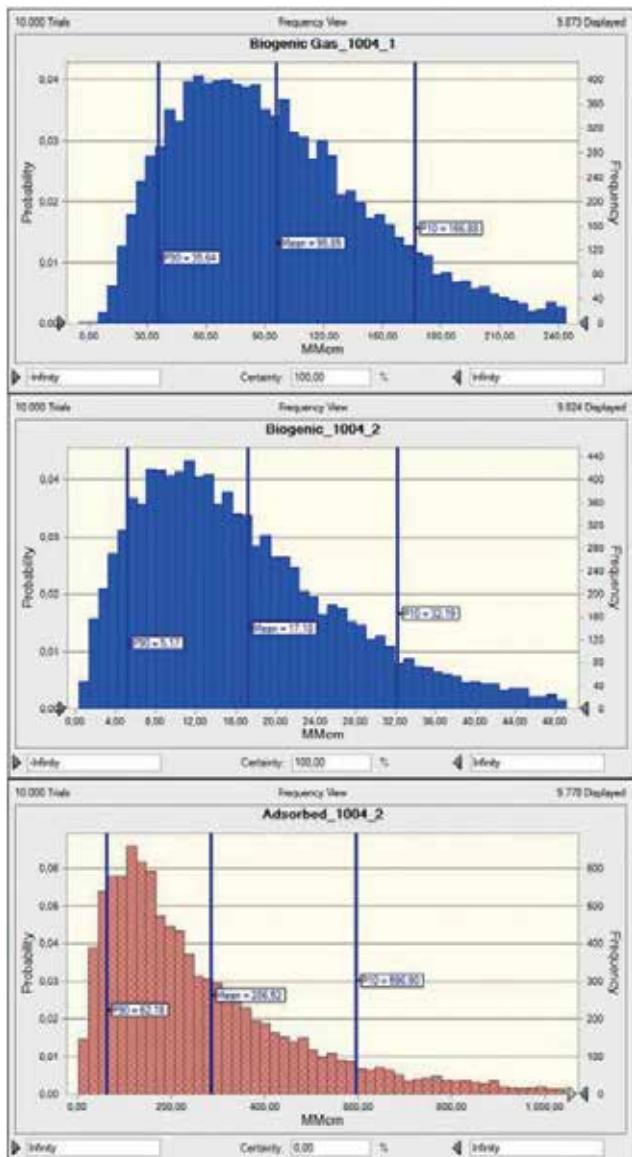
S obzirom na stupanj istraženosti, dostupne podatke, kao i geološke i naftogeološke karakteristike, odlučili smo u okviru ovog projekta detaljno prikazati Lemeške naslage Like. One su izgrađene od pločastih vapnenaca s proslojcima rožnjaka i rijetkim proslojcima bentonita i tufova, kao i laminiranih vapnenaca i vapnenačkih šejlova bogatih organskom tvari.

Prezentirani su podatci o TOC-u (Total Organic Carbon), termalnoj zrelosti, poroznosti, tipu kerogena, genezi, debljini i prostiranju naslaga, litologiji, strukturalnim i geološkim značajkama, koji su kasnije i interpretirani.

Within Horizon2020, call B.2.9. "Energy Policy support on unconventional gas and oil" of the European Commission, the GEUS (Geological Survey of Denmark and Greenland) was appointed to lead the "EUOGA – European Unconventional Oil and Gas Assessment" project.



Geološka karta Lemeških naslaga područja Poštaka u Lici  
Geological map of the Lemeš deposits in the Poštak area of Lika



Jedna od ilustracija iz konačnog izvješća za Lemeški bazen

One of the illustrations from the final report on the Lemeš Basin

The aim of the project was to collect, with the help of subcontractors, i.e., members of the EuroGeoSurveys, the existing published findings on shale deposits in Europe, relevant for the application of unconventional methods for acquiring oil and gas. The focus was on the development of a common methodology for assessing resources and publishing results within a GIS database. Publicly accessible data were also collected on activities related to unconventional oil and gas resources, as well as data on official political stances on this matter.

Finally, 74 locations of shale were isolated in Europe, distributed in 30 basins and satisfying predefined criteria.

According to acquired knowledge, available data, as well as geological and petroleum-geological characteristics, we have decided to present the Lemeš deposits of Lika in detail. These deposits are composed of platy limestone interbedded with chert and sparsely interbedded with bentonite and tuff, as well as laminated limestone and limey shale rich in organic matter.

Data on the TOC (total organic carbon), thermal maturity, porosity, kerogen type, genesis, thickness and distribution of deposits, lithology, and structural and geological properties were presented and later interpreted.

# Informacije o kvaliteti sedimenata, monitoring i sustav procjene kao podrška transnacionalnoj suradnji za zajedničko upravljanje vodama u dunavskom bazenu

## Sediment-quality Information, Monitoring and Assessment System to Support Transnational Cooperation for Joint Danube Basin Water Management

Koordinator za HGI-CGS / Coordinator for HGI-CGS: **Danijel IVANIŠEVIĆ**

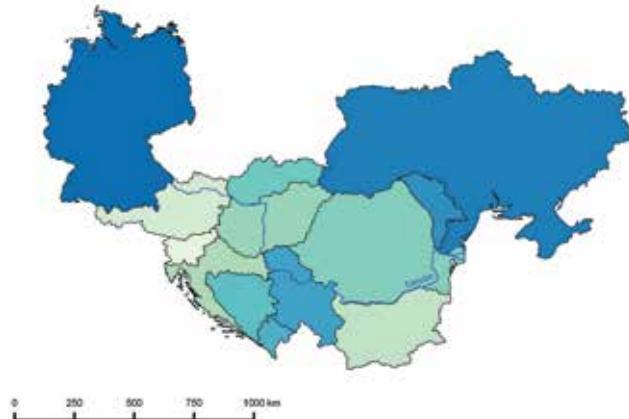
Projekt akronima SIMONA je Interreg projekt sufinanciran iz Programa prekogranične suradnje za područje dunavskog slijeva. Projekt je započeo 1. lipnja 2018. i traje do 31. svibnja 2021., a njegova vrijednost je 1,75 milijuna €. U projektu sudjeliće 29 institucija partnera i pridruženih strateških partnera iz 13 zemalja s područja dunavskog slijeva, od Njemačke pa sve do Ukrajine. Vodeći partner je Geološki zavod Slovenije, dok je HGI-CGS voditelj radnog paketa vezanog za protokole uzorkovanja i laboratorijske protokole. Pridruženi strateški partneri HGI-CGS -a su Hrvatske vode i Vode Srpske.

The project under the acronym SIMONA is an Interreg project co-financed by the Danube transnational programme of cooperation. It is worth € 1.75 million, initiated on the 1<sup>st</sup> of June 2018 and will proceed until 31 May 2021.

Twenty-nine partners and associated strategic partner institutions are involved in the project. They come from 13 countries of the Danube basin region, from Germany to Ukraine. The lead partner is the Geological Survey of Slovenia, while the HGI-CGS is leading a work package on sampling and laboratory protocols.



Institucije partneri u projektu SIMONA  
Partner institutions in the SIMONA project



**Geografski pregled država partnera u projektu SIMONA**  
Geographical overview of the partner countries in the SIMONA project

Cilj projekta je na temelju postojećih, ali neujednačenih, protokola uzorkovanja, analize, procjene i monitoringa kvalitete drenažnog sedimenta, izraditi standardizirane i harmonizirane protokole za čitavo područje dunavskog slijeva. Kvaliteta sedimenta odnosi se na sadržaj opasnih tvari (anorganskih i organskih) propisanih Europskom okvirnom direktivom o vodama.

Izuzev navedenog, cilj je izraditi aplikaciju na mreži, koja će sadržavati izrađene protokole, i koja će služiti kao sustav unosa podataka o kvaliteti drenažnog sedimenta. Dodatno, aplikacija će sadržavati i sustav obrade unesenih podataka, sa svrhom evaluacije.

Čitav projekt je popraćen uvježbavanjem strateških partnera zaduženih za implementaciju projektnih rezultata na razini države (primjerice Hrvatske vode). Istovremeno, strateški partneri predstavljaju savjetodavna tijela tijekom projekta, kako bi izrađeni protokoli bili prilagođeni njihovim potrebama, ali i unaprijeđeni i usklađeni s ostalim državama partnerima.

The associated strategic partners of the HGI-CGS are Hrvatske vode and Vode Srpske.

The aim of the project is to develop standardised and harmonised protocols for the whole Danube basin region, based on existing, but non-harmonised sampling, analysis, evaluation and monitoring protocols for drainage sediment quality assessment. Sediment quality refers to the hazardous substances content (inorganic and organic), as prescribed by the EU Water Framework Directive.

In addition, the goal is to create an online application that will contain developed protocols and serve as an entry system for the drainage sediment quality data. Moreover, the application will contain a data processing system for the purposes of evaluation.

The entire project is accompanied with training of the strategic partners responsible for implementation of the project results at the country level (e.g. Hrvatske vode). At the same time, strategic partners have an advisory role during the project, to make the protocols adapted to their needs, but also improve them and make them compatible with other partner countries.



Dunav kod Dalja (foto A. Banak)  
Danube River at the village of Dalj (photo by A. Banak)

# Geološka karta Nacionalnog parka Kornati M 1:50.000

## Geological Map of the Kornati National Park M 1:50,000

Voditelj projekta / Project Manager: dr. sc. **Vlatko BRČIĆ**

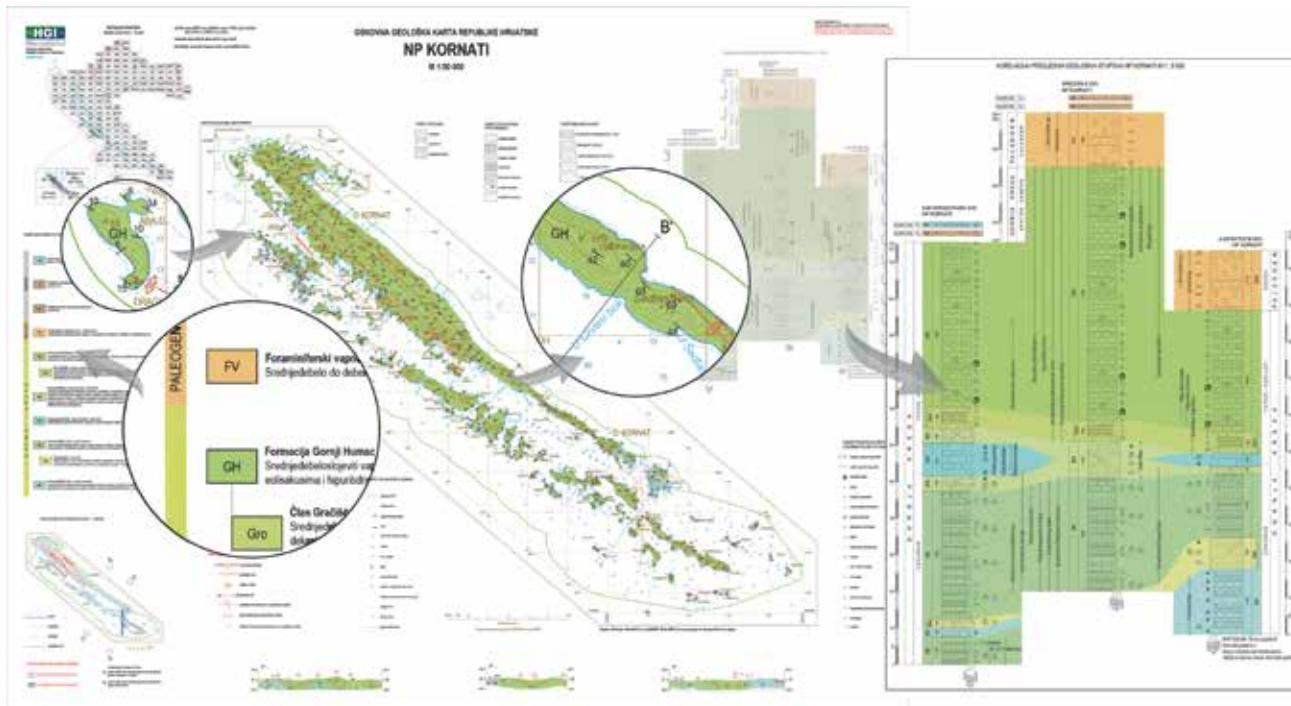
Suradnici / Collaborators: dr. sc. Tvrko KORBAR, Ladislav FUČEK, mr. sc. Damir PALENIK, dr. sc. Ivan MIŠUR, Nikola BELIĆ, Marko ŠPELIĆ, dr. sc. Lara WACHA, Marko BUDIĆ, dr. sc. Duje KUKOČ, dr. sc. Koraljka BAKRAČ

Temeljem ugovora s javnom ustanovom Nacionalni park (NP) Kornati, tijekom 2018. godine provedena su sustavna geološka istraživanja cijelog područja NP Kornati. Istraživanja uključuju pripremu postojeće dokumentacije, prospexiju, snimanje geoloških stupova i profila, geološko kartiranje, reambulaciju, kabinetska i laboratorijska istraživanja. Karta je terenski fina-lizirana u listopadu 2018., a dovršena u digitalnom i tiskanom formatu do kraja godine.

Provđena temeljna geološka istraživanja osnova su za provo-đenje budućih zajedničkih projekata geostaze, stalna postava izložbe vrsta stijena i fosila s područja nacionalnog parka,

Based on the contract with NP Kornati, during the year 2018, systematic geological surveys of the entire area of NP Kornati were carried out. Research included preparation of existing documentation, prospection, geological columns and profiles, geological mapping, reambulation, desk and laboratory research (total project duration is one year). The map was finalized and completed in digital and printed formats in December 2018.

The underlying geological research forms the basis for the imple-mentation of future joint projects (geo-trails, exhibition of rock and fossil species, geo-tourist guides, speleology etc.). In addition to NP Kornati, the main beneficiaries of the success of this project



OGK RH NP Kornati 1:50.000 (autori: V. Brčić, T. Korbar, L. Fuček, D. Palenik, N. Belić, I. Mišur, L. Wacha. Suradnici: M. Špelić, M. Budić, D. Kukoč)  
BGM RH of NP Kornati 1:50,000 (authors: V. Brčić, T. Korbar, L. Fuček, D. Palenik, N. Belić, I. Mišur, L. Wacha; collaborators: M. Špelić, M. Budić, D. Kukoč)



*Chondrodonta na otoku Mrtnjak*

*Chondrodonta on the island of Mrtnjak (photo by V. Brčić)*

geoturistički vodič/tumač, speleologija i sl.). Osim NP Kornati, glavni korisnici uspješno provedenog projekta biti će lokalna zajednica, posjetitelji parka te znanstvena i obrazovna zajednica. Potencijalni doprinosi istraživanja su bolja preventivna zaštita područja, geološka podloga za 42 do sada otkrivena speleološka objekta, obogaćivanje sadržaja posjetiteljskog centra, edukacija o vrijednosti prostora, publiciranje do sada neobjavljenih znanstvenih i popularno-znanstvenih činjenica u domaćoj i svjetskoj literaturi te povećana mogućnost dobivanja sredstava iz EU fondova.

Logistički vrlo zahtjevan projekt (89 otoka ukupne površine približno 50 km<sup>2</sup>) potpomogli su stručno voditeljstvo (Zlatko Ružanović i Vladislav Mihelčić) te djelatnici NP Kornati (svakodnevni prijevoz brodom). Ovim putem se ujedno i zahvaljujemo na pomoći bez koje ne bi bilo moguće izvođenje spo-menutog projekta.

will be the local community, park visitors, and the scientific and educational community.

The potential contribution of this research includes better preventive protection of the area, geological base maps for the 42 discovered speleological objects, enrichment of the visitor centre content, education on the value of the area, publication of scientific and popular-scientific facts in the domestic and world literature, and increased possibilities of receiving EU funding.

Expert associates (Zlatko Ružanović and Vladislav Mihelčić) as well as employees NP Kornati (boat transport) supported this logistically challenging project (89 islands with a total area of approximately 50 km<sup>2</sup>). In this way, we wish to thank them for their contribution.

The HGI-CGS project team were: Vlatko Brčić, Tvrto Korbar, Ladislav Fuček, Damir Palenik, Ivan Mišur, Nikola Belić, Marko Špelić, Lara Wacha, Marko Budić, Duje Kukoč, and Koraljka Bakrač.



*Pogled sa Gustaca na Koritnjak (foto M. Budić)*

*View from Gustac to Koritnjak (photo M. Budić)*



*Pogled s Mane na Kornat (foto M. Budić)*

*View from Mana to Kornat (photo M. Budić)*

# Geopark Imotska jezera

## Geopark Imotski Lakes

Voditelj projekta / Project Manager: dr. sc. **Vlatko BRČIĆ**

Tijekom kolovoza i rujna 2018. godine na širem području Grada Imotskog i susjednih općina provedena su sustavna geološka i speleološka istraživanja u svrhu proglašenja Geoparka Imotska jezera. Geološka istraživanja uključuju: pregled terena i odabir lokacija značajnih sa lithostratigrafskog i strukturno-geološkog aspekta. Provedena su i hidrogeološka i limnogeološka istraživanja pojedinih odabranih objekata. U projekt su uključena sva tri zavoda HGI-CGS-a, a radovi se izvode u suradnji s Dinaric Hub d.o.o., lokalnom upravom te Turističkom zajednicom Grada Imotskog.

Predviđena površina geoparka je  $124 \text{ km}^2$  na kopnu te  $1.5 \text{ km}^2$  jezera. Od geomorfoloških pojava mogu se opažati krško polje, jezera, rijeke, kanjon, planinski krajolik, vrtače i spilje.



Administrativna granica budućeg Geoparka „Imotska jezera“  
The administrative boundary of the planned Geopark "Imotski lakes"

During August and September 2018, in the wider area of Imotski, systematic geological and speleological surveys were carried for the purpose of establishing Geopark "Imotski lakes". Geological research included field surveys and the selection of locations significant for their lithostratigraphic and structural-geological features, as well as hydrogeological and limnogeological research of selected areas. All three departments of the HGI-CGS are involved



Crveno jezero i gornjokredni vapnenci  
Red lake and Upper Cretaceous limestones



Brana akumulacijskog jezera Ričice  
The dam of the reservoir lake Ričice



**Jezero Galipovac i Prološko blato u daljini**

Galipovac lake and Prološko blato in the distance

Nadmorska visina varaira od 262 m do 774 m, klima područja je mediteranska do kontinentalna. Broj stanovnika je 10.764, a važnija naselja su Imotski, Lokvičići, Runovići, Proložac, Donji Vinjani, Glavina Donja, Podbablje, Ričice i Krivodol.

Osnivanje Geoparka Imotska jezera na području RH pridonijelo bi prvenstveno podizanju svijesti o važnosti zaštite geološke i geomorfološke baštine te prepoznavanju geoturizma kao jedinstvene turističke ponude. Glavni zadatak je zaštita, obrazovanje i održivi razvoj pojedinih i specifičnih mjesta i krajolika od međunarodnoga geološkog značaja.

in the project, with cooperation of the Dinaric Hub Ltd., local government and the Tourist Board of Imotski.

The foreseen surface area of the geopark is 124 km<sup>2</sup>, including 1.5 km<sup>2</sup> of lake areas. A number of geomorphological forms can be seen and visited: karst polje, lakes, rivers, canyon, hills, sink-holes and caves.

Altitude varies in the range of 262–774 m and the climate is Mediterranean to continental. Number of inhabitants is 10,764 and larger settlements are Imotski, Lokvičići, Runovići, Proložac, Donji Vinjani, Glavina Donja, Podbablje, Ričice and Krivodol.

The establishment of the Geopark "Imotski lakes" on the territory of the Republic of Croatia would primarily contribute to raising awareness of the importance of protecting geological and geomorphological heritage and recognizing geotourism as a unique touristic attribute. The main tasks are protection, education, and sustainable development of the unique sites and landscapes of international geological significance.



**Modro jezero (foto J. Terzić)**

Blue lake (photo by J. Terzić)

# Geološki i seizmološki aspekti geodinamike Kvarnera – razotkrivanje kvarnerskog rasjeda

## Geological and Seismological Aspects of Geodynamics in Kvarner Area – Unveiling of the Kvarner Fault

Glavni istraživač / Principal investigator: dr. sc. **Tvrtko KORBAR**

<https://geosekva.wordpress.com/>



Istraživački projekt akronima GEOSEKVA, predviđenog trajanja 4 godine, financira Hrvatska zaklada za znanost (HRZZ IP-06-2016-1854) od 2017. godine. Matična institucija projekta je Hrvatski geološki institut, a na projektu sudjeluju 22 osobe: 13 suradnika iz matične institucije: T. Korbar, K. Petrinjak, L. Fuček, D. Palenik, S. Bergant, N. Belić, V. Brčić, M. Špelić, M. Budić, O. Hasan, D. Brunović, P. Ferić, L. Wacha, 3 iz drugih domaćih institucija: M. Surić, S. Markušić i T. Fiket, 2 inozemna suradnika: A. Del Ben i V. Kastelic te 4 konzultanta: M. Frechen, B. Tomljenović, Č. Benac i T. Durn. Projekt je organiziran kroz 11 zadataka. Konačni cilj projekta je izrada seismotektonskog modela šireg područja Kvarnera.

The GEOSEKVA research project, planned to duration of four years, has been funded by the Croatian Scientific Foundation (CSF IP-06-2016-1854) since 2017. The project's parent institution is the HGI-CGS, and there are 22 individuals participating: 13 collaborators from the parent institution – T. Korbar, K. Petrinjak, L. Fuček, D. Palenik, S. Bergant, N. Belić, V. Brčić, M. Špelić, M. Budić, O. Hasan, D. Brunović, P. Ferić, L. Wacha; 3 from other domestic institutions: M. Surić, S. Markušić, and T. Fiket; 2 foreign associates: A. Del Ben and V. Kastelic, and four consultants: M. Frechen, B. Tomljenović, Č. Benac, and T. Durn. The project is organised into 11 tasks. The final goal of the project is the construction of a seismotectonic model of the wider Kvarner area.

The kick-off meeting was held in April 2017, followed by the commencement of geological mapping along selected profiles, and directed fieldwork research of the most interesting sites in the wider Kvarner area. The project was preliminarily presented at the international conference *Man and Karst* in Zadar, and for the wider audience in two shows on the Croatian radio and on the project website. The associates participated in several workshops. A repository of data acquired through the project has been created.

After the positive review of the project's first year, research has continued according to plan also in 2018. S. Markušić participated at the *36th General Assembly of the European Seismological Commission* on Malta. A Guralp company seismograph was purchased and set up in Baška on the island of Krk, however, it was returned to the supplier due to malfunction in mid- 2018. The academic licence for the Schlumberger Petrel programme was acquired



Suradnici na kick-off sastanku u Hrvatskom geološkom institutu (foto: M. Budić)  
Associates at the kick-off meeting in the HGI-CGS (photo by M. Budić)

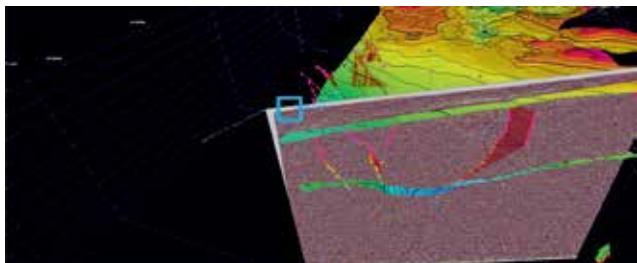


Terenska istraživanja na području Rijeke – subhorizontalna kataklazirana rasjedna zona na Grobniku (foto: T. Korbar)

2. Fieldwork in the Rijeka area – subhorizontal cataclastic fault zone in Grobnik

U travnju 2017. održan je *kick-off* sastanak, a zatim je započeto geološko kartiranje duž odabranih profila te usmjereno terensko istraživanje najzanimljivijih lokaliteta na širem području Kvarnera. Projekt je preliminarno prezentiran na međunarodnom skupu *Men and Karst* u Zadru, a za širu publiku u 2 emisije Hrvatskog radija te na mrežnoj stranici projekta. Suradnici su sudjelovali na nekoliko radionica. Kreiran je repozitorij podataka koji se prikupljaju na projektu.

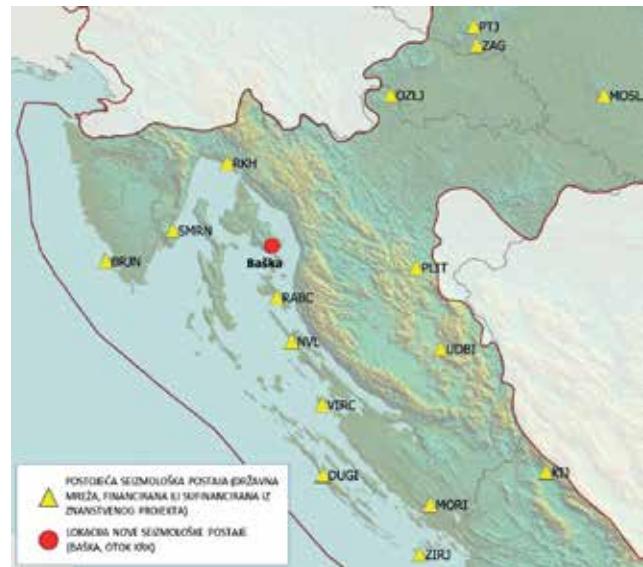
Nakon pozitivne ocjene prve godine projekta, istraživanja su nastavljena prema planu i u 2018. S. Markušić je sudjelovala na *36th General Assembly of the European Seismological Commission* na Malti. Nabavljen je i postavljen seismograf tvrtke *Guralp* u Baški na otoku Krku, koji je sredinom 2018. vraćen dobavljaču na servis zbog kvara. Za potrebe interpretacije seizmičkih podataka i izrade 3D modela nabavljen je akademска licenca za program *Schlumberger Petrel*. M. Špelić i A. Del Ben su prezentirali prve interpretirane seizmičke podatke krajem 2018. na međunarodnom kongresu u Italiji. Tijekom 2018. kupljena je i licenca za program *Midland Valley Move* koji je predviđen za izradu 3D modela odabranih struktura na kopnu i u podmorju, sa ciljem mogućeg prostornog i vremenskog definiranja ključnih rasjeda.



Prikaz interpretiranih profila i površina u 3D prozoru programa *Schlumberger Petrel* (izradio M. Špelić)

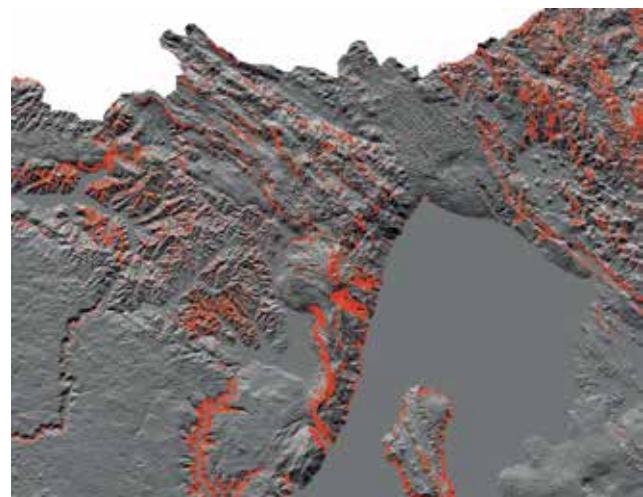
Display of interpreted profiles and surfaces in the *Schlumberger Petrel* software 3D window (prepared by M. Špelić)

for the needs of interpretation of seismic data and creation of 3D models. M. Špelić and A. Del Ben presented the first interpreted seismic data at the end of 2018 at an international congress in Italy. In 2018, the licence was purchased also for the *Midland Valley Move* programme, built for creating 3D models of selected land and submarine structures, with the aim of possible spatial and temporal definition of key faults.



Pregledna karta dijela mreže seismoloških postaja Republike Hrvatske i lokacija novog seismografa na otoku Krku (Baška)

Overview map of a part of the seismologic stations of the Republic of Croatia network and the location of the new seismograph on the island of Krk (Baška)



Karta lineamenata šireg područja Rijeke dobivena pomoću karte nagiba (izradio P. Feric)

Lineament map of the wider Rijeka area obtained using slope map (prepared by P. Feric)

# Osnovna hidrogeološka karta Republike Hrvatske 1:100.000

## Basic Hydrogeological Map of the Republic of Croatia 1:100,000

Glavni istraživač / Principal investigator: dr. sc. **Josip TERZIĆ**

Osnovna hidrogeološka karta (OHGK) je jedan od temeljnih projekata našeg instituta i provodi se u Zavodu za hidrogeologiju i inženjersku geologiju. Hidrogeologija, znanost o podzemnim vodama, je tehnička znanost, dio geološkog inženjerstva i bliska ostalim strukama koje se bave vodama, pogotovo podzemnim (hidrologija, hidrotehnika, kemija, biologija...). Na projektu u ovom trenutku radi 12 hidrogeologa.

Tijekom ovog desetljeća došlo je do velikih promjena u vanjskim čimbenicima koji utječu na naš rad, a na koje teško možemo utjecati. Tako je u prvoj polovici razdoblja OHGK financirana putem tzv. zProjekata tadašnjeg Ministarstva znanosti, obrazovanja i športa. To je financiranje bilo prenisko za potrebe kvalitetnog izvođenja projekta, a vremenom se čak i smanjivalo, pa se za rad na kartama koristio novac iz vlastitih izvora. Projekt

The Basic Hydrogeological Map (BHGM) is one of our Institute's fundamental projects, and its production is conducted in the Department of Hydrogeology and Engineering Geology. Hydrogeology, the science of groundwater, is a technical science, forming a part of geological engineering, and close to other professions studying water (hydrology, hidrotechnics, chemistry, biology...). There are currently 12 hydrogeologists working on this project.

During the past decade, big changes have occurred in the external factors affecting our work, which we could hardly influence. In the first half of this period, the BHGM was financed by so-called zProjects of the then Ministry of Science, Education and Sports. This financing was too low for the needs of high-quality project implementation, and with time this funding was further decreased, such that money from the HGI-CGS own funds was



Pogled na izvorišnu zonu Imotskog polja i Prološko blato  
Aerial view of the discharge zone in Imotski polje and Prološko blato



Krški izvor Zagorske Mrežnice  
Karst spring of Zagorska Mrežnica river



Prikupljanje kišnice radi monitoringa stabilnih izotopa na vrhu Biokova  
(Sv. Jure)

Rainwater sampling for stable isotope monitoring on the top of Biokovo Mt.  
(Sv. Jure)



Mjerenje protoka na rijeci Gacki (foto T. Frangen)

Flow measurements on Gacka river (photo by T. Frangen)

je tada vodila dr. sc. Željka Brkić i u tom je razdoblju nekoliko radnih rukopisa (tumača i karata) privredno završnoj fazi, te se počelo raditi na novim uputama. Nakon 2013. ukidaju se zProjekti, no HGI-CGS odlučuje zadržati temeljne projekte kao dio naše stoljetne tradicije i činjenice kako je riječ o nečemu što je od izrazite važnosti za društvo. Projekt se počinje financirati simbolično, tzv. „glavarinama“ znanstvenika koji na njemu rade. Uz to se sve više koristi i dodatno financiranje vlastitim sredstvima – sada pojačano i projektima Europske unije. U takvim okolnostima zamrzava se izrada uputa, no nekoliko se listova dovršava do faze recenzije, tri prolaze recenziju, a jedan je do sada službeno objavljen – što je zapravo prvi publicirani list OHGK.

Ovisno o mogućem dobivanju programskog financiranja, usmjeravat će se i rad na OHGK. U skladu sa sve jačim GIS alatima i bazama podataka, u budućnosti će se karte više objavljivati po prirodnim cjelinama, a manje isječene po shemi listova. Dodatci kartografskim i tekstualnim dijelovima lako će se ispravljati i dorađivati, a objavljeni listovi s tumačima davati na raspolaganje cjelokupnoj stručnoj i zainteresiranoj javnosti, periodički, u poboljšanim verzijama ovisno o novim spoznajama.

used for work on the maps. At the time the project was led by Željka Brkić, PhD, and in that period several manuscripts (explanatory notes and maps) were brought to the final phase, and work was initiated on new instructions for the construction of BHGM. After 2013, zProjects were terminated, but the HGI-CGS decided to maintain the fundamental projects as part of our centennial tradition and as an endeavour of extreme importance for society. The project began to be funded symbolically, by so-called "capitations" of scientists working on it. Additional financing by the HGI-CGS' own funds is also used to an increasing extent, and now intensified also by EU projects. Due to such circumstances the work on instructions is halted, but several sheets are completed to the review level, with three that passed peer reviews, one of which has been officially published. This one is actually the first published sheet of the BHGM.

The work on the BHGM will be directed depending on the possible allocation of programme financing. In tune with the more robust GIS tools and databases, maps will in the future be published according to natural entities, and less according to sheet schematics. Additions to cartographical parts and text will be made easily, and the published sheets with explanatory notes will be put at disposal to the entire professional and general interested public, periodically, and in improved versions depending on new findings.

# Klimatske promjene i utjecaj na vodoopskrbu

## Climate Change and Impacts on Water Supply

Voditelj projekta / Project Manager: dr. sc. **Gerhard KUSCHNIG**, Bečki vodovod (Wiener Wasserwerke), Austrija  
 Koordinator za HGI-CGS i Hrvatske vode / Coordinator for CGS and Croatian waters: dr. sc. **Josip TERZIĆ**



Logotipi programa i projekta  
 Logos of programme and project



Jedan od prvih većih projekata financiranih od strane EU u HGI-CGS-u bio je CC-WaterS (2009-2012). Projekt je izведен u sklopu transnacionalnog programa jugoistočne Europe (TC-SEE Program), partner su bile Hrvatske vode (HV), a HGI-CGS izvođač, uz imenovanje nacionalnog koordinatora iz HGI-CGS-a. U projektu su sudjelovali istraživači iz svih triju zavoda. Radovi se mogu razdijeliti u hidrogeološki (voditelj J. Terzić) i paleoklimatski dio (voditelj S. Miko). U projektu je surađivalo dvadesetak istraživača iz HGI-CGS-a i više vanjskih suradnika. Sudjelovalo je 18 partnerskih institucija iz devet zemalja.

Fokus projekta bio je na razradama klimatskih scenarija do 2100. godine i njihovom utjecaju na vodoopskrbu. U Hrvatskoj su odabrana tri pokušna područja duž jadranske obale: Vransko jezero na Cresu, zaleđe Zadra i zapadni dio otoka Korčule. Klimatske modele izradili su stručnjaci Državnog hidrometeorološkog zavoda, a hidrološke bilance Josip Rubinić na temelju hidrogeoloških studija stručnjaka iz HGI-CGS-a. U paleoklimatskom dijelu (samo za pokušna područja u Hrvatskoj) osvrnuло se na varijacije klime tijekom holocena i nastojalo uklopiti ove recentne.

Vodne bilance svih triju pokušnih područja izračunate su prema današnjem stanju, kao i one utemeljene na klimatološkim prognozama za dva buduća 30-godišnja klimatološka niza: 2021.-2050. i 2071.-2100. Rezultati su ukazali na mogućnost znatnog pada dotoka u vodnoj bilanci do kraja ovoga stolje-

One of the first major projects at the HGI-CGS funded by the EU was CC-WaterS (from 2009 to 2012). The project was carried out within the South East European Transnational Programme (TC-SEE Programme). Hrvatske vode (Croatian water management authority) were project partner was, and HGI-CGS was their subcontractor, with the appointment of a national coordinator from the HGI-CGS. Researchers from all three departments of the HGI-CGS participated in the project implementation. Activities were divided into two parts, a hydrogeological (under the leadership of J. Terzić) and a paleoclimatic part (leader S. Miko). About 20 researchers from the HGI-CGS and several external associates collaborated on the project. A total of eighteen partner institutions from nine countries participated.

The focus of the project was the elaboration of climatic scenarios until the year 2100 and their impact on the water supply. Three pilot areas in Croatia were selected along the Adriatic coast: Vrana Lake on the island of Cres, the hinterland of the city of Zadar and the western part of the island of Korčula. Climatic models were developed by experts from the Croatian Meteorological and Hydrological Service, while Josip Rubinić made hydrological balance calculations based on the hydrogeological study of experts from the HGI-CGS. Within the paleoclimatic part of activities (only concerning study areas in Croatia), the climatic variations during the Holocene were discussed, and the correlation with recent ones were attempted.

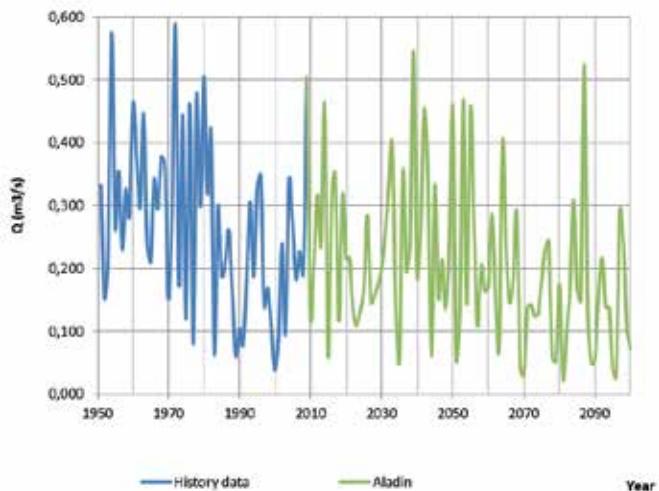
The water balance calculations of all three study areas were analysed in relation to the present state. In addition, balances were calculated based on climate estimations for the two future 30-year climatological series: from 2021 to 2050 and from 2071 to 2100. The results indicated a possibility of significant decrease in recharge, affecting water balance until the end of this century. The predicted loss was only 0.5 % for Vrana Lake (Cres), but up to 30 % for the Blatsko polje on the island of Korčula and 32 %

ća, pa je prognoziran gubitak od tek 0,5% na Vranskom jezeru (Cres), ali 30% za Blatsko polje na Korčuli i čak 32% za Bokanjačko blato. Analizirane su moguće promjene u namjeni prostora pod utjecajem prognoziranih klimatskih promjena, te utjecaj tih promjena na kakvoću vode – što je bilo od posebnog značaja za naša pokusna područja koja su priobalna, pa svako smanjenje u bilanci može dovesti do pojačanih prodora morske vode u osjetljive krške vodonosnike.

Ovaj projekt je bio izrazito uspješan, njegovi se rezultati još danas citiraju i koriste u brojnim drugim projektima, te je bio jedan od ključnih projekata za kapitalizaciju, čime je znatno doprinio dobivanju brojnih sljedećih i budućih EU projekata u HGI-CGS-u.



S pripremnog sastanka projekta CC-WaterS  
Preparatory meeting for the CC-WaterS project



Povijesna i predviđena efektivna infiltracija u krškom vodonosniku Blatskog polja na Korčuli jasno ukazuje na trend smanjenja i sve izraženije ekstreme

Historical and estimated effective infiltrations into karst aquifer of Blatsko polje on the island of Korčula clearly point to a decreasing trend and more pronounced extremes

for the Bokanjačko blato. Possible changes in land use were analysed in areas under the impact of estimated climatic changes, as well as the impact of these changes on water quality, which was of particular importance to the affected population of the coastal study areas. Any decrease in the water balance can lead to the increased seawater intrusion into sensitive karst aquifers.

This project was highly successful; its results are still cited and used in many other projects. Moreover, it was one of the key projects for capitalisation, contributing significantly to the contracting of many future EU projects at the HGI-CGS.

# Projekti primjene EU Okvirne direktive o vodama u Hrvatskoj

## Projects for the Implementation of EU Water Framework Directive in Croatia

Voditeljica projekata / Project Manager: dr. sc. **Željka BRKIĆ**

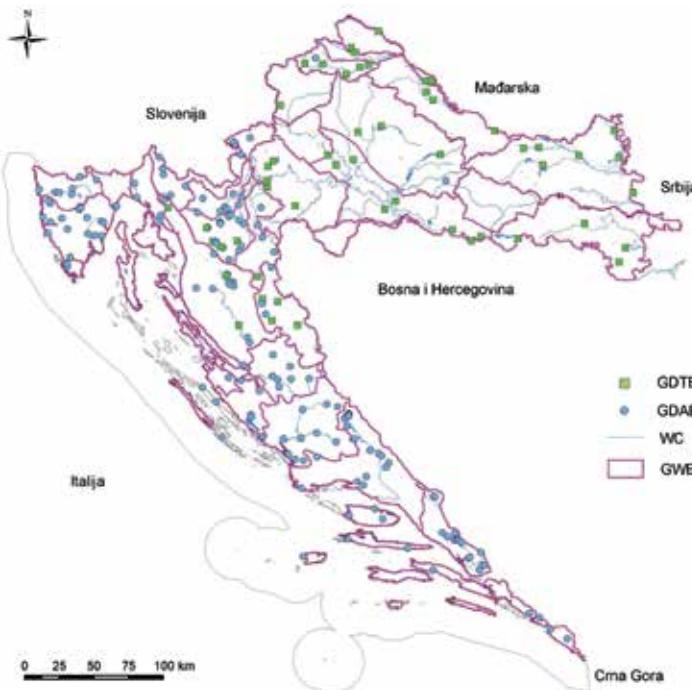
Suradnici / Collaborators: dr. sc. Ozren LARVA, dr. sc. Tamara MARKOVIĆ, Mladen KUHTA, dr. sc. Maja BRIŠKI, Mario DOLIĆ, prof. dr. sc. Sanja GOTTSSTEIN

Iako je EU Okvirna direktiva o vodama (ODV) donesena 2000. godine i kao takva vrlo brzo postala važan dokument za upravljanje vodama u Europskoj uniji, u Hrvatskoj se ozbiljnije počela primjenjivati tek unazad 10-ak godina. Ulaskom u EU Hrvatska je postala obveznik pripreme planova upravljanja vodnim

Although the EU Water Framework Directive (WFD), passed in 2000, became an important document on water management in the EU, Croatia has started its implementation more actively only 10 years ago. By joining the EU, Croatia became obliged to prepare river basin management plans, which are delivered every six years and based on the WFD.

Along with the WFD enactment at the beginning of this century, the HGI-CGS recognised the importance of this document. Based on numerous groundwater data stored at the HGI-CGS and other institutions, there were already attempts to delineate the groundwater bodies (GWBs) of the Black Sea and Adriatic catchments in the way that was prescribed by the WFD. In 2009, the HGI-CGS carried out a study entitled "Groundwater status and risk assessment in the Pannonian part of the Republic of Croatia", which consolidated the existing GWBs into 20 separate bodies, performing an analysis of quantitative and chemical status of groundwater bodies. This was one of the studies that led to the first river basin management plan in the Republic of Croatia (from 2013 to 2015).

"Assessment of the groundwater status in areas with groundwater associated with surface waters and groundwater-dependent terrestrial ecosystems" (2016) was a study carried out by the HGI-CGS for the purpose of a new river basin management plan development (from 2016 to 2021). Groundwater-dependent ecosystems were described, and an assessment of the GWB status was performed. Based on the proposed methodology, ecosystems that are associated with or dependent on



Ekosustavi ovisni o podzemnim vodama u RH. Tumač oznaka: GDTE – kopneni ekosustav ovisan o podzemnim vodama, GDAE – vodenim ekosustav ovisan o podzemnim vodama, WC – vodotok, GWB – cjelina podzemnih voda (CPV)

Groundwater dependent ecosystems in the Republic of Croatia. Legend: GDTE – groundwater dependent terrestrial ecosystems, GDAE – groundwater dependent aquatic ecosystems, WC – watercourse, GWB – groundwater body (CPV)



**Uzorkovanje podzemne vode za određivanje koncentracija CFC-a i SF**  
Groundwater sampling for the purpose of CFC and SF concentrations determination



**Uzorkovanje podzemne vode za određivanje koncentracija plemenitih plinova**  
Groundwater sampling for the purpose of noble gasses concentrations determination

područjima koji se donose svakih šest godina, a čija se izrada bazira na ODV.

Usporedno sa stupanjem na snagu ODV početkom ovog stoljeća, HGI-CGS je prepoznao važnost ovog dokumenta. Na temelju brojnih podataka o podzemnim vodama koji su pohranjeni u HGI-CGS-u, ali i drugim ustanovama, već tada su postojali pokušaji izdvajanja cjelina podzemnih voda (CPV) u Crnomorskem i Jadranskom slivu na način kako to traži ODV. Studiju „Ocjena stanja i rizika cjelina podzemnih voda u panonskom dijelu Republike Hrvatske“, u okviru koje su dotadašnje CPV grupirane u njih 20, i u okviru koje je načinjena analiza količinskog i kemijskog stanja podzemnih voda, HGI-CGS je načinio 2009. godine. To je bila jedna od studija na temelju kojih je načinjen prvi plan upravljanja vodnim područjima u RH (2013–2015).

„Ocjena stanja podzemnih voda na područjima koja su u direktnoj vezi s površinskim vodama i kopnenim ekosustavima ovisnim o podzemnim vodama“ (2016) bila je studija koju je HGI-CGS napravio za potrebe izrade novog plana upravljanja vodnim područjima (2016–2021). Izdvojeni su ekosustavi ovisni o podzemnim vodama, te je načinjena ocjena stanja CPV unutar kojih su utvrđeni ekosustavi povezani s ili ovisni o podzemnim vodama na temelju predložene metodologije. Koncepcijom 2017. i u 2018. godini provedena su istraživanja s ciljem utvrđivanja prosječne starosti podzemnih voda pomoću okolišnih obilježivača CFC-a, SF<sub>6</sub> i <sup>3</sup>H/<sup>3</sup>He. U studiji „Definiranje kriterija za ocjenu učinkovitosti mjera zaštite podzemnih voda i ekosustava ovisnih o podzemnim vodama“ (2018) istaknuta je važnost kvantificiranja prosječne starosti podzemnih voda kako bi se ustanovili stvarni rokovi i trendovi, te isplanirala djehotvorna praksa upravljanja vodama.

groundwater were identified. At the end of 2017 and in 2018, investigations were conducted in order to determine the mean groundwater residence time using environmental markers of CFC, SF<sub>6</sub>, and <sup>3</sup>H/<sup>3</sup>He. The importance of quantifying the mean residence time of groundwater was emphasized through the study entitled "Defining criteria for assessing the efficiency of groundwater and groundwater-dependent ecosystems protection measures" (2018). The purpose was to define realistic periods and trends and develop effective water management practices.

# Umrežavanje za opskrbu pitkom vodom u jadranskoj regiji

## Networking for Drinking Water Supply in the Adriatic Region

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<http://www.drinkadria.eu>

Zavod za hidrogeologiju i inženjersku geologiju HGI-CGS-a uspješno je proveo trogodišnji projekt akronima DRINKADRIA koji je završen 30. rujna 2016. Implementacija je sufinancirana u iznosu od 85% iz instrumenta prepristupne pomoći Europske unije (IPA Adriatic) namijenjenih usklađivanju zakonodavstva i jačanju prekogranične suradnje šireg jadranskog područja. U projektu je sudjelovalo 17 projektnih partnera iz osam država: Grčke, Albanije, Srbije, Crne Gore, Bosne i Hercegovine, Hrvatske i Slovenije pod vodstvom partnera iz Italije. Ostali partneri iz RH bili su Građevinski fakultet Sveučilišta u Rijeci, Istarski vodovod d.o.o. i Istarska županija, te kao suradničke



Pogled na krško polje Jezero (Vrgorac polje), pilot područje projekta  
View of the karst polje Jezero (Vrgorac polje), pilot area of the project

The Department of Hydrogeology and Engineering Geology of the HGI-CGS successfully completed a three-year project under the acronym DRINKADRIA on the 30<sup>th</sup> of September 2016. Implementation of the project was co-financed by the Instrument for Pre-accession Assistance (IPA Adriatic) at a rate of 85%. The main goals of the project were harmonisation of legislation and strengthening cross-border collaboration in the wider Adriatic region. The project involved 17 project partners from eight countries: Greece, Albania, Serbia, Montenegro, Bosnia and Herzegovina, Croatia and Slovenia, under the guidance of partners from Italy. Other partners from the Republic of Croatia were the Faculty of Civil Engineering of the University of Rijeka, Istarski vodovod Ltd, and Istra County, while cooperating institutions were Hrvatske vode, Istarski vodozaštitni sustav Ltd, and Primorje-Gorski kotar County. The total budget of the project was € 6.64 million. The main objective of the project was to optimise the management of the cross-border local and regional water supply systems, with emphasis on water quality and analysis of water resources availability, and considering the impact of climate change and specific socio-economic aspects.

As part of the project and in collaboration with the Hydro-Engineering Institute of Sarajevo, we investigated hydrogeological relations in the cross-border catchment of the Prud spring and the entire area of the groundwater discharge from the same aquifer. Tracer tests were carried out in order to improve the conceptualisation of the catchment area, which was also supported by climatological and hydrological analyses of the study area developed in cooperation with experts from the Faculty of Civil Engineering in Rijeka. The water balance analysis was focused on the

institucije Hrvatske vode, Istarski vodozaštitni sustav d.o.o. i Primorsko-goranska županija. Ukupan proračun projekta iznosi je 6,64 milijuna €.

Glavni projektni cilj bio je optimizirati upravljanje prekograničnim lokalnim i regionalnim sustavima vodoopskrbe, s naglaskom na kakvoću i analizu raspoloživosti vodnih resursa s obzirom na utjecaj klimatskih promjena i specifičnih društveno-ekonomskih aspekata.

U sklopu projekta smo s Institutom za hidrotehniku iz Sarajeva (HEIS) istražili hidrogeološke odnose u prekograničnom slijevu izvora Prud i cijeloj zoni istjecanja podzemnih voda istog vodonosnika. U okviru istraživanja izvedeno je trasiranje radi poboljšanja konceptualizacije područja, čemu su doprinijele klimatološke i hidrološke analize istražnog područja izrađene u suradnji sa stručnjacima Građevinskog fakulteta u Rijeci. Analiza vodnih bilansi usmjerena je upravo na predviđene klimatske promjene. Istraživanje je osuvremenjeno analizama stabilnih izotopa kisika ( $\delta^{18}\text{O}$ ) i vodiča ( $\delta^2\text{H}$ ) izrađenih pomoći novog izotopnog analizatora Picarro, čija je kupovina sfinancirana iz projekta. U sklopu projekta prikupljeni su podatci koji će poslužiti kao temelj doktorskog rada Marine Filipović, čije je radno mjesto, uz još jedno, u cijelosti bilo osigurano kroz projekt.



Ubacivanje trasera u ponor u polju Jezero  
Introducing the dye / tracer into the ponor / swallow hole in Jezero polje

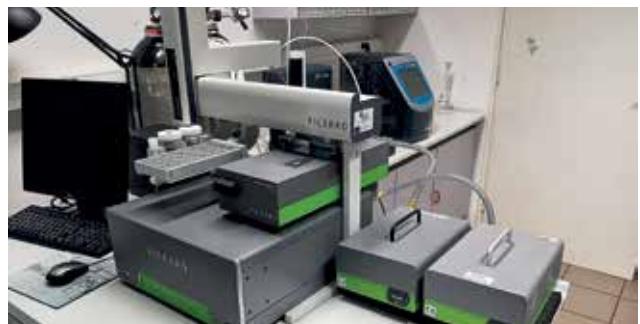
predicted climate change. The research has been modernised with the analyses of stable isotopes of oxygen ( $\delta^{18}\text{O}$ ) and hydrogen ( $\delta^2\text{H}$ ), carried out by the new Picarro isotope analyser, which was acquired from project funds. As part of the project, data was collected which will serve as the basis for the PhD thesis of Marina Filipović, whose work post, along with another one, was funded by the project.



Uzorkovanje i *in situ* mjerjenje na krškom izvoru Prud – regionalnom izvoru javne vodoopskrbe  
Sampling and *in situ* measurements at the karst spring Prud – a regional public water supply source



Uzorkovanje i *in situ* mjerjenje na priobalnoj krškoj zoni izviranja Mandina mlinica  
Sampling and *in situ* measurements in the coastal karst discharge zone of the Mandina mlinica



Laserski analizator stabilnih izotopa Picarro, kupljen u sklopu projekta  
Picarro laser analyser of stable isotopes, acquired from project funds

# Pregled hidrogeoloških istraživanja za uspostavu zona sanitарне заštite, primjer zadarskog vodoopskrbnog sustava

## Overview of Hydrogeological Research Preceeding the Establishment of Sanitary Protection Zones, Example of Zadar Water Supply System

Autor teksta / Author of the text: dr. sc. **Josip TERZIĆ**

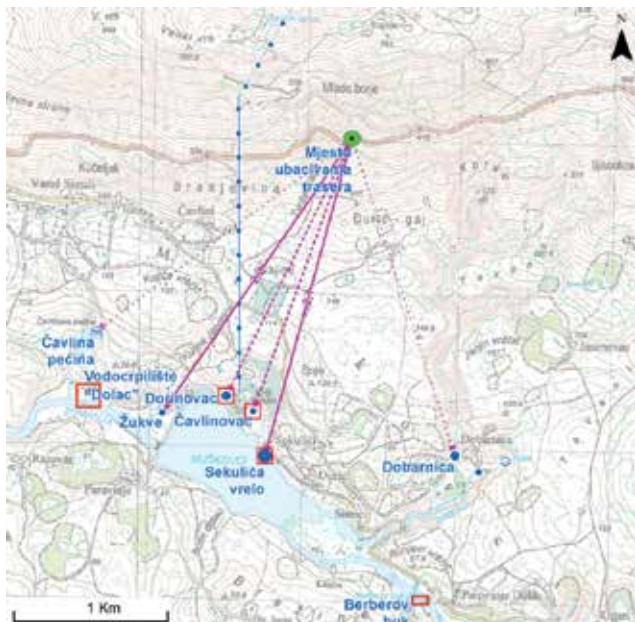
Niz istraživanja sa svrhom uspostave zona sanitарне заštite (ZSZ) najvažnijih zadarskih izvorišta izveden je 2012.-2017. Riјec je o hidrogeološkim sustavima Bokanjac – Poličnik (BP) i Muškovci – Berberov buk (MBB). Istraživanja je financirala Zadarska županija, a izvođena su u više faza koje su obuhvaćale proučavanje dokumentacije, hidrogeološka kartiranja, trasiranja podzemnih tokova i izradu elaborata ZSZ prema važećem pravilniku. Istraživanja je vodio Josip Terzić, a u različitim faza-

A series of investigations were carried out from 2012 to 2017 in order to establish the sanitary protection zones (SPZs) of the most important water supply sources in the Zadar area. The investigations refer to the Bokanjac – Poličnik (BP) and Muškovci – Berberov Buk (MBB) hydrogeological systems. The research was financed by the Zadar County, and it was carried out in several phases, which included documentation review, hydrogeological mapping, tracer testing of groundwater flow and constructing a report on the SPZ according to the actual regulations. The research was headed by Josip Terzić and associates participating at various stages: Hrvoje Burić, Tihomir Frangen, Jasmina Lukač Reberski, Goran Kresnik, Ante Pavičić, Josip Rubinić (Faculty of Civil Engineering, Rijeka), and Andrej Stroj.

As part of the BP system, the following water supply facilities were investigated: wells in Bokanjac, the Jezerce estavelle, the Oko well, the Boljkovac well and the Golubinka coastal spring. Their catchments and sub-catchments are located in the Ravni kotari area, and they are significantly intertwined. Previous research was adjusted according to the new legislation and expertise. New parts of the terrain were mapped, and the existing maps were organized in GIS environment. The MBB system, yielding a significant quantity of water, is recharged by water from



Isječak zemljovida II. ZSZ priobalnog krškog izvora Golubinka  
Map section of the 2<sup>nd</sup> SPZ of the coastal karst spring Golubinka

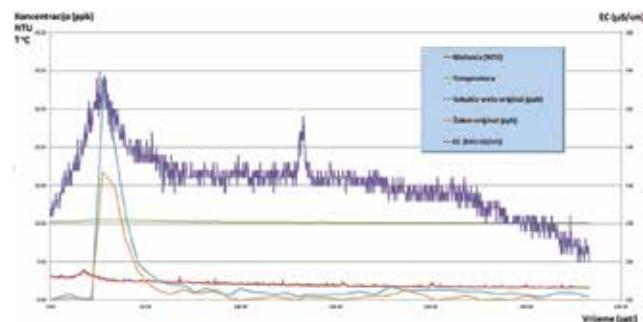


Prikaz vodozahvata MBB s izvedenim trasiranjem kroz epikrški pojaz  
The MBB catchment with performed tracer testing through the epikarst zone

ma sudjelovali su Hrvoje Burić, Tihomir Frangen, Jasmina Lukač Reberski, Goran Kresnik, Ante Pavičić, Josip Rubinić (Građevinski fakultet, Rijeka) i Andrej Stroj.

U sklopu sustava BP obrađivani su vodoopskrbni objekti: Bojanjački zdenci, estavela Jezerce, zdenac Oko, zdenac Boljkovac i priobalni izvor Golubinka. Njihovi su sljevovi i podsljevovi smješteni u području Ravnih kotara i veoma isprepleteni. Starija istraživanja su obrađena u skladu s novom legislativom i novim stručnim spoznajama. Naglasak je bio na kartiranju dijelova terena koji nisu bili obrađivani ranije, uz prilagodbu postojećih kartografskih podloga GIS tehnikama. Količinom vode važniji sustav MBB zahvaća vode triju krških izvora, te površinski zahvat Berberov buk (voda rijeke Zrmanje). Izvori Sekulić, Dorinovac i Čavlinovac kaptirani su i betoniranim natkrivenim kanalom njihove se vode sakupljaju u kaptazi Dolac. Podzemne vode se u ove izvore slijevaju iz velebitskog masiva, no većim dijelom krškim kanalima iz Like, kroz ponore u području Gračaca. Kada vode triju krških vrela nisu dovoljne, u vodoopskrbu se uključuje zahvat Berberov buk i zahvaćaju se vode rijeke Zrmanje. Takav je zahvat neophodan jer vode ostalih zahvata u hidrološkom minimumu nisu dostatne za opskrbu grada Zadra, njegovog šireg zaleđa i brojnih turista. Provedena su sva istraživanja kao za sustav BP, uz trasiranje za odredbu granice II. ZSZ kroz pliće epikrško podzemlje. Rezultati ovih istraživanja bit će korišteni u više znanstvenih radova i u Osnovnoj hidrogeološkoj karti područja.

three karst springs and the Berberov buk catchment (water from the Zrmanja River). At Sekulić, Dorinovac and Čavlinovac springs intake structures were built and their water is conveyed by closed concrete canal into the Dolac intake structure. These springs receive recharge by groundwater from the Velebit Mt. massif, but mostly by karst channels from Lika region, through the ponors / swallow holes in the area of Gračac. When the water from the three karst springs is insufficient, water is supplied from the Berberov buk catchment and the Zrmanja River. Such a procedure is necessary, because the water from the other catchments is not sufficient for the supply of the city of Zadar, its wider hinterland and numerous tourists during summer hydrological minimum. The same research as in the case of the BP system was carried out, with the addition of tracer testing, in order to define a border of the 2<sup>nd</sup> SPZ in the shallow epikarst underground. The results of these studies will be used in several scientific papers and for the purpose of constructing the Basic hydrogeological map of the area.



Trasiranje naftionatom i pojava boje podudarna s porastom elektrovodljivosti (EC). Traser je ubaćen točno kad je počela kiša, a cesta je bila soljena protiv smrzavanja

Tracing with naphthionate and the appearance of colour positively correlated with the increase in electric conductivity (EC). The tracer was introduced exactly when precipitation started, washing away the salt sprinkled on the road to prevent freezing

# Crpilište Sikirevci – Regionalni vodovod istočne Slavonije

## Sikirevci Pumping Site – Regional Water Supply for Eastern Slavonia

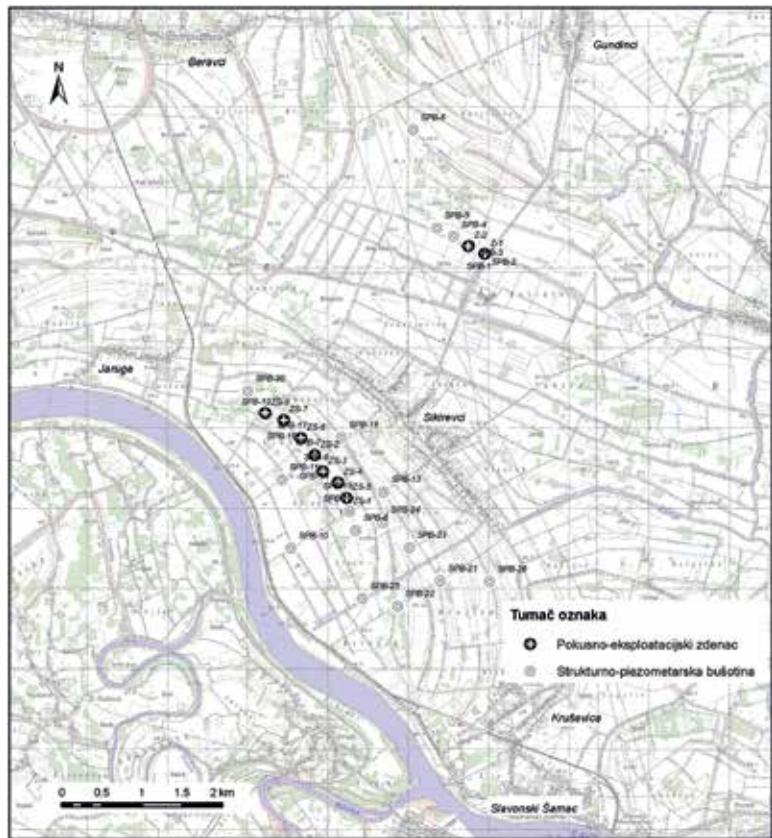
Voditeljica projekata / Project Manager: dr. sc. **Željka BRKIĆ**

Suradnici / Collaborators: mr. sc. Ivan BAGARIĆ, prof. dr. sc. Andrea BAČANI, dr. sc. Ozren LARVA, dr. sc. Maja BRIŠKI, dr. sc. Tamara MARKOVIĆ

Regionalni vodovod crpilišta istočne Slavonije počeo je s radom puštanjem crpilišta Sikirevci u pogon početkom 2009. godine. Crpilište je smješteno između naselja Sikirevci i rijeke Save i sastoji se od osam zdenaca. Zdencima su zahvaće-

The regional water supply system in eastern Slavonia was put into operation in early 2009 through the opening of the Sikirevci pumping site. The pumping site is situated between the village of Sikirevci and the Sava River, and consists of eight wells. These wells collect water from gravel and sand deposits with exceptionally good hydrogeological properties.

This was not the originally chosen location for pumping site. The first site was planned between Velika Kopanica and Babina Greda, but it was not further investigated. In the beginning of the 1990s, the multi-purpose Danube-Sava Canal project was developed. The projected route of the Canal transverses the planned water-pumping site, which is why the location of the site was moved somewhat southwards, near the Gundinci-Sikirevci road and Jasinja Canal. At both locations, a gravel and sand aquifer was discovered, containing accumulated groundwater supplies sufficient for water supply of the region. Groundwater quality is typical for eastern Slavonia, i.e. it contains increased concentrations of iron and manganese and requires processing prior to releasing into the water supply system. However, the water-pumping site still has not been built. In 2004, the HGI-CGS conducted new hydrogeological research in the area between the villages of Sikirevci and Babina Greda and the Sava River. It showed that the quality of groundwater is good and it does not need to be processed, which would make drinking water accessible to households in short time.



Položajna karta crpilišta Sikirevci  
Position map of the Sikirevci pumping site

ne šljunkovito-pjeskovite naslage iznimno dobrih hidrogeoloških značajki.

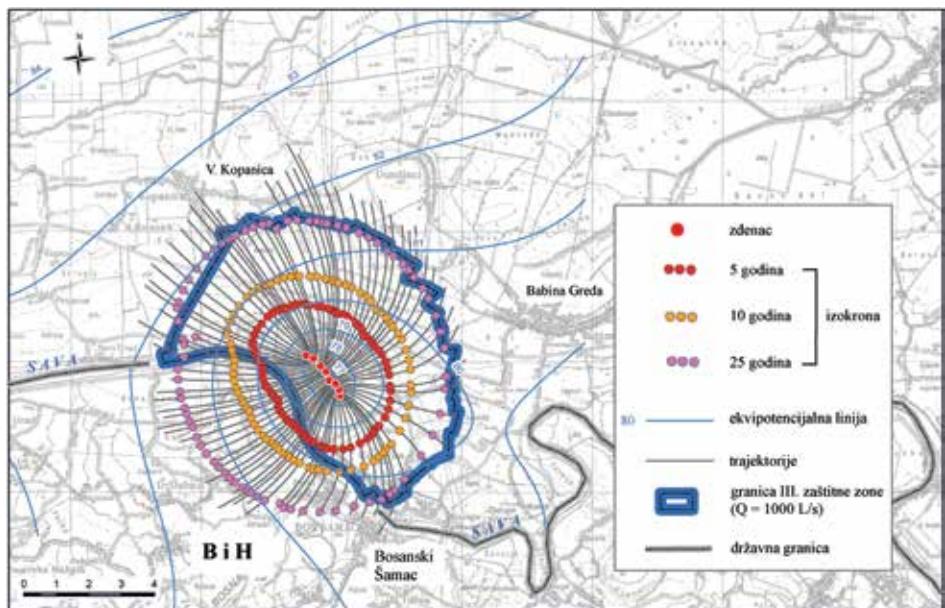
To nije bila prvo izabrana lokacija crpilišta. Prva lokacija crpilišta bila je planirana na potezu između Velike Kopanice i Babine Grede, međutim daljnji razvitak crpilišta nije uslijedio. Početkom 1990-ih godina izrađen je projekt višenamjenskog kanala Dunav–Sava, čija projektirana trasa prolazi kroz planirano crpilište, zbog čega je lokacija crpilišta premještena nešto južnije, u blizini križanja ceste Gundinci–Sikirevci i Jasinskog kanala. Na obje lokacije utvrđen je šljunkovito-pjekoviti vodonosnik u kojem su akumulirane zalihe podzemne vode dostatne za vodoopskrbu cijele regije. Kakvoća podzemne vode je uobičajena za istočnu Slavoniju, pa voda sadrži povećane koncentracije željeza i mangana koje zahtijevaju preradu prije puštanja u vodoopskrbni sustav. Međutim, ni tada crpilište nije izgrađeno. Nakon obnovljenih hidrogeoloških istraživanja 2004. godine, koja je vodio HGI-CGS, između naselja Sikirevci, Babine Grede i rijeke Save utvrđena je kakvoća podzemne vode pogodna za piće, koju nije potrebno dodatno prerađivati, što je omogućavalo da se pitka voda razmjerno brzo dovede u kućanstva.

Istraživanja uspostavljena 2004. godine HGI-CGS je nastavio provoditi i narednih 10-ak godina, kako bi završio s definiranjem zona sanitarnе zaštite crpilišta (2014). Osim istraživanja ugovorenih s Hrvatskim vodom, HGI-CGS je uložio i vlastita sredstva kako bi sa znanstvenog stanovišta mogao doprinijeti boljem razumijevanju dinamike podzemne vode u zahvaćenom vodonosniku. Istraživanja su se sastojala od brojnih mjerenja, uzorkovanja i ispitivanja podzemnih voda, što je prikazano u doktorskoj disertaciji znanstvene novakinje iz HGI-CGS-a, a dijelom i objavljeno u znanstvenim radovima.



Kućica u kojoj je smješten eksploracijski zdenac na crpilištu Sikirevci  
Object containing the exploitation well at the Sikirevci pumping site

In the following 10 years, the HGI-CGS continued carrying out the investigations, in order to complete the delineation of SPZs of the pumping site (2014). Apart from the research funded by Hrvatske vode, the HGI-CGS also invested its own resources in order to contribute to a better understanding of groundwater dynamics in the affected aquifer from a scientific point of view. The research consisted of numerous measurements, groundwater sampling and analyses, as shown in the PhD dissertation of a research assistant from the HGI-CGS, part of which was published in scientific papers.



Prijedlog zona sanitarnе zaštite crpilišta Sikirevci  
Proposed sanitary protection zones of the Sikirevci pumping site

# Učinkovite prakse upravljanja korištenjem zemljišta s ciljem zaštite vodnih resursa i nestrukturalne mjere zaštite od poplava

## Efficient Practices of Land Use Management Integrating Water Resources Protection and Non-structural Flood Mitigation Experiences

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<http://www.interreg-central.eu/Content.Node/PROLINE-CE.html>

Trogodišnji projekt akronima PROLINE-CE započeo je u srpnju 2016. godine u sklopu Programa suradnje Središnja Europa 2014. – 2020., sufinanciranog od strane Europske unije. Ukupan proračun projekta iznosi 2,75 milijuna € i dijeli ga 13 projektnih partnera iz osam država (Austrija, Njemačka, Mađarska, Italija, Poljska, Slovenija i Hrvatska). Projekt se provodi pod vodstvom austrijskog Saveznog ministarstva poljoprivrede, šumarstva, okoliša i vodnog gospodarstva, a glavni je cilj ublažavanje negativnih utjecaja klimatskih promjena različitim načinima korištenja zemljišta, kako bi se poboljšala kakvoća i

The 3-year project under the acronym PROLINE-CE was initiated in July 2016, as part of the Central Europe 2014–2020 cooperation programme and is co-financed by the EU. The total budget of this project is € 2.75 million, and it is divided among 13 project partners from eight countries (Austria, Germany, Hungary, Italy, Poland, Slovenia, and Croatia). The project is carried out under the guidance of the Austrian Federal Ministry for Agriculture, Forestry, Environment and Water Management, and the main objective is to mitigate the adverse impacts of climate change by different techniques of land use, in order to improve the quality and quan-



Postavljanje uzorkivača kišnice na Sv. Juri (vrh Biokova) (foto I. Baniček)  
Setting up the rainwater sampler on the top of Biokovo Mt. (photo by I. Baniček)



Uzorkovanje voda na krškom izvoru Opačac kod Imotskog (foto I. Baniček)  
Water sampling at the karst spring Opačac near the town of Imotski  
(photo by I. Baniček)

količina vode potrebna za održivu vodoopskrbu i ublažili utjecaji poplava i suša.

Istraživači Zavoda za hidrogeologiju i inženjersku geologiju HGI-CGS-a kao voditelji prve projektne aktivnosti (radnog paketa) analizirali su trenutno stanje upravljanja vodama i načine korištenja zemljišta u zemljama sudionicama, te su na temelju provedenih istraživanja prepoznati i opisani najznačajniji pozitivni i negativni čimbenici koji utječu na kakvoću i količinu pitke vode. Važan doprinos dobiven je od strane dionika koji su znatno doprinijeli svojim iskustvima i savjetima. Na temelju toga razvijen je sažeti pregled najboljih upravljačkih praksi u središnjoj Europi te je razvijen katalog inovativnih mjer i praksi za integraciju u postojeće upravljačke smjernice.

Istražna područja u Hrvatskoj smještena su u južnoj Dalmaciji, gdje je definirano trenutno stanje gospodarenja zemljištem te su s obzirom na to provedena hidrogeološka istraživanja, uspostavljen je monitoring kemijskih i fizikalno-kemijskih parametara izvorskih voda te stabilnih izotopa kisika i vodika u izvorskim vodama i oborini. Poljoprivreda je identificirana kao glavni pritisak na kvalitetu podzemnih voda, ali je zapažen i utjecaj urbanih zona, prvenstveno iz susjedne Bosne i Hercegovine. Uspješnoj implementaciji projekta doprinosi dvoje mladih inženjera, Matko Patekar i Ivona Baniček, čija su radna mjesta u cijelosti financirana iz projekta.



Pogled na Imotsko polje u vrijeme visokih voda (izvor: imotski.net)  
Aerial view of Imotsko polje during wet season (source: imotski.net)

Uzorci pripremljeni za analizu u hidrokemijskom laboratoriju zavoda (foto I. Baniček)

Samples prepared for analysis in the hydrochemical laboratory of the DHGEG



Dolina Neretve (foto S. Pasecky)  
Neretva River valley (photo by S. Pasecky)

tity of water required for a sustainable water supply and to mitigate flood and drought impacts.

Researchers from the Department of Hydrogeology and Engineering Geology at the HGI-CGS were leading the first project activity (work package). They analysed the current state of water management and techniques of land use in the participating countries and based on that research, they recognised and described the most significant positive and negative factors that affect the quality and quantity of drinking water. The stakeholders contributed significantly with their experience and advice. As a result, a summarised overview of the best management practices in Central Europe has been developed, as well as a catalogue of innovative measures and practices for integration into the existing management guidelines.

The study areas in Croatia are located in southern Dalmatia, where the current status of land use management was described and hydrogeological investigations were carried out. In addition, the monitoring of chemical and physicochemical parameters of spring waters was established, as well as the monitoring of stable isotopes of oxygen and hydrogen in spring water and precipitation. Agriculture was identified to have a major influence on groundwater quality, but the impact of urban zones, primarily from neighbouring Bosnia and Herzegovina, has also been noted. The successful project implementation involves contribution of two young engineers, Matko Patekar and Ivona Baniček, whose work posts are entirely financed from the project funds.

# Suradnjom prema naprednim sustavima upravljanja učincima korištenja zemljišta na vodne režime u dunavskoj regiji

## Cooperating Towards Advanced Management Routines for Land Use Impacts on the Water Regime in the Danube River Basin

Koordinatorica za HGI-CGS / Coordinator for HGI-CGS: dr. sc. **Jasmina LUKAČ REBERSKI**  
<http://www.interreg-danube.eu/approved-projects/camaro-d>

Projekt akronima CAMARO-D, odobren u sklopu Programa transnacionalne suradnje Dunav 2014. – 2020., započeo je s implementacijom u siječnju 2017. te traje do lipnja 2019. godine. Ukupan budžet projekta je 2,58 milijuna €, a sufinanciran je od strane europskih fondova ERDF i IPA. U projekt je uključeno 14 projektnih partnera i 9 pridruženih partnera iz 9 država, s ciljem razvoja sveobuhvatnih smjernica za stratešku



Države projektnih partnera  
 Partner countries in the project



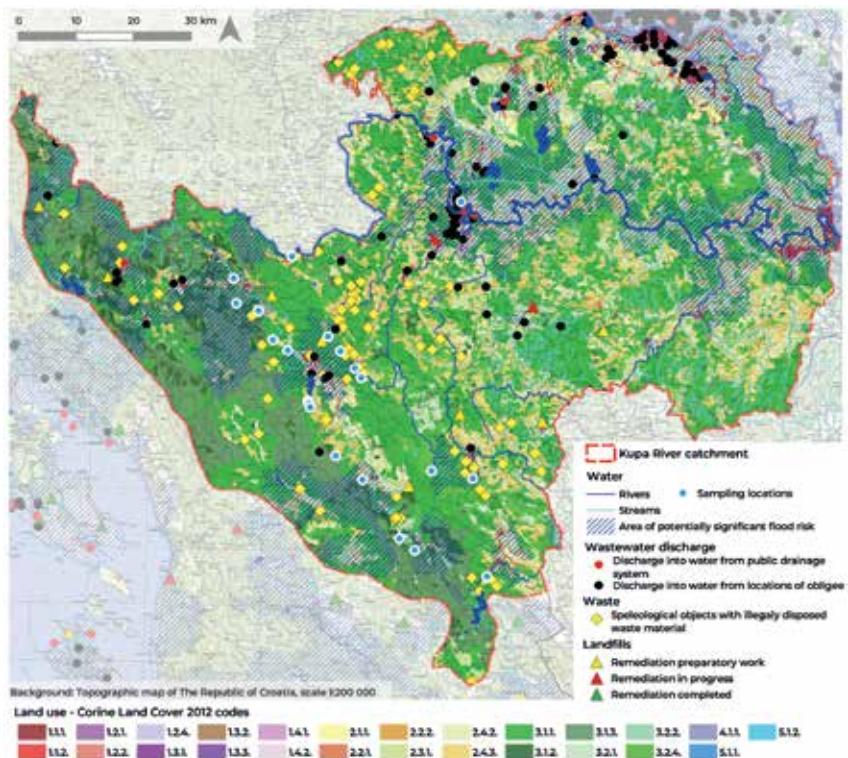
The project under the acronym CAMARO-D, approved under the Danube 2014-2020 Transnational Cooperation Programme, started in January 2017 and will last until June 2019. The total budget of the project is € 2.58 million, and it is co-financed by the European IPA and ERDF. The project involves 14 project partners and 9 associated partners from nine countries, with the aim to develop comprehensive guidelines for strategic policies on the implementation of an innovative and international land-use development plan (LUDP) at the Danube Basin level. An active approach to this new management tool will be provided to all stakeholders and decision-makers through "Guidance for sustainable land-use planning" (GUIDR), developed within the project. This will establish a framework for transnational cooperation in the Danube Basin area.

The main goals of the project, with regard to climate change, are long-term protection of water resources and improvement of flood protection. The CAMARO-D project results will provide input data for further development of the EU strategy for the

politiku implementacije inovativnog međunarodnog „Razvojnog plana upravljanja zemljištem“ (Land Use Development Plan, LUDP) na razini dunavskog slijeva. Aktivan pristup tom novom upravljačkom alatu svim zainteresiranim dionicima i odlučujućim tijelima ostvarit će se preko „Smjernica za održivo planiranje korištenja zemljišta“ (Guidance for sustainable land use planning, GUIDR) razvijenih u sklopu projekta. To će omogućiti stvaranje okvira transnacionalne suradnje na dunavskom sljevnom području.

Glavni ciljevi projekta su dugoročna zaštita vodnih resursa i unaprijeđenje zaštite od poplava, uzimajući u obzir klimatske promjene. Rezultati projekta CAMARO-D predstavljat će ulazne podatke za daljnji razvoj Strategije EU za dunavsku regiju (EUSDR) i ostalih dokumenata vezanih za upravljanje vodama. Predložene mjere za učinkovito i održivo upravljanje zemljištem testirat će se i dokumentirati u sklopu različitih pilot aktivnosti. HGI-CGS, podržan od strane Hrvatskih voda

kao pridruženog partnera, dat će svoj doprinos projektu provođenjem direktnih i indirektnih aktivnosti na pilot području slijeva rijeke Kupe. Provodit će se hidrogeološka istraživanja



Pilot područje u RH – slijev rijeke Kupe: karta korištenja zemljišta i negativni utjecaji u slijevu  
Pilot area in the Republic of Croatia – the Kupa River catchment: land-use map and negative impacts in the catchment

Danube region (EUSDR) and other documents on water management. Proposed measures for effective and sustainable land-use management will be tested and documented as part of var-



Poplava u Karlovcu 13. ožujka 2018. (foto Ž. Duić)

Flood in the City of Karlovac on 13<sup>th</sup> March 2018 (photo by Ž. Duić)



Nacionalna radionica održana na hrvatskom pilot području (foto A. Selak)  
National workshop held in the Croatian pilot area (photo by A. Selak)



Dječja radionica održana u Karlovcu (foto A. Selak)

Workshop for children held in Karlovac (photo by A. Selak)

koja će obuhvatiti *in situ* mjerena glavnih fizikalno-kemijskih parametara, uzorkovanja kišnice i vode na najznačajnijim izvirovima slijeva, hidrokemijske laboratorijske analize i proučavanje procesa otapanja karbonatnih stijena. Uz navedene direktnе aktivnosti, komunikacija s glavnim dionicima na pilot području, kao i razmjena znanja i pozitivnih iskustava, rezultirat će razvojem preporuka za održivo upravljanje i zaštitu vodnih resursa te obranu od poplava, ne samo na razini slijeva rijeke Kupe, već i na nacionalnoj razini.

ious pilot activities. The HGI-CGS, supported by Hrvatske vode as an associated partner, will contribute to the project by conducting direct and indirect investigations in the pilot area of the Kupa River catchment. Hydrogeological research, including *in situ* measurements of the main physicochemical parameters, rainwater and water sampling at the most important springs in the catchment, hydrochemical laboratory analyses, and the study of the carbonate rock dissolution process will be carried out. In addition to the above mentioned activities, communication with main stakeholders in the pilot area, as well as exchange of knowledge and positive experiences, will result in the development of recommendations for flood defence and sustainable management and protection of water resources, not only at the Kupa River catchment level, but at the level of the entire country.

# Razvoj IT platforme za upravljanje rizicima od poplava i ublažavanje štetnih posljedica po okoliš – Gdi Ensemble FloodSmart

## Development of IT Platform for Flood Risk Management and Mitigation of Environmental Damage – GDI Ensemble Floodsmart

Koordinatorica za HGI-CGS / Coordinator for HGI-CGS: dr. sc. **Tihomir FRANGEN**  
<https://gdi.net/hr/2017/11/20/project-gdi-ensemble-floodsmart/>

Poplave su od davnina predstavljale veliku opasnost za ljudе i imovinу, а širenjem urbaniziranih površina i uz klimatske promjene, ta opasnost postaje još većа. Donošenje odluka u kriznim situacijama uzrokovanim poplavama je izrazito zahtjevno. Ulozi u formi ljudskih života, njihovih domova i imovine su direktnо ugроženi, a situacija na terenu je vrlo dinamična i često teško predvidljiva. Iz tog razloga su IT tvrtka GDI i HGI-CGS

Floods have presented a major threat to population and property for a long time, and with climate change and expansion of urbanised areas, this danger is becoming even greater. Decision-making in crisis situations caused by floods is extremely demanding. The lives and livelihoods of people are directly threatened, and the situation on the ground is rapidly changing and is often difficult to foresee. For this reason, the IT company GDI and the



Logotipi projekta i institucija koje ga finansiraju  
 Logos of the project and the financing institutions

odlučili zajedno napraviti programsko rješenje koje će olakšati pristup svim relevantnim informacijama u tim kritičnim trenutcima.

Osnovna ideja je stvoriti programsko rješenje koje će objediniti sve segmente relevantne za donošenje odluka u upravljanju rizicima od poplave. Programsko rješenje će objediniti definirane radne procese i alate kako bi stručne i odgovorne osobe bez detaljnog poznavanja temeljnog GIS softvera bile u mogućnosti kroz jednostavna sučelja koristiti procedure, odrediti potrebne parametre i isporučiti potrebne rezultate, koji će se koristiti u donošenju odluka u upravljanju rizicima od poplave, u organizaciji obrane i spašavanja od poplave, te ublažavanju štetnih posljedica po okoliš. Rezultati projekta će integrirati predviđanje opasnosti od poplava i aktivnosti na zaštiti od poplava prije samog događaja poplava i nakon događaja, kroz jedan sustav gdje će ažurne informacije biti dostupne svim do nositeljima odluka u realnom vremenu.

Tvrta GDI će osmisiliti softversko rješenje, a HGI-CGS će pružiti pomoć prilikom formiranja baze podataka i modeliranja procesa relevantnih za definirane ciljeve projekta.

Projekt sufinancira EU iz strukturnih i investicijskih fondova

HGI-CGS decided to create a software solution that will facilitate the access to all relevant information in these critical moments.

The basic idea is to create a software solution that will join all relevant decision-making segments in flood risk management. The software solution will integrate defined work processes and tools, in such manner that experts and responsible persons without thorough knowledge of basic GIS software are able to apply the procedures through simple interfaces, determine the required parameters and deliver necessary results. Next, the results are to be used to make decisions in flood risk management, organization of flood defence and flood rescue, and mitigation of adverse environmental consequences. The project results will integrate flood threat assessment and flood prevention activities before and after the flood event itself, through a single system where up-to-date information will be available in real-time to all decision-makers.

The GDI company is designing a software solution, and the HGI-CGS is providing assistance in forming a database and modelling processes relevant to the defined project goals.

The project is co-financed by European Structural and Investment Funds.

# Istražni radovi za potrebe glavnog projekta Retencija Drežničko polje

## Investigations for the Final Design of the Držnica Polje Retention

Voditelj projekta / Project Manager: dr. sc. **Renato BULJAN**

Suradnici / Collaborators: dr. sc. Vlatko GULAM, dr. sc. Tihomir FRANGEN, dr. sc. Josip TERZIĆ, dr. sc. Iris BOSTJANČIĆ, dr. sc. Andrej STROJ, Nedeljko STANIĆ

Koncepcija tehničkog rješenja projekta je produženo zadržavanje poplavnih voda u Drežničkom polju i na taj način smanjenje intenziteta vodnih valova na izvorima Zagorske Mrežnice. Kontrolirano istjecanje vode omogućiti će optimalno energetsko iskorištenje snage vode slijeva na HE Gojak i HE Lešće.

Obavljeni su geodetski, geofizički, inženjerskogeološki (IG) i hidrogeološki (HG) radovi, bušenje strukturnih piezometarskih bušotina s ispitivanjem VDP-a i plitkih bušotina s izvođenjem SPT-a, uzorkovanjem stijenske mase i tla, zatim laboratorijska geomehanička ispitivanja uzoraka i trasiranje tokova vode u podzemlju iz polja. Načinjena je HG obrada područja s procjenom utjecaja retencije na izvore Zagorske Mrežnice i Tounjčice.



Ponor u Drežničkom polju

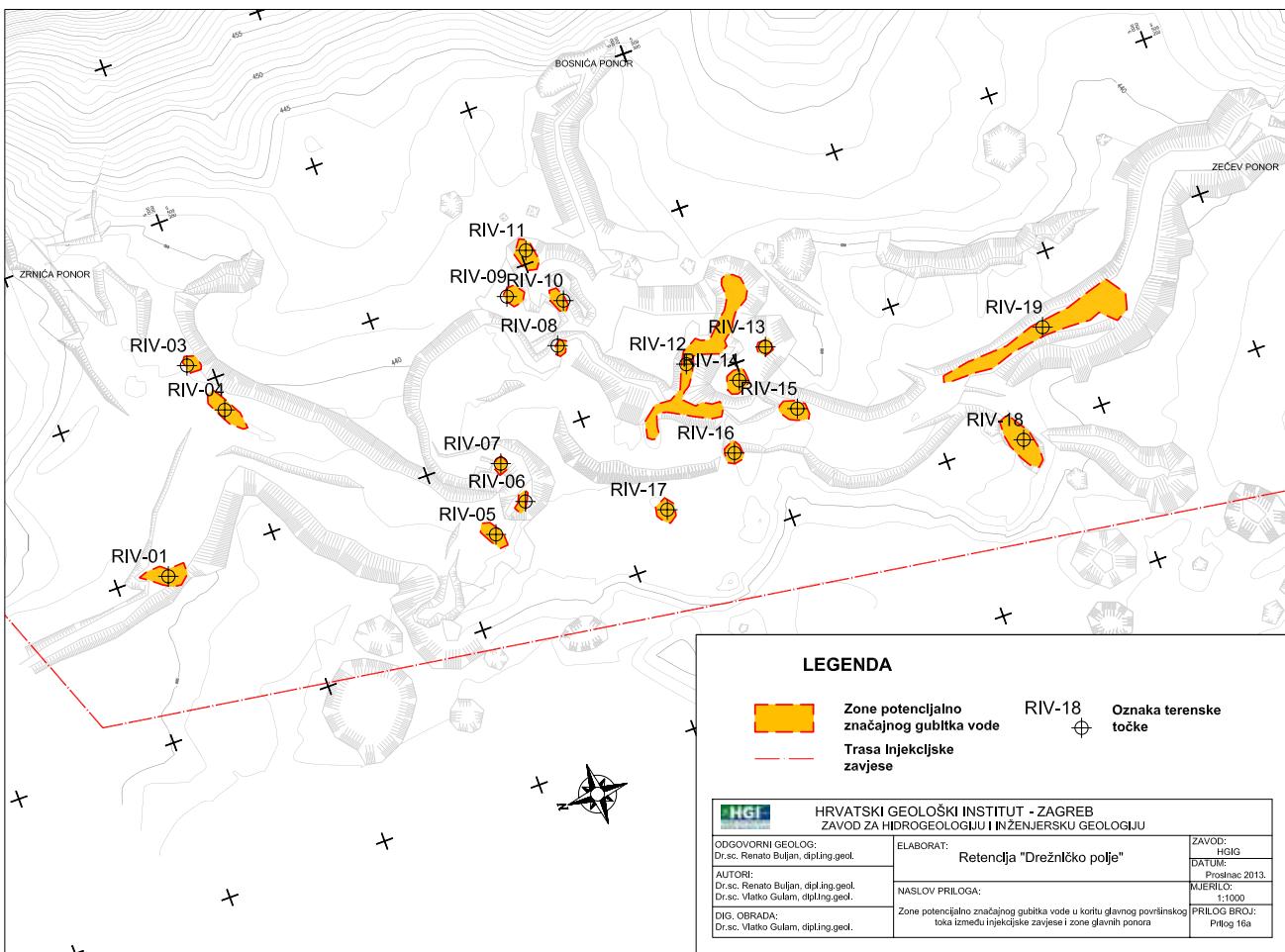
Ponor / swallow hole in Drežnica polje

The concept of the project's technical solution is the prolonged retention of floodwaters in the Drežnica polje, thus reducing the intensity of the water surge at the springs of the Zagorska Mrežnica River. A controlled water discharge will enable the optimal energy utilisation of water power of the catchment areas of hydro-power plants of Gojak and Lešće.

Geodetic, geophysical, engineering geological (EG), and hydrogeological (HG) studies were carried out, structural piezometric boreholes were drilled along with water permeability tests and shallow research boreholes along with standard penetration testing. Moreover, rocks and soil were sampled, geomechanical testing of samples was carried out in the laboratory, and subterranean flows of the karst polje were tracer tested. The area was studied from a HG aspect with an estimation of retention impact on the springs of Zagorska Mrežnica and Tounjčica rivers.

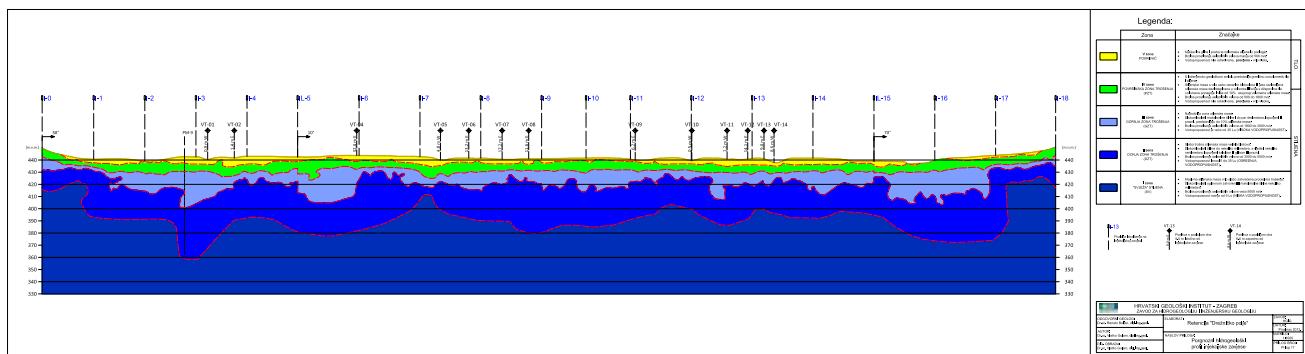
These studies confirmed the results of previous research and enabled new insights into HG relations in the hydrogeological system of the Zagorska Mrežnica catchment during the period of flooding, as well as new insights into the spring area of the Tounjčica River, which is not a direct extension of the Zagorska Mrežnica River.

In the main zone of the Drežnica polje ponors / swallow holes, the cover deposits (anthropogenic material, consolidated colluvium, proluvium, and lake sediment) and underlying bedrock (limestones and limestone breccias) were determined. The prospection of 14 karst sinkholes along the projected grout curtain enabled a discrimination of low, moderate, and high activity sinkholes and swallow holes. Eighteen zones with four types of water infiltration points were delineated in the river bed between



Zone potencijalno značajnog gubitka vode u koritu glavnog površinskog toka između injekcijske zavijese i zone glavnih ponora

Zones of potentially significant water losses in the bed of the principal water course between the grout curtain and main poron zone



Prognostni hidrogeološki profil i injekcijske zavijese

Prognosis hydrogeological cross-section and grout curtain

Radovima su potvrđene stare i polućene nove spoznaje o HG odnosima u hidrogeološkom sustavu slijeva Zagorske Mrežnice kada je polje poplavljeno te o izvoruštu Tounjčice koje nije izravni nastavak vode Zagorske Mrežnice.

U glavnoj zoni poniranja Drežničkog polja izdvojene su naselage pokrivača (nasip, konsolidirani sipar, proluvijalni nanos i jezerski sediment) i stijena podloge (vapnenci i vapnenačke breče). Prospekcija 14 ponikava duž projektirane injekcijske zavjese omogućila je izdvajanje na slabo aktivne, srednje aktivne i aktivne ponikve i ponore. U koritu površinskog toka između injekcijske zavjese i ruba polja okontureno je 18 zona za koje su izdvojena četiri tipa poniranja vode: koncentrirano kroz krški kanal (ponor) širine veće od 20 cm; koncentrirano kroz kanal širine veće od 20 cm formiran u pokrivaču (IG-tlo); difuzno kroz pukotine širine do 5 cm; difuzno procjeđivanje vode kroz pokrivač (IG-tlo). U prognoznom HG profilu duž injekcijske zavjese izdvojeno je pet zona trošenja – moguće je uočiti razvedenost granica zona, a posebno granicu između zona II i III, čime je naglašena izrazita okršenost karbonatne stijenske mase. Ponad glavne zone ponora izdvojeno je 7 mesta i 3 zone u kojima su mogući gubici vode duž karbonatnog boka polja.

the grout curtain and the margin of the polje: concentrated infiltration through the karst conduit (ponor) of > 20-cm width; point infiltration through the karst conduit of > 20-cm width formed in the soil cover (EG-soil); diffuse infiltration through caverns of > 5-cm width; and diffuse infiltration of water through the soil cover (EG-soil). In the projected HG profile along the grout curtain five weathering zones were isolated – the indentation of the zone boundaries, especially the boundary between zones II and III can be perceived, where the karstification of the carbonate rock mass is pronounced. Above the main zone of the swallow holes, seven locations and three zones were isolated, where water loss occurs along the carbonate margin of the polje.

# Podrijetlo, ponašanje i modeliranje transporta nitrata u varaždinskom aluvijalnom vodonosniku

## Origin, Behavior and Transport Modelling of Nitrates in the Varaždin Alluvial Aquifer

Glavna istraživačica / Principal investigator: dr. sc. **Tamara MARKOVIĆ**

<http://projects.hgi-cgs.hr/tranital/>

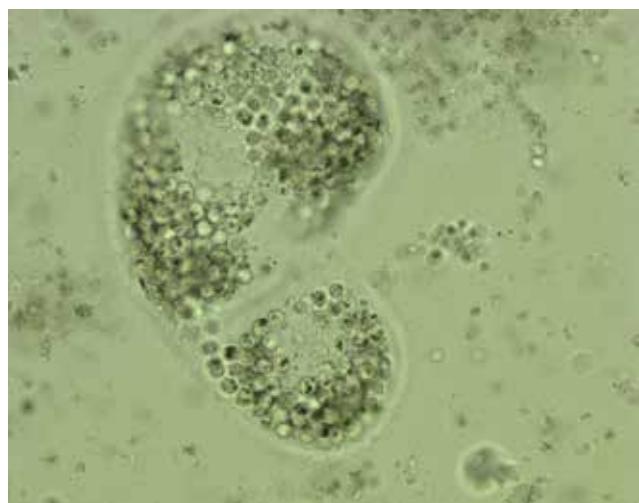
Ovaj projekt akronima TRANITAL financira Hrvatska zaklada za znanost (HRZZ), a predviđeno je trajanje od ožujka 2017. do veljače 2021. godine. Suradničke institucije su Biološki odsjek Prirodoslovno-matematičkog fakulteta Sveučilišta u Zagrebu i Glavni vodnogospodarski laboratorij Hrvatskih voda.

U aluvijalnom vodonosniku na području grada Varaždina pojavljuju se visoke koncentracije nitrata. Područje istraživanja zahvaća slivna područja crpilišta "Varaždin" i "Vinokoščak". Dosadašnja istraživanja provedena na ovom području su, s obzirom na probleme nitrata, ili s hidrogeološkog ili s poljoprivrednog gledišta. Na području nikada nije provedeno sustavno interdisciplinarno istraživanje ponašanja i raspodjele nitrata u



Odvodni kanal HE Varaždin (foto T. Marković)

The HE Varaždin drainage canal (photo by T. Marković)



Microcystis wesenbergii u uzroku vode iz šljunčare ŠRD Vidovec (foto A. Kulaš)

Microcystis wesenbergii in water sample from the ŠRD Vidovec gravel pit (photo by A. Kulaš)

The project under the acronym TRANITAL is funded by the Croatian Science Foundation and is scheduled to run from March 2017 to February 2021. The collaborating institutions in the project are the Department of Biology, Faculty of Science at the University of Zagreb, and the Central Water Management Laboratory of Hrvatske vode.

High nitrate concentrations occur in the alluvial aquifer in the area of the City of Varaždin. The research area covers the catchments of Varaždin and Vinokščak pumping sites. Previous investigations carried out in this area were conducted either from a hydrogeological or from the agricultural point of view, considering the approach to nitrate contamination. Interdisciplinary research has never been carried out on the behaviour and distribution of nitrate in the aquifer. This kind of research should include researchers from different disciplines, and various investigation techniques for the study of denitrification and nitrification processes in the aquifer system. The six objectives of the project are:

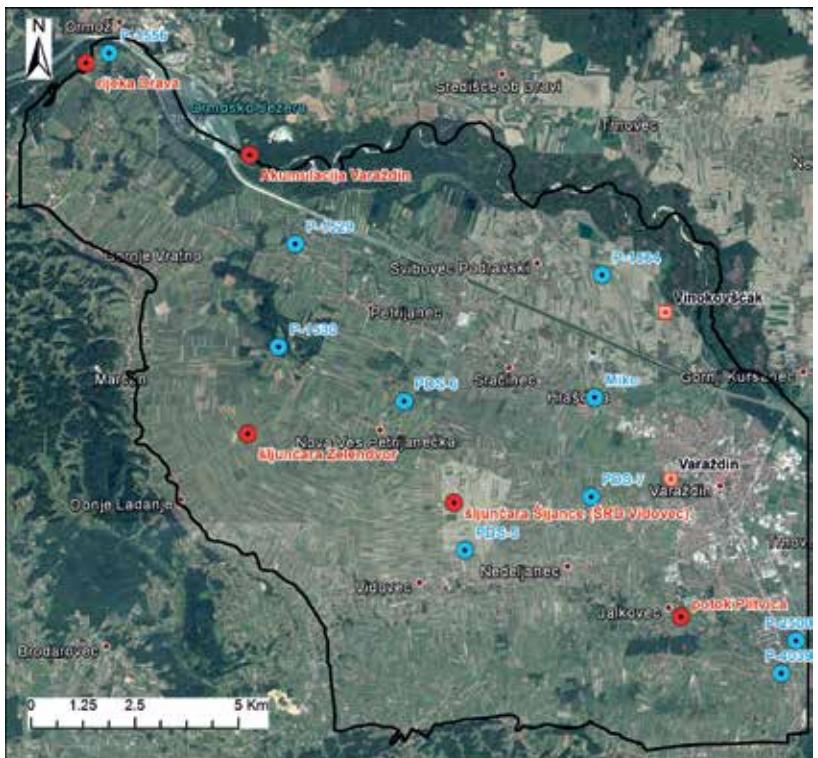


Pripremanje opreme prije uzorkovanja vode na ŠRD Vidovec  
(foto T. Marković)

Equipment preparation prior to water sampling at the ŠRD Vidovec  
(photo by T. Marković)

vodonosniku, koje bi uključivalo istraživače iz različitih disciplina, te različite tehnike istraživanja denitrifikacijskih i nitrifikacijskih procesa u vodonosnom sustavu. Šest je ciljeva projekta: 1. Razviti multi-parametarski pristup za određivanje značajki aluvijalnog vodonosnika pomoći hidrauličkim, kemijskim, izotopnim i mikrobiološkim pokazateljima; 2. Odrediti ulogu površinskih voda u napajanju/dreniranju aluvijalnog vodonosnika i njihov utjecaj na koncentraciju dušika u aluvijalnom vodonosniku; 3. Odrediti mineraloška i kemijska svojstva tla i njihov utjecaj na dušikov ciklus; 4. Određivanje podrijetla nitrata i procesa koji mogu dovesti do poboljšanja kakvoće podzemne vode; 5. Načiniti model toka podzemne vode i transporta nitrata u aluvijalnom vodonosniku; i 6. Prenijeti spoznaje o podrijetlu, ponašanju i transportu nitrata u aluvijalnom vodonosniku. Glavni cilj projekta je osigurati znanstveno opravdani pristup i prijenos znanja između znanstvenika iz različitih disciplina koji će istraživati vodonosnike čija je kakvoća narušena zbog visokih koncentracija nitrata, te prenijeti znanje upravi, planerima i vodnim grupacijama na lokalnoj i državnoj razini, kako bi se osiguralo ekološki održivo upravljanje vodnim resursima i poljoprivrednom proizvodnjom.

1. Develop a multi-parametric approach for determination of the properties of alluvial aquifers, using hydraulic, chemical, isotope, and microbiological indicators; 2. Determine the role of surface waters in feeding / draining of the alluvial aquifer, and how they affect the concentration of nitrogen in the alluvial aquifer; 3. Determine mineralogical and chemical properties of soil and how they affect the nitrogen cycle; 4. Determine nitrate sources and processes, which may lead to the improvement of the groundwater quality; 5. Construct a model of groundwater flow and nitrate transport in the alluvial aquifer; and 6. Transfer knowledge about the sources, behaviour and transport of nitrate in the alluvial aquifer. The main objective of the project is to provide a scientifically justified approach and to transfer knowledge between scientists from different disciplines, who will investigate the aquifers of deteriorated quality due to high nitrate concentrations. Moreover, the objective is to transfer knowledge to management, planners, and water management groups at the local and national level, to ensure ecologically viable water resource management and agricultural production.



Točke uzorkovanja podzemnih i površinskih voda  
Groundwater and surface water sampling points

# Utjecaj specifične površine oplošja čestice na hidrogeološka svojstva prapora i na njima razvijenih tala istočne Hrvatske

## Impact of Specific Surface Area on Hydrogeological Properties of Loess Deposits and Loess-Derived Soils in Eastern Croatia

Glavni istraživač / Principal investigator: dr. sc. **Kosta URUMOVIĆ**

<http://projects.hgi-cgs.hr/issah/>

Znanstveni i praktični interes o praporima je izrazito polidisciplinaran. Pri tome su interesantne teme dijelom zajedničke, ali prvenstveno specifične: osnovni i akcesorni granulometrijski i petrografski sastav, geometrijska svojstva pora, sadržaj organskih tvari i fosilnih ostataka, sadržaj vlage, protočnost i zadržavanje vode, fizikalna i kemijska interakcija sadržane vode i krutine, okolišna hidrografska obilježja, geotehnička svojstva, lokalni i regionalni morfološki položaj i obilježja podinskih naslaga. Primarni interes je u geološkim, hidrološkim, pedološkim, graditeljskim i drugim, naročito ekološkim, disciplinama koje imaju tematski različita težišta i dubinu istraživanja pojedinih svojstava i regionalnih obilježja prapora.

Strateški značaj prapornih naslaga se za RH prvenstveno temelji na poljoprivrednom i građevinskom korištenju te na zaštiti podzemnih voda. Ovaj je projekt zamišljen kao interdisciplinarno istraživanje utjecaja specifične površine čestice na mjerilu uzorka na hidrogeološke, geomehaničke, pedološke i poljoprivredne uvjete u realnom mjerilu.

Jedan od ciljeva ovog projekta bio je oformiti istraživačku grupu mladih hrvatskih znanstvenika iz različitih institucija i različitih polja znanosti, i usmjeriti je u istraživanje sitnozrnastih klastičnih naslaga te proizvesti podlogu budućih interdisciplinarnih istraživanja u svrhu zaštite podzemnih voda i efikasnog korištenja zemljишta. U listopadu 2018. godine je na mjesto poslijedoktoranda na projektu zaposlen Marco Pola, znanstvenik

The scientific and practical interest in loess is highly multidisciplinary. Therefore, interesting topics of study are common to a certain extent, but most of all specific: the granulometric and petrographic composition of primary and accessory minerals in loess, geometrical properties of pores, organic matter and fossil content, moisture content, water percolation and retention properties, physical and chemical water-solids interaction, environmental hydrographic properties, geotechnical properties, local and regional morphological position, and the characteristics of underlying deposits. The primary interest is in geological, hydrological, pedological, construction and other, especially ecological, disciplines that have thematically different foci and depths of research of particular properties and regional characteristics of loess.

The strategic significance of loess deposits for the Republic of Croatia lies in its agricultural use, construction and groundwater protection. This project has been conceived as interdisciplinary research of the particles' specific surface area impact at the sample scale, on hydrogeological, geomechanical, pedological, and agricultural conditions in real scale.

One of the aims of the project was to set up a research group of young Croatian scientists from different institutions and different fields of science and to direct this group to study fine-grained clastic deposits. In addition to that, the group of scientists will form the basis for future interdisciplinary research in terms of



Tipični praporni profil u Mohovu (foto I. Pavičić)  
Typical loess section in Mohovo (photo by I. Pavičić)



Praporni profil u Ilok (foto I. Pavičić)  
Loess section in Ilok (photo by I. Pavičić)

iz Italije, koji će se baviti strukturno hidrogeološkom rekonstrukcijom istraživanih područja.

Istraživanja u sklopu ovog projekta regionalno su prvenstveno usmjerena na prostor Baranje, Srijema i istočne Slavonije, gdje prapori i praporu slične tvorevine prekrivaju velike površine. Znanstveno utemeljeno poznavanje njihovih svojstava na konkretnim lokacijama i njihova regionalizacija važna su podloga za aktualni napredak i dugoročni razvitak ovih krajeva.

Ovaj uspostavljeni istraživački projekt akronima ISSAH financira Hrvatska zaklada za znanost od veljače 2018. do siječnja 2023. godine.

groundwater protection and efficient land use. In October 2018 Marco Pola, a scientist from Italy, was employed as a Post-Doc on this project. He will work on the structural-hydrogeological reconstruction of the study areas.

Investigations within the project are regionally concentrated primarily in the area of Baranja, Srijem and eastern Slavonia, where loess and loess-like deposits cover large surfaces. Scientifically confirmed knowledge of their properties at defined locations and their regionalisation is an important foundation for the current progress and long-term development of these regions.

This installation research project (acronym ISSAH) is funded by the Croatian Science Foundation from February 2018 until January 2023.

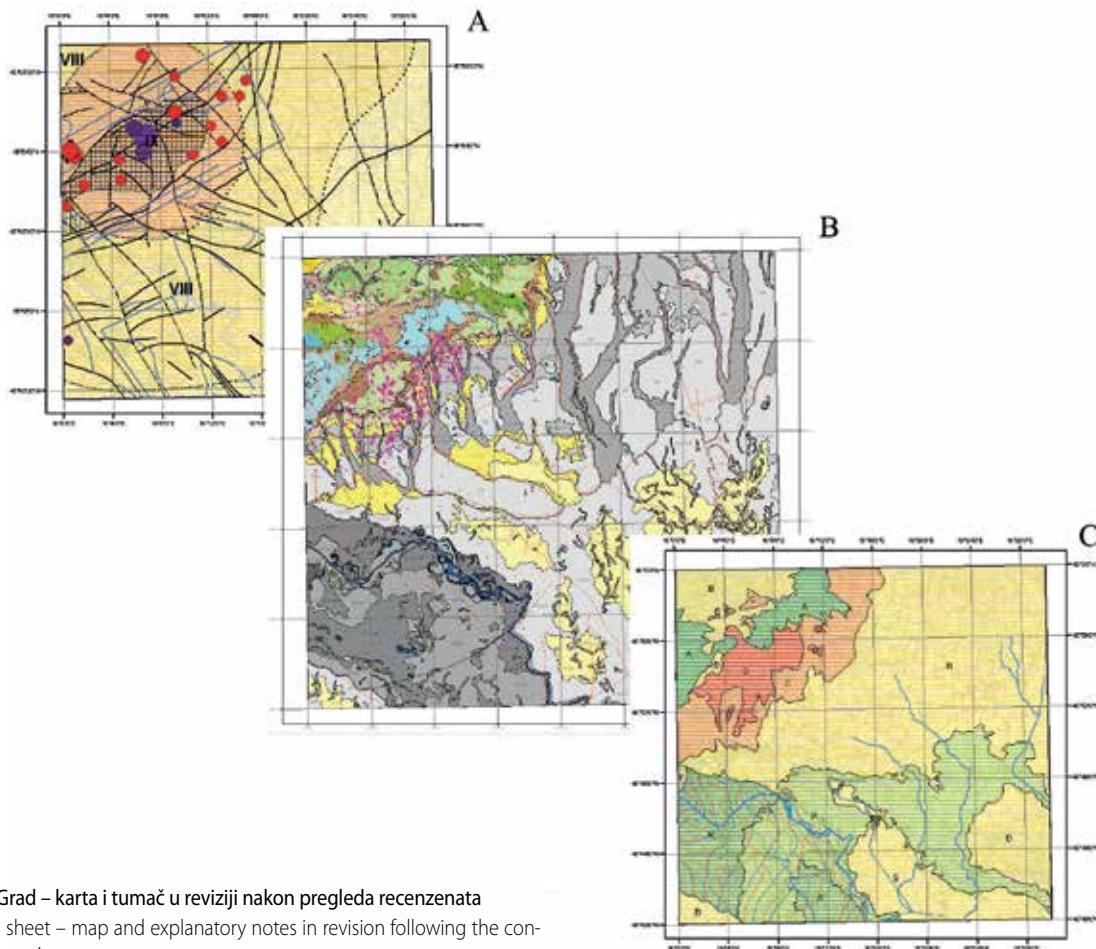
# Osnovna inženjerskogeološka karta Republike Hrvatske 1:100.000

## Basic Engineering Geological Map of the Republic of Croatia 1:100,000

Glavni istraživači / Principal investigators: dr. sc. **Renato BULJAN**, dr. sc. **Davor POLLAK** (since 2017)

Temeljni zadatak izrade OIGK u proteklih 10 godina bio je definiranje IG značajki geoloških materijala i masa karakterističnih za cijelu RH i pojedine teritorijalne cjeline (Dinaridi, Panonski bazen, županije, gradovi i općine).

The fundamental task of the Basic Engineering Geological Map (BEGM) project during the last 10 years has been the definition of engineering geological (EG) characteristics of geological materials and masses typical for the entire Republic of Croatia (RH) and



List Ivanić Grad – karta i tumač u reviziji nakon pregleda recenzentata  
Ivanić Grad sheet – map and explanatory notes in revision following the conducted peer review



Model klizišta u Hrvatskoj Kostajnici izrađen prema snimkama bespilotne letjelice

Model of a landslide in Hrvatska Kostajnica produced from UAV recordings

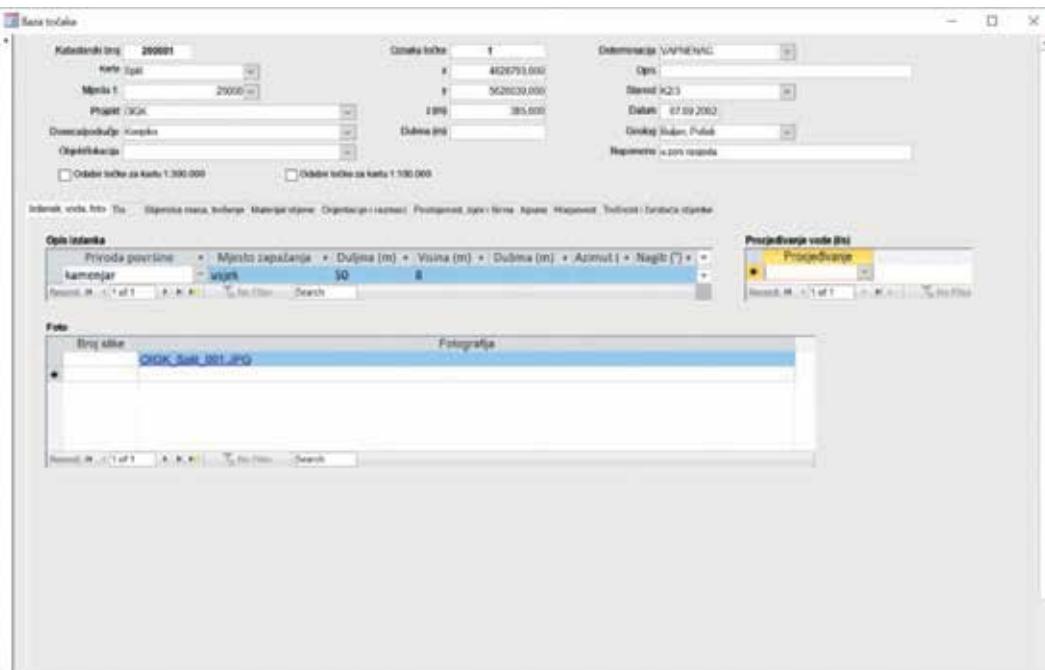
Istraživanja su obavljena u skladu s raspoloživim sredstvima. Dodatno su članovi tematske grupe (7-10 istraživača) angažmanom na privrednim projektima prikupili relevantne i vrijedne podatke za izradu OIGK. Prikupljeni podaci omogućili su i znanstvena istraživanja i izradu četiriju disertacija s temama: statističko modeliranje geometrijskih značajki diskontinuiteta (Navratil), izučavanje erozije na ogolinama Istre (Gulam), stereoskopska analiza klizišta i relativne opasnosti od klizanja (Podolszki) te razvoj sustava za procjenu ugroženosti od odrona u karbonatnim stijenama (Bostjančić). U proteklom razdoblju također je uspostavljen i opremljen Inženjerskogeološki laboratorij.

Istraživano je u Dinaridima kod izrade projekata autocesta Karlovac-Split-Dubrovnik i Žuta Lokva-Križišće, cesta Dubrovnik-Herceg Novi i Ravča-Drvenik, projekta Most Kopno-Pelješac, rekonstrukcija pruge Karlovac-Knin-Split, u kamenolomima flišnih naslaga ponad Kaštela (OIGK listovi Gospic, Knin, Drniš, Split-Primošten, Omiš, Imotski, Ploče, Ston, Dubrovnik), a zatim i kod projekata Nizinska pruga Zagreb-Rijeka, rekonstrukcija pruge Oštarije-Rijeka-Šapjane, Retencija Drežničko polje za HE Gojak i HE Lešće (OIGK listovi Rijeka, Crikvenica, Delnice, Ogulin, Otočac). U Istri je istraživana erodibilnost ogolina u flišnim naslagama klizišta Boljun-Borut, Brus, Sveti Donat i uz akumulaciju Butoniga (OIGK listovi Pula, Rovinj, Labin, Trst).

individual territorial entities (Dinarides, Pannonian Basin, counties, cities, and municipalities).

Research was carried out in accordance with available funds. Members of the team (a group of 7–10 researchers) have acquired additional relevant and valuable data for the creation of the BEGM through engagement in commercial projects. The acquired data have enabled both scientific research, as well as the writing of four PhD dissertations with the following topics: statistical modelling of geometrical characteristics of discontinuities (Navratil), the study of erosion on Istrian gullies (Gulam), stereoscopic analysis of landslides and relative landslide hazard (Podolszki), and the development of rockfall hazard assessment system in carbonate rocks (Bostjančić). The EG laboratory has also been established and equipped in the described period.

Research was carried out in the Dinarides through work on projects for the Karlovac-Split-Dubrovnik and Žuta Lokva-Križišće highways, the Dubrovnik-Herceg Novi and Ravča-Drvenik roads, the Mainland-Pelješac bridge project, the reconstruction of the Karlovac-Knin-Split railway, in the flysch sediment quarries above Kaštela (BEGM sheets Gospic, Knin, Drniš, Split-Primošten, Omiš, Imotski, Ploče, Ston, Dubrovnik), and then also through the projects Lowland railway Zagreb-Rijeka, and the reconstruction of the Oštarije-Rijeka-Šapjane railway, the Drežničko polje retention for the Gojak and Lešće hydroelectric powerplants (BEGM sheets Rijeka, Crikvenica, Delnice, Ogulin, Otočac). In Istria, research has



Izgled baze podataka vezane uz OIGK  
Display of the database related to the BEGM

U Panonu su dovršeni OIGK listovi Krapina i Zagreb s tumačima, dok je u završnoj fazi list Ivanić Grad.

Kod istraživanja nestabilnih padina Medvednice dovršena je IG mikrozonacija urbanizirane zone Zagreba (DIGK-I), a temeljem glavnih mehaničkih značajki tipova tla, u izradi je Detaljna IG karta JZ obronaka Medvednice (DIGK-II). Od 2009. do 2015. u sklopu hrvatsko-japanskog projekta o istraživanju klizišta, nestabilnih padina i debrinih tokova razmijenjena su iskustva o načinu kartiranja i modeliranja klizišta te geotehničkim mjerama za njihovu stabilizaciju.

Zadnjih se godina u IG istraživanja uvode nove tehnologije i metode, a sustavno se rade i analize materijala i geoloških uvjeta koji dovode do aktiviranja geohazardnih IG pojava i procesa (klizišta, odroni, erozija). Prikupljeni podaci se pohranjuju u baze, a izrađeni katastri koristit će se kod izrade karata podložnosti i hazarda.

been conducted on the erodibility of outcrops in flysch sediments of landslides Boljun–Brus, Sveti Donat, and near the Butoniga accumulation (BEGM sheets Pula, Rovinj, Labin, Trst).

In the Pannonian, the BEGM sheets Krapina and Zagreb have been completed, together with the explanatory notes, while the Ivanić Grad sheet is currently being finalized.

The investigation of the unstable slopes of the Medvednica Mt. enabled EG micro-zonation of urbanised zone of the City of Zagreb to be completed (DEGM-I), while with regard to the main mechanical characteristics of soil types, the Detailed EG map of the SW slopes of Medvednica Mt. (DEGM-II) is in production. From 2009 to 2015, experiences on the methods of landslide mapping and modelling, and on geotechnical measures for their stabilisation, were exchanged in the Croatian-Japanese project on landslides, unstable slopes, and debris flow research.

In recent years, new technologies and methods have been introduced in EG research, with analyses of materials and geological conditions that lead to the activation of EG hazard phenomena and processes (landslides, rockfalls, erosion) being systematically performed. Acquired data are stored in databases, while the generated cadastres will be used in the production of susceptibility and hazard maps.

# Sanacija usjeka i zasječka na dijelu željezničke mreže Hrvatskih željeznica

## Remediation of Cutting Slopes on a Part of the Railway Network in Croatia

Autori teksta / Authors of the text: dr. sc. Dražen NAVRATIL, dr. sc. Renato BULJAN

HGI-CGS je od 2013. do 2016. godine sudjelovao u sklopu šestosjčlanog konzorcija u izradi izvedbenog projekta za HŽ Infrastrukturu d.o.o. Projektni zadatci su obuhvaćao dvije faze. U prvoj fazi proveden je detaljan specijalistički pregled, odnosno inženjerskogeološka prospexija, usjeka i zasječka na dionicama pruga Zagreb GK – Rijeka, Oštarije – Split Predgrađe, Rijeka – Šapjane – državna granica i Škrljevo – Bakar.

Provedena kategorizacija usjeka i zasječka prema stabilnosti poslužila je kao osnova za definiranje prioriteta za daljnju sanaciju istih. Za potrebe prve faze projekta korištena je RHRS kategorizacija (Rockfall Hazard Rating System, SAD) koja predstav-



Odrod na dionici pruge Oštarije – Split (između željezničkih kolodvora Labin Dalmatinski i Kaštel Stari)  
Rockfall on a railway section of the Oštarije – Split railway (between railway stations Labin Dalmatinski and Kaštel Stari)



Predusjek tunela Križnjak pruge Oštarije – Split (između željezničkih kolodvora Labin Dalmatinski i Kaštel Stari)  
Cutting of the Križnjak tunnel on the Oštarije – Split railway (between railway stations Labin Dalmatinski and Kaštel Stari)

From 2013 to 2016, HGI-CGS participated in a six-member consortium for the development of the main design for HŽ Infrastruktura Ltd. The project consisted of two phases. The first phase included detailed specialist examination i.e. EG prospection of cuttings on the railway sections: Zagreb – Rijeka, Oštarije – Split suburb, Rijeka – Šapjane – state border and Škrljevo – Bakar.

The categorisation of segments according to stability served as a basis for defining priorities for their remediation. For the needs of the first project phase, the USA Rockfall Hazard Rating System (RHRS) categorisation was used, which is one of the most developed systems for assessing rockfall hazard and instability along

Ija jedan od najrazvijenijih sustava za procjenu hazarda odrona i nestabilnosti duž kosina u stijenama. RHRS kategorizacija prvenstveno je napravljena za ceste/autoceste u drugačijim geološkim sredinama, stoga je bilo potrebno prilagoditi istu za pruge, odnosno za karbonatne i flišne kompleksne stijena, s obzirom da su željeznički usjeci/zasjeci najvećim dijelom izvedeni u njima.

U drugoj fazi projekta, prema rezultatima provedene kategorizacije, a u suglasju s odgovornim osobama HŽ Infrastrukture, izrađeni su idejni i izvedbeni projekti sanacije za najugroženije usjeku/zasjeku. HGI-CGS je u ovoj fazi projekta izradio detaljne inženjerskogeološke podloge za 62 najkritičnija usjeka/zasjeka koji direktno prijete sigurnosti željezničkog prometa.

Od ukupno 497 km navedenih dionica pruga, provedena je kategorizacija kritičnih usjeka/zasjeka ukupne duljine 75,15 km, a za potrebe izvedbenih projekta sanacije 62 usjeka/zasjeka izrađene su inženjerskogeološke podloge ukupne duljine 13,55 km.

U sklopu ovog projekta Iris Bostjančić je 2016. godine doktorirala na temu „Razvoj sustava za procjenu ugroženosti od odrona duž željezničkih pruga u karbonatnim stijenama u Republici Hrvatskoj“. U sklopu doktorskog rada razrađeni su elementi za razvoj sustava ugroženosti od odrona koji predstavlja prvi korak u cijelovitom upravljanju hazardima i rizicima od odrona, kako na prugama tako i na svim ostalim linearnim infrastrukturnim objektima.

Sudjelovanje u ovakvim projektima predstavlja dobar primjer multidisciplinarnog znanstvenoistraživačkog pristupa i implementacije geološkog inženjerstva u rješavanju problematike upravljanja rizicima i hazardima od odrona.



Usjek Matulji neposredno ispod benzinske crpke "Vrata Jadran" na riječkoj obilaznici, pruga Rijeka – Šapjane – državna granica (između željezničkih kolodvora Matulji i Rijeka)

Cutting Matulji just before the "Vrata Jadran" gas station on the City of Rijeka bypass, the Rijeka – Šapjane – state border railway (between railway stations Matulji and Rijeka)

rock slopes. The RHRS categorisation was primarily made for roads / motorways in different geological environments, so it was necessary to adapt it to railways, as well as carbonate and flysch rock complexes where the investigated railway segments are situated.

According to the results of the categorisation, in the second project phase, the conceptual and main designs for remediation of the most unsafe rock segments were developed in agreement with the responsible persons from HŽ Infrastruktura. At this stage of the project, the HGI-CGS constructed a detailed EG basis for the 62 most critical segments, which directly threaten the safety of railway traffic.

Out of 497 km of these railway sections, segments considered critical totalled 75.15 km. For the purpose of developing main designs for 62 segments, an EG base totalling 13.55 km was constructed.

As part of this project, Iris Bostjančić defended a PhD thesis in 2016 entitled "Development of rockfall threat assessment system along railways in carbonate rocks in the Republic of Croatia". In the thesis, the elements for the development of a rockfall threat assessment system were elaborated, which is the first step in complete hazard and rockfall risk management of railways and all other linear infrastructural objects.

These projects are a good example of the multidisciplinary research approach and implementation of geological engineering in solving risk and rockfall hazard management issues.

# Detaljna inženjerskogeološka karta Podsljemenske urbanizirane zone Grada Zagreba

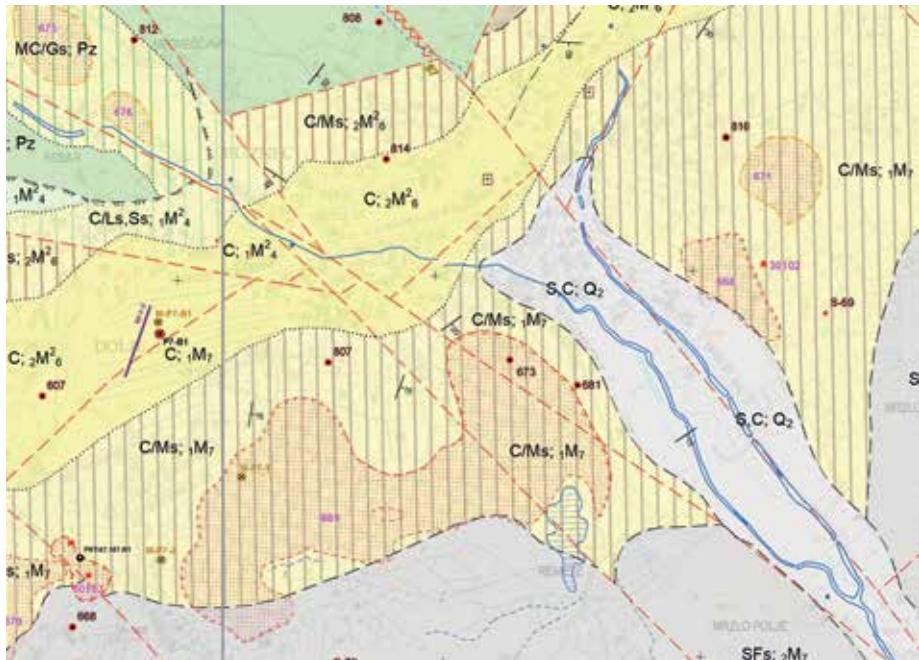
## Detailed Engineering Geological Map of the Podsljeme Urbanized Zone of the City of Zagreb

Autor teksta / Author of the text: dr. sc. **Laszlo PODOLSKI**

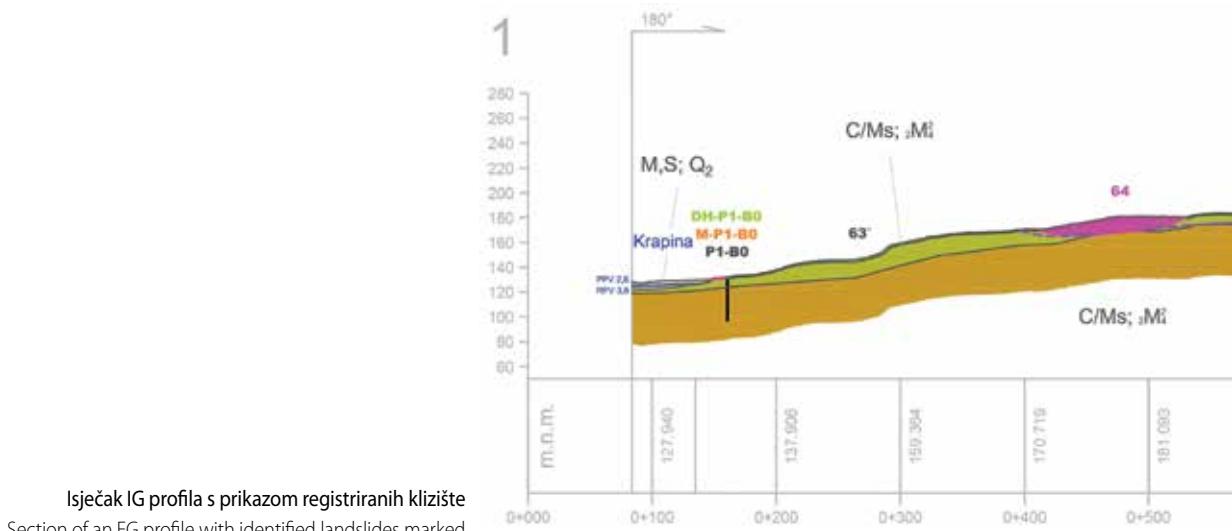
U cilju izrade detaljnih podloga i utvrđivanja nestabilnih padina na području Grada Zagreba, na južnim obroncima Medvednice provedeni su projekti Detaljna inženjerskogeološka karta Podsljemenske urbanizirane zone mjerila 1:5.000 Faza I (u razdoblju od 2004. do 2007. godine) i Faza II (u razdoblju od 2015. do 2018. godine). Površina područja istraživanja je iznosila približno 175 km<sup>2</sup>. Prva faza istraživanja (DIGK-Faza I) dala je detaljan pregled naslaga u dvije dimenzije (2D) i prikazana je na geološkoj karti mjerila 1 : 25.000, hidrogeološkoj karti mjerila 1 : 25.000, te detaljnim inženjerskogeološkim kartama

For the purpose of producing detailed maps and identifying unstable slopes in the area of the City of Zagreb, projects were carried out on the southern slopes of Medvednica Mt. The detailed engineering geological map (DEGM) of the Podsljeme urbanised zone at the scale 1 : 5,000 was constructed in the project, with phase I lasting from 2004 to 2007 and phase II from 2015 to 2018. The extent of the study area was approximately 175 km<sup>2</sup>. The first phase of the research (DEGM-Phase I) brought out a detailed overview of the deposits in two dimensions (2D) and was presented on a geographic map at the scale of 1 : 25,000, a hydrogeological map at the scale of 1 : 25,000 and in DEGMs at the scale of 1 : 5,000. A landslide cadastre was also created for the study area, with 707 registered landslides.

The main studies that were performed in the second phase (DEGM-Phase II) consisted of subsurface investigations in order to collect data in 3D. Studies were carried out in order to collect data on the cover or surface weathering zone thickness and determine geological, EG, and geomechanical properties of the cover / surface weathering zone. The investigations were based on the construction of geotechnical exploration wells, along with geological, geomechanical, and geophysical research, as well as accompanying laboratory analyses. Moreover, within the DEGM-Phase II, data on land-



Isječak IG karte s prikazom registriranih klizišta  
Section of the EG map with identified landslides marked



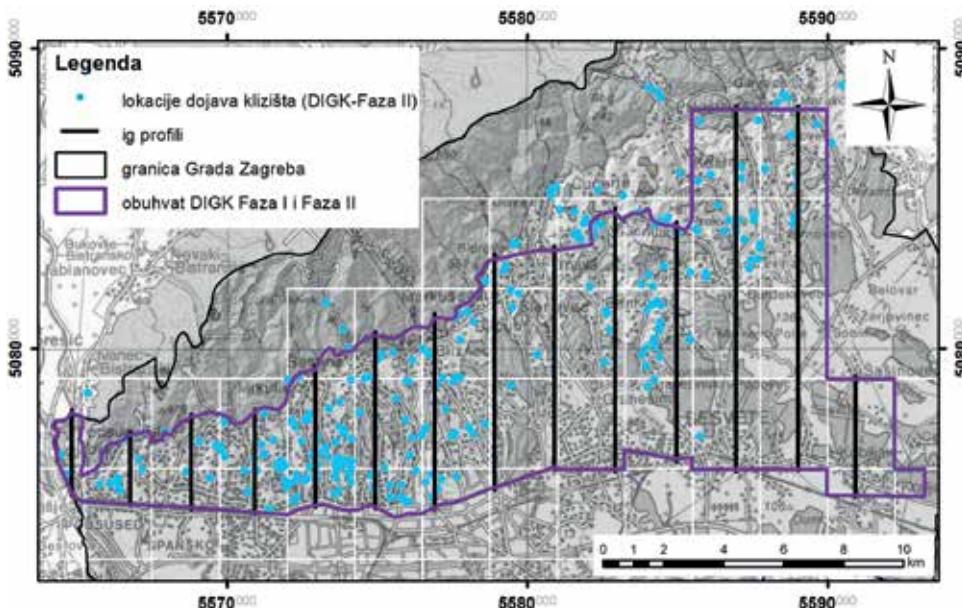
Isječak IG profila s prikazom registriranih klizišta  
Section of an EG profile with identified landslides marked

mjerila 1 : 5.000. Izrađen je i katastar klizišta za predmetno područje sa 707 registriranih klizišta. Osnovni radovi koji se izvodili u drugoj fazi (DIGK-Faza II) su bila dubinska istraživanja radi pridobivanja podataka u trećoj dimenziji prostora (3D). Istraživanja su izvedena radi kako bi se prikupili podaci o deblji-

slides were updated (213 landslides were registered or updated and entered into the database) and 14 engineering-geological profiles of the study area were constructed. Additionally, modifications and refinements of existing EG maps were implemented by continuously including the data throughout the project duration. The research and data collected in these projects are related to the same study area. The results overlap, complement each other and generally provide a better framework for considering existing issues related to the implementation of better spatial planning, construction, and monitoring, while considering geological, seismic and geotechnical aspects in a wider sense.



Klizište u Podsljemenskoj urbaniziranoj zoni koje je oštetilo cestu  
Landslide in the Podsljeme urbanised zone which caused damage to the road

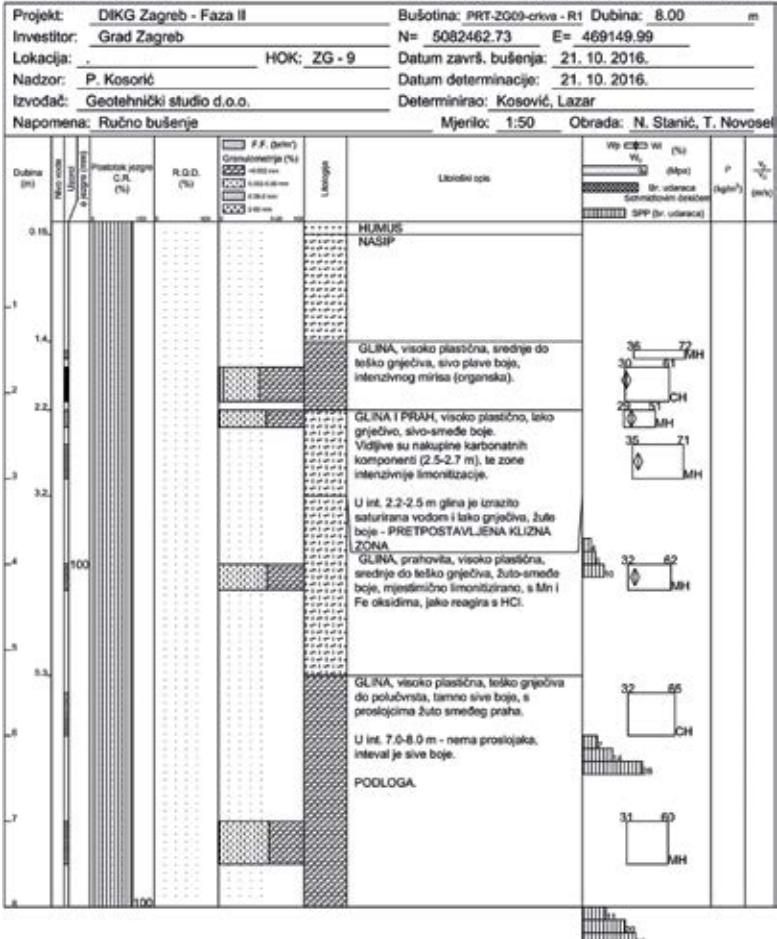


Područje obuhvata DIGK na južnim obroncima Medvednice

Area of the DEGM covering the southern slopes of Medvednica Mt.

ni pokrivača ili površinske zone trošenja, te radi utvrđivanja geoloških, inženjerskogeoloških i geomehaničkih svojstava pokrivača/površinske zone trošenja. Istražni radovi su bili bazirani na izvedbi geotehničkih istražnih bušotina, uz učešće geoloških, geomehaničkih i geofizičkih istraživanja, te pratećih laboratorijskih ispitivanja. Također u sklopu DIGK-Faza II provedeno je i ažuriranje podataka vezanih uz klizišta (213 klizišta je registrirano ili ažurirano i uneseno u izrađenu bazu podatka), a izvršena je i izrada 14 inženjerskogeoloških profila predmetnog područja. Uz navedeno, izvršene su i izmjene i dorade postojećih inženjerskogeoloških karata uključivanjem podataka prikupljenih tijekom trajanja projekta (DIGK-Faza II). Provedena istraživanja i prikupljeni podaci u sklopu ovih projekata odnose se na isto istraživano područje te se međusobno preklapaju, nadopunjavaju i sveukupno daju kvalitetniji okvir za sagledavanje postojeće problematike vezane uz provođenje što kvalitetnijeg planiranja, gradnje i nadzora s obzirom na geološke, seizmičke i geotehničke aspekte u širem smislu.

#### PROFIL BUŠOTINE



Profil bušotine izvedene na klizištu u sklopu DIGK-Faza II

Profile of the borehole constructed at the landslide site within the DEGM-Phase II

# Most kopno-Pelješac

## Mainland-Pelješac Bridge

Voditelj projekta / Project Manager: dr. sc. **Renato BULJAN**

Autori teksta / Authors of the text: dr. sc. **Davor POLLAK, Tomislav NOVOSEL**

Most kopno-Pelješac premošćuje Malostonski zaljev i povezuje Komarnu s kopnene strane, i Brijestu na poluotoku Pelješcu. S ukupnim rasponom od 2404 m i 10 podmorskih pilota, taj će most biti najdulji u RH. Most također zadovoljava jedan od osnovnih zahtjeva slobodnoga plovног profila ispod mosta, koji bi trebao biti visok 55 m.

Zbog višestrukih izmjena projekta, istraživanja su provedena u nekoliko faza na lokacijama podmorskih pilota. Ona su uključivala *in-situ* testiranja: istraživačko bušenje s jezgrovanjem, *down-hole* seizmičko profiliranje, cone-penetracijski test s mjenjima pornih tlakova (CPTU), testove džepnog penetrometra, inženjerskogeošku determinaciju jezgre i laboratorijske analize uzoraka iz jezgre (granulometrija, Atterbergove grane, RTG difrakcija i testove za utvrđivanje mehaničkih svojstava materijala tla i stijene).

Područje izgrađuju gornjokredne i donjoeocenske karbonatne stijene, gornjoeocenske flišne naslage i kvartarni sedimenti

The Mainland – Pelješac bridge is designed to span the Mali Ston Bay, linking Komarna on the mainland and the Brijesta cove on the Pelješac peninsula. It is going to be the longest bridge in Croatia with total length of 2404 m, supported by 10 submarine pylons. One of the essential requirements of the bridge design was to allow the passage of marine traffic below, which determined a bridge height of 55 m.

Due to multiple changes in design, investigations were performed in several stages at each of the locations of pylons' foundations. These included *in-situ* testing: core drilling, *down-hole* seismic profiling, cone penetration testing with pore pressure measurements (CPTU), pocket penetrometer tests, EG core examination / description, and laboratory analyses of the core samples (granulometry, Atterberg limits, X-ray diffraction analysis and mechanical properties of soil and rock).

The area under consideration is composed of Upper Cretaceous and Lower Eocene carbonate rocks, Upper Eocene flysch depos-

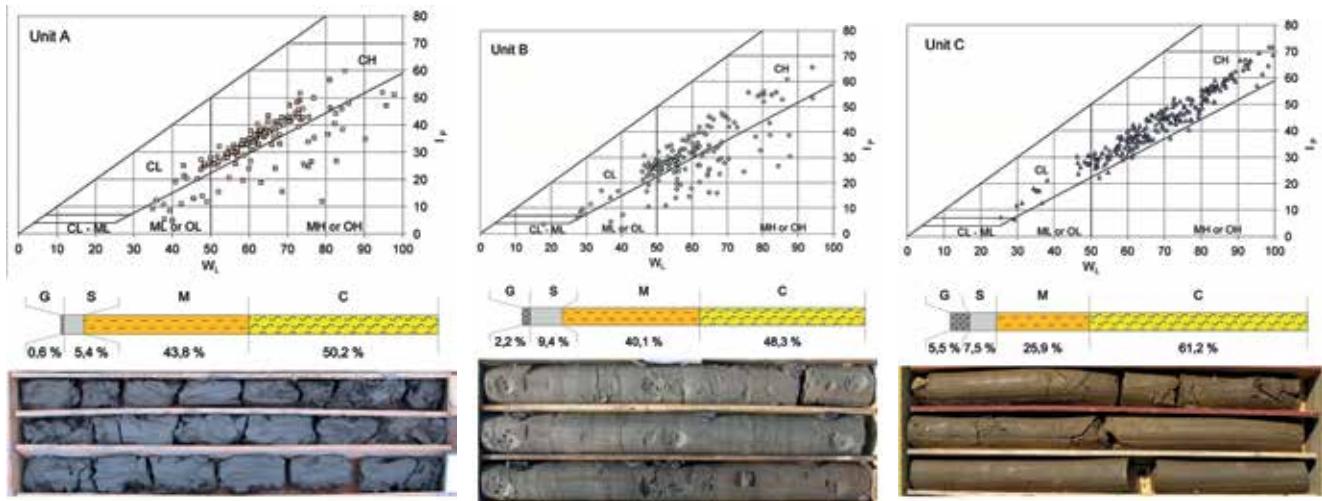


Planirani izgled mosta kopno-Pelješac (izvor: <http://pipenbaber-consulting.com/project/peljesac-bridge/36>)

Visualisation of Mainland – Pelješac bridge (source: <http://pipenbaber-consulting.com/project/peljesac-bridge/36>)



Istraživačko bušenje s trajekta  
Exploratory drilling from a ferryboat



Osnovne značajke inženjerskogeoloških jedinica tla u području mosta (Buljan et al., 2012)

The principal properties of engineering geological soil units in the area for bridge construction (Buljan et al., 2012)

koji su podijeljeni u tri inženjerskogeološke jedinice. Uz samu obalu zaljeva morsko dno je izgrađeno od karbonatnih stijena strmih nagiba, a sav preostali dio zaljeva prekriva ravna muljevita podloga. Dubina mora je uglavnom 28 m.

U središnjem dijelu zaljeva kvarterni sedimenti uglavnom premašuju debljinu od 75 m, a mogu doseći i do 100 m. Provedena istraživanja su dokazala da gornjih 60 m naslaga u generaliziranom profilu uglavnom ima vrlo slaba, nepovoljna inženjerska svojstva. Ta konstatacija, velik raspon mosta i visoka seizmičnost područja upućuju na zaključak da će gradnja mosta biti vrlo zahtjevna i skupa, ali i riskantna.

its, and Quaternary sediments covering the seafloor of the Mali Ston Bay. The coastline area is formed in steeply inclined carbonate rocks, but the whole remaining length of the bridge axis is above flat and muddy seabed, at a depth of 28 m on average.

The thickness of sediments in the central part of the bridge exceeds 75 m and reaches up to 100 m. The exploration revealed that the upper 60 m of the sediment profile generally has very poor, unfavourable engineering properties. These findings, together with the bridge span and seismicity of the area, led to the conclusion that construction of the bridge will be very challenging, expensive, and risky.

# Napredno transnacionalno upravljanje rizikom korištenja zemljišta izradom karata podložnosti na klizanje

## Transnational Advanced Management of Land Use Risk through Landslide Susceptibility Maps Design

Voditelj projekta / Project Manager: dr. sc. **Vlatko GULAM**

<https://www.safearth.eu/>



Logo Interreg IPA CBC programa i safEarth projekta

Logos of the Interreg IPA Cross-border Cooperation Programme and the safEarth project

Klizišta kao veliki okolišni problem, dodatno naglašen u uvjetima sve intenzivnijih klimatskih promjena, predstavljaju okonsku projekta safEarth. Iako brojna, klizišta i problemi vezani uz njih ni u jednoj od partnerskih država nisu obuhvaćena prostorno planerskim zakonskim aktima. Također, sustavno praćenje navedene pojave na državnoj razini od strane geološke struke izostaje.

Sukladno tome, glavni ciljevi projekta safEarth su razrada metodologije izrade karata podložnosti na klizanje, te izrada strategije implementacije razrađenih metodologija definiranja prostornog rizika od klizišta u zakone o prostornom planiranju.

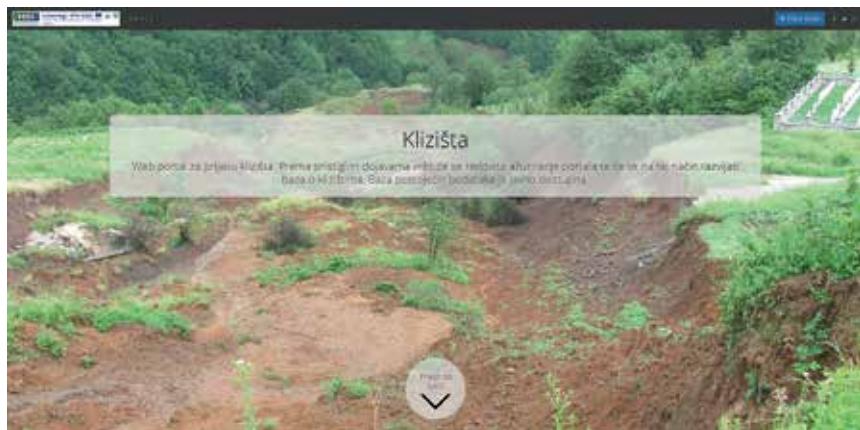
Druga prioritetna os programa, a posebno specifični cilj 2.1, prepoznaju potrebu poboljšanja očuvanja prirode i okoliša te unaprjeđenja sustava upravljanja kao prevenciju rizika od prirodnih katastrofa.

Sve izneseno upućuje na jaku vezu između glavnih ciljeva safEarth projekta i

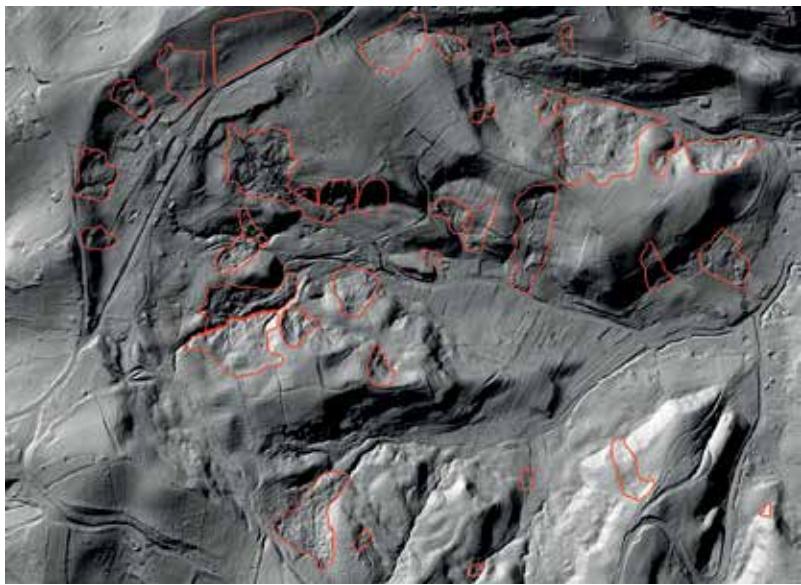
Landslides, as a major environmental problem, exacerbated by climate change, and their investigation, formed the backbone of the safEarth project. Although frequent, landslides and related problems are not covered by spatial planning regulations in any of the partner countries. Moreover, systematic monitoring of this phenomenon is absent from the geological profession at the state level.

Accordingly, the main goals of the safEarth project are to develop a methodology for the production of landslide susceptibility maps and a strategy for implementing the developed methodologies for defining spatial risk of landslides in spatial planning regulatory framework.

The second priority axis of the programme, particularly the specific objective 2.1, recognises the need to improve protection of



Web portal za prijavu klizišta pokrenut u sklopu safEarth projekta  
Web portal for landslide registration, launched within the safEarth project



Katastar klizišta na dijelu površine grada Petrinje kreiran iz detaljnih digitalnih modela terena  
The landslide cadastre of a part of the City of Petrinja, created from detailed digital elevation models

Interreg IPA prekograničnog programa (HR-BA-ME 2014-2020). HGI-CGS je kao vodeći partner prepoznao priliku da svoje i partnerske intelektualne kapacitete usmjeri u razradu metodologije prostornog definiranja rizika od pojave klizišta, te na taj način doprinese poboljšanju sustava prevencije rizika od prirodnih katastrofa.

safEarth projektni partneri redom dolaze iz centara geološke izvrsnosti jugoistočne Europe (HGI-CGS, Zavod za geološka istraživanja Crne Gore te Rudarsko-geološko-građevinski fakultet – Tuzla), a stručnjaci navedenih centara posjeduju znanje i iskustvo potrebno za postizanje glavnih ciljeva projekta.

Razvojna agencija Žepče, kao ambiciozna i u pogledu EU projekata iskusna institucija, je prepoznata kao partner koji će rezultate safEarth projekta lako implementirati u poboljšanje životne sredine stanovništava Općine Žepče, teško pogođene katastrofalnim pojavama klizišta 2014. godine.

nature and the environment, as well as the management system, as risk prevention from natural disasters.

All this suggests a strong link between the main goals of the safEarth project and the Interreg IPA Cross-border Cooperation Programme (HR-BA-ME 2014-2020). As a lead partner, the HGI-CGS recognised the opportunity to focus its and the partners' intellectual capacities on the development of the methodology for defining the spatial risk of landslides, thereby contributing to the improvement of the natural disasters risk prevention system.

The safEarth project partners come from centres of excellence in geology of South East Europe (HGI-CGS, Geological Survey of Montenegro and Faculty of Mining, Geology and Civil Engineering, Tuzla). Experts from these centres possess the knowledge and experience needed to achieve the main goals of the project.

The Development Agency Žepče, as an ambitious and experienced institution in terms of EU projects, was recognised as a partner that will easily implement the safEarth project's results in improving the living environment for the residents of the Žepče Municipality, heavily affected by the catastrophic landslides of 2014.

# Karta mineralnih i energetskih sirovina Republike Hrvatske

## Map of the Mineral and Energy Resources of the Republic of Croatia

Glavni istraživači / Principal investigators: dr. sc. Zoran PEH, dr. sc. Željko DEDIĆ (since 2018)

Istraživanja mineralnih sirovina u HGI-CGS-u imaju dugu tradiciju, ali se sa sustavnom izradom odgovarajuće karte, koja prikazuje cjelovitu sliku mineralno-sirovinskog potencijala RH, započelo tek početkom devedesetih godina prošlog stoljeća. KMES se sastoji od dva dijela koji predstavljaju primarne ciljeve istraživanja: 1) katastar mineralnih sirovina koji nastaje kao rezultat istraživanja metalnih, nemetalnih i energetskih sirovina i proučavanja zakonitosti njihova pojavljivanja; i 2) prikaz prostorne raspodjele mineralnih sirovina unutar pojedinih geoloških formacija (karta geološke potencijalnosti). Izrada KMES-a je koordinirana s ostalim djelatnostima Zavoda za mineralne sirovine, čime su određeni njeni sekundarni ciljevi: procjena potencijalnosti i valorizacija ležišta pojedinih mineralnih sirovina u lokalnim i regionalnim okvirima (Dinaridi i Panonska Hrvatska) koji su u najvećem broju slučajeva povezani s projektima i programima pokrenutima u suradnji s gospodarstvom.

Research on mineral resources has a long tradition in the HGI-CGS, but the systematic production of an appropriate maps, displaying a complete image of the Republic of Croatia (RH) mineral resource potential, was initiated only in the beginning of the 1990s. The Map of Mineral and Energy Resources (MMER) is composed of two parts, representing primary research goals: 1) the cadastre of mineral resources being created as the result of metal, non-metal, and energy resource research and the study of regularity of their appearance; and 2) the display of spatial distribution of mineral resources within individual geological formations (map of geological potential). The creation of the MMER is coordinated with other activities of the Department of Mineral Resources, which determines its secondary goals: the assessment of potential and evaluation of certain mineral resource deposits in local and regional terms (the Dinarides and the Pannonian Basin), which are mostly connected with projects and programmes in cooperation with various economic subjects.



Eksplotacijsko polje Podberam, panoramska slika  
Exploitation field Podberam, panoramic image



Eksplotacijsko polje Beavec Voz  
Exploitation field Beavec Voz

U proteklom desetljeću osnovu za izradu KMES-a činile su izrade rudarsko-geoloških studija županija, elaborata o mineralnim sirovinama za pojedina ležišta, kao i sudjelovanje u europskim projektima u kojima je stečeno iskustvo potrebno za izradu informacijske platforme podataka o mineralnim sirovinama u RH.

U narednom razdoblju do 2021. godine KMES će doživjeti promjene uspostavom nove i redizajnirane platforme podataka i znanja o mineralnim sirovinama u RH. Razvijanjem upravljačkog operativnog sustava mineralnih sirovina utemeljenog na zajedničkim standardima najviše razine u smislu strukture baze podataka, web-servisa, upravljanja metapodatcima i integraciju nestrukturiranih podataka. Cilj je omogućiti jednostavno korištenje informacija povezanih sa primarnim i sekundarnim mineralnim sirovinama i pružiti krajnjim korisnicima sve dostupne informacije od primarnog izvora do tokova otpada, od istraživanja do eksplotacije i tržišta, od procjene dostupnosti resursa do studija predviđanja o opskrbni i potražnji za mineralnim sirovinama u RH.

In the past decade, the basis for the creation of the MMER were mining-geological studies of counties, reports on minerals resources of individual deposits, as well as participation in EU funded projects, which provided the experience necessary for the construction of the IT platform of data on mineral resources in the RH.

In the following period until 2021, the MMER is expected to undergo changes with the establishment of a new and redesigned platform of data and knowledge on mineral resources in the RH. Moreover, the near future will witness the development of an operational system of mineral resources founded on the highest level of common standards in the sense of database structure, web-service, metadata managing, and the integration of unstructured data. The aim is to facilitate the use of information related to primary and secondary mineral resources and provide end-users with all available information, from primary sources to waste flows, from research to exploitation and the market, from resource availability assessment to prediction studies of supply and demand of mineral resources in the RH.



Eksplotacijsko polje Rovinj (Mondelako),  
ležište gornjojurskih boksita u blizini Rovinja  
Exploitation field Rovinj (Mondelako), the Upper  
Jurassic bauxites near Rovinj

# Održivo gospodarenje kamenim agregatima

## Sustainable Aggregates Resource Management

Koordinator za HGI-CGS / Coordinator for HGI-CGS: dr. sc. **Slobodan MIKO**  
<http://www.sarmaproject.eu>

Tijekom 2009. godine pokrenut je trogodišnji europski projekt akronima SARMa na području jugoistočne Europe (SEE), financiran od strane ERDF-a u kojem su sudjelovali Uprava za rудarstvo Ministarstva gospodarstva i poduzetništva RH i HGI-CGS te još 14 partnera iz 10 država. Vodeći partner je bio Geološki zavod Slovenije. Kameni agregati se koriste u izgradnji stambenih, poslovnih i infrastrukturnih objekata te u industriji. Zemlje SEE su bogate agregatima, ali ni upravljanje ni ponuda nisu koordinirani unutar ili izvan područja. Na lokalnoj razini, problem su znatni utjecaji na okoliš, ograničeno recikliranje, potreba za savjetovanjem dionika i njihove sposobnosti te nedostatak društvene suglasnosti za eksploataciju. Stoga su dva glavna cilja projekta bila:

- Razvijanje zajedničkog pristupa održivom gospodarenju kamenim agregatima diljem SEE, osobito prema učinkovitijem iskopavanju i manjem društveno-ekološkom utjecaju, uzimajući u obzir i gospodarenje otpadom, te
- Poticanje politike održive mješovite opskrbe (Sustainable Supply Mix-SSM) u zemljama SEE, tj. korištenje višestrukih izvora, uključujući reciklirani otpad i industrijske nusproizvode (šljaka), koji zajedno povećavaju koristi i sigurnost budućeg snabdijevanja agregatima.

Ciljevi SARMa-e uz to su obuhvaćali: koordinaciju i upravljanje agregatnim resursima, povećanje prijenosa potrebnih znanja i podržavanje proširenja mogućnosti u tvrtkama, vlasti i civilnom društvu. Aktivnosti ostvarene unutar projekta SARMa povezuju institucionalne aktere, donosiće odluka, političke izvršitelje, gospodarski sektor, operatere u kamenolomima, civilno društvo i nevladine organizacije kroz radionice i postignute zaključke u tri različita mjerila. Na lokalnoj razini ciljevi su: optimizirati učinkovitost proizvodnje osnovnih agregata; sprječiti

In 2009, a three-year EU project entitled SARMa was launched in the area of Southeast Europe (SEE) financed by the ERDF. The Department of Mining of the Ministry of Economy and Entrepreneurship of the RH, and the HGI-CGS participated in this project, with other 14 partners from 10 countries. The lead partner was the Geological Survey of Slovenia. Stone aggregates are used for the construction of residential, business, and infrastructure objects, and in industry. The SEE countries are rich in aggregates, but neither the management, nor the supply, are coordinated within or outside the area. On a local level, problems are the significant environmental impact, limited recycling, stakeholders' need for counselling and their capabilities, and the lack of social consensus for exploitation. The two main goals of the project were thus:

- Development of a common approach to sustainable management of stone aggregates throughout SEE, especially towards a more effective excavation and lower social-ecological impact, taking into account waste management,
- Encouragement of Sustainable Supply Mix (SSM) policy in SEE countries, i.e. the use of multiple sources, including recycled waste and industrial by-products (slag), which jointly increase benefits and the security of future aggregate supply.

The objectives of SARMa additionally included: coordination and management of aggregate resources, increase in transfer of necessary knowledge, and the support for expansion possibilities in companies, government, and the society. The activities accomplished within the SARMa project connected institutions, decision makers, political executives, the economy sector, quarry operators, civil society, and NGOs through workshops and achieved conclusions at three different scales. On the local level the goals are: to optimise basic aggregate production efficiency; to prevent or diminish the influence of exploitation on the environment and



Publikacije izdane u sklopu projekta SARMa  
SARMa project publications

ili umanjiti utjecaj eksploatacije na okoliš i poboljšati sanaciju; svesti ilegalnu eksploataciju na minimum; promovirati recikliranje te povećati zainteresiranost i sposobnost utjecajnih skupina za razumijevanje i ispravno tumačenje problematike vezane uz eksploataciju agregata i za dijalog s lokalnim vlastima i vlasnicima kamenoloma.

Izrađeni su priručnici koji su sinteza zapažanja partnera na projektu SARMa i ne predstavljaju službene stavove upravnih tijela pojedinih zemalja SEE, već autora priručnika.

improve remediation; reduce illegal exploitation to the minimum; promote recycling and increase interest and capability of influential groups for understanding and correct interpretation of problems related to aggregate exploitation; and create dialogue with local authorities and quarry owners.

Manuals were produced that provide a synthesis of the SARMa project partners' observations. These manuals reflect the opinions of their authors, rather than governing bodies of the involved SEE countries.

# Održivo planiranje kamenih agregata u jugoistočnoj Europi

## Sustainable Aggregates Planning in South East Europe

Koordinator za HGI-CGS / Coordinator for HGI-CGS: dr. sc. **Slobodan MIKO**

<http://www.sarmaproject.eu>

HGI-CGS i Agencija za okoliš (AZO) sudjelovali su od 2012. do 2014. godine kao partneri u ovom projektu akronima SNAP-SEE, koji je okupio 27 partnera iz 12 zemalja jugoistočne Europe u pokušaju razmjene iskustva i najboljih praksi u rješavanju problema u sektoru gospodarenja mineralnih sirovina s naglaskom na tehnički kamen (kameni agregati) i reciklirane sirovine koji bi ih mogle zamijeniti.

From 2012 until 2014, the HGI-CGS and the Croatian Environmental Agency (CEA) participated as partners in the project "Sustainable Aggregates Planning in South East Europe" (SNAP-SEE), which united 27 partners from 12 countries of SEE in the attempt to exchange experiences and best practices in solving problems within the mineral resources management sector, with the emphasis on technical stone (stone aggregates) and recycled resources that might replace them.

The specific purpose of the project was to create and distribute the "Aggregates planning toolbox" for helping co-operation of authorities and stakeholders in the SEE in order to improve their aggregates planning and management processes.

The SNAP-SEE Aggregates planning toolbox includes 4 products which are mutually connected and supported:

1. "Vision of best practices with regard to aggregates planning in Southeast Europe": this document presents a vision for a transition to integrated, comprehensive sustainable planning in SEE. It includes discussions of the issues that need to be addressed, interim steps that can be taken toward more sustainable planning, and a review of the components a sustainable plan should contain.

2. How to build a sustainable aggregates plan: the "How-to" document represents a roadmap for planning, including discussions of the planning process itself and its various steps. Examples of well written planning modules are provided that embody the principles, approaches, and actions necessary to achieve the goals of the vision laid out in the best practices report.

3. Consulting stakeholders when applying best practices in sustainable aggregates planning: the "Consultations" document



Priručnik „Vizija najboljih praksi u planiranju eksploatacije kamenih agregata u SEE“ (Horvath et al., 2014)

Manual "Vision of best practices with regard to aggregates planning in South East Europe" (Horvath et al., 2014)

Specifična svrha projekta bila je stvoriti i distribuirati „Alat za planiranje agregata“ da pomogne suradnju vlasti i dionika u JIE kako bi unaprijedili svoje procese planiranja i upravljanja agregatima.

SNAP-SEE Alati za planiranje agregata sadrže 4 proizvoda koja su međusobno povezana i podržavaju se:

1. Vizija najboljih praksi za planiranje agregata u jugoistočnoj Europi: Ovaj dokument predstavlja viziju za prijelaz na integrirano, sveobuhvatno održivo planiranje u jugoistočnoj Europi. To uključuje rasprave o problemima koje treba rješavati, privremene mјere koje se mogu poduzeti prema održivom planiranju i pregled komponenti koje bi održivi plan trebao sadržavati.

2. Kako izgraditi održivi plan za agrega-te: Dokument „Kako“ predstavlja putokaz za planiranje, uključujući i rasprave o procesu planiranja i njegovih različitih koraka. Primjeri dobro napisanog modula planiranja su, uz uvjet da utjelovljuju načela, pristupe i akcije potrebne za postizanje ciljeva vizije, definirani u izvješću najboljih praksi.

3. Savjetovanje dionika prilikom primjene najboljih praksi u održivom planiranju agregata: U dokumentu „Konzultacije“ daje se vodič „korak-po-korak“ na koji način planirati i provoditi konzultacije dionika kako bi se osiguralo da industrija, vlade, nevladine organizacije i civilno društvo mogu pružiti ulazne podatke i sudjelovati u procesu planiranja. Također, dostupni su materijali izgradnje kapaciteta.

4. Metodologija obrade i analize podataka potrebna za planiranje agregata: U prilogu najbolje prakse u održivom planiranju agregata. Dokument „Podatci i analiza“ razmatra različite vrste podataka i analiza koje daju osnovu za proces planiranja. Obuhvaća definicije podataka, značaj, dostupnost, strukturu i potrebe. Prezentirane su metode provjere i analize podataka, uključujući pristupe prognozama zahtjeva.

provides a step-by-step guide for planning and conducting stakeholder consultations in order to ensure that industry, government, non-governmental organisations, and civil society can provide input to and participate in the planning process. Capacity building materials are also provided.

4. Data and analysis methodologies for aggregates planning: in support of best practices in sustainable aggregates planning: the “Data and analysis” document discusses the various types of data that provide essential background information for the planning process. Data definitions, significance, availability, structure, and needs are addressed. Methods for validating and analysing data are presented, including approaches to demand forecasting.



Projektne radionice i terenski obilasci  
Project workshops and excursions

# Županijske studije o mineralnim sirovinama

## County-Level Mining-Geological Studies

Voditelji projekta / Project Managers: dr. sc. **Slobodan MIKO**, dr. sc. **Željko DEDIĆ**, mr. sc. **Boris KRUK**

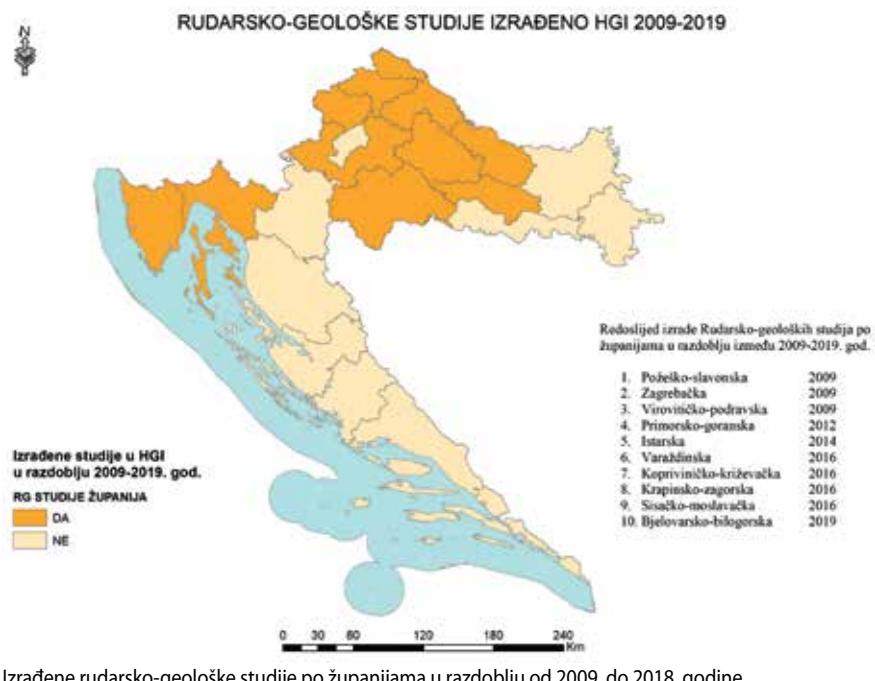
Autor teksta / Author of the text: dr. sc. **Željko DEDIĆ**

Suradnici / Collaborators: dr. sc. Ozren HASAN, dr. sc. Nikolina ILIJANIĆ, Ljiljana KRUK, Erli KOVAČEVIĆ GALOVIĆ, Stjepan CRNOGAJ

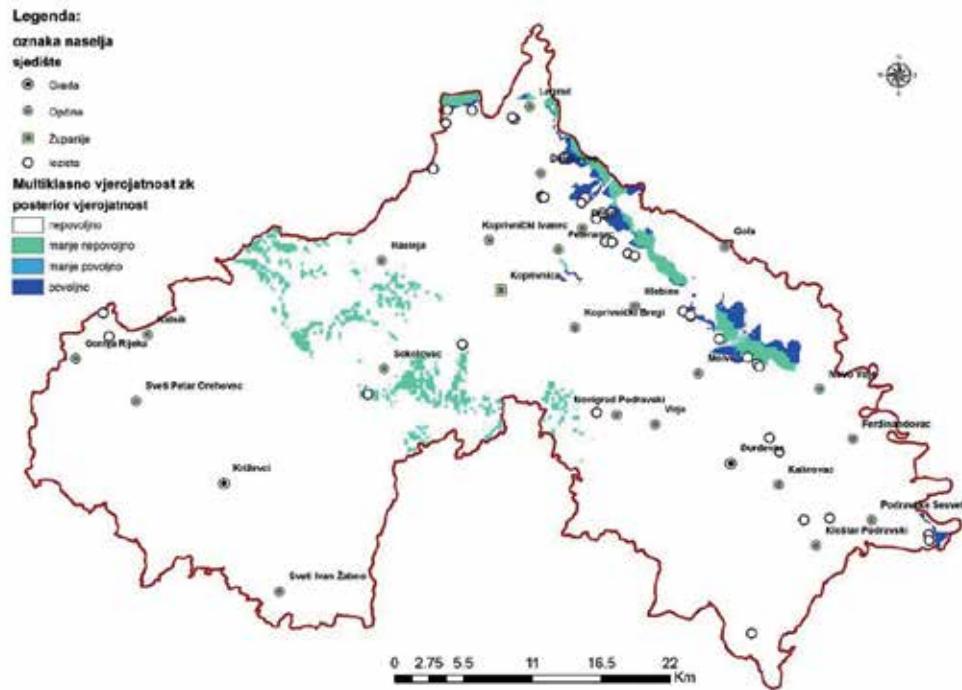
Rudarsko-geološke (RG) studije izrađuju se sukladno važećem Pravilniku o sadržaju i načinu izrade rudarsko-geoloških studija (NN 142/13). Osnovni cilj izrade RG studija je usmjeriti istražne radove i eksploataciju mineralnih sirovina, kao i utvrditi geološku potencijalnost različitih mineralnih sirovina prema odredbama za provođenje prostornih planova županija. Također, cilj RG studija je definiranje prostora na kojima je moguće istraživanje i eksploataciju mineralnih sirovina, a služe kao podloga za izradu prostornih planova županija u dijelu koji se bavi gospodarenjem mineralnim sirovinama.

Mining-geological (MG) studies are made in accordance with the current regulations on the content and method of conducting mining-geological studies (NN 142/13). The main goal of MG studies is to manage the exploration and exploitation of mineral resources, as well as to determine the geological potential of various mineral resources according to counties' spatial plans implementation regulations. In addition, the goal of MG studies is to define the areas where exploration and exploitation of mineral resources is possible. Moreover, MG studies serve as the basis for preparation of counties' spatial plans, in part dealing with mineral resource management.

These studies encompass the review of the baseline, namely the representation of a county's spatial planning documentation with regard to the exploration and exploitation of mineral resources and an overview of mining companies. However, its most important contribution is the representation of mineral resources exploration areas and exploitation fields, their economic significance in terms of mineral resource exploitation and the development of the zones of geological potentiality: suitability zones (without the immediate interest of other users) and conflict zones (there is interest of other users, but the exploration of mineral resources is not prohibited). Acquired spatial geological data can be included into the spatial-planning documentation of a county, and the conclu-



Izrađene rudarsko-geološke studije po županijama u razdoblju od 2009. do 2018. godine  
Completed mining-geological studies by counties in the period between 2009-2018



Rezultati multiklasnog modela. Klasifikacija povoljnosi je bazirana na posterior vjerovatnosti

Multiclass model results. Suitability classification is based on the posterior probability

Osim pregleda polaznih osnova, zatim prikaza prostorno-planške dokumentacije županije glede istraživanja i eksploatacije mineralnih sirovina, prikaza rudarskih gospodarskih subjekata, najvažniji doprinos studije je u prikazu istražnih prostora i eksploatacijskih polja mineralnih sirovina te gospodarskog značaja eksploatacije mineralnih sirovina, kao i u izradi zona geološke potencijalnosti: zona pogodnosti (bez trenutnog interesa ostalih korisnika) i zona konflikta (postoji interes ostalih korisnika, no nije zabranjeno istraživanje mineralnih sirovina). Pridobiveni prostorni geološki podatci mogu se uključiti u prostorno-plansku dokumentaciju županije, a zaključci usmjeriti politiku održivog gospodarenja mineralnim sirovinama u pojedinoj županiji.

RG studiju je svaka županija obvezna izraditi prema Zakonu o rudarstvu (NN 56/13 i NN 14/14), koji se odnosi na definiranje mineralnih sirovina. Zavod za mineralne sirovine je u proteklom desetogodišnjem razdoblju izradio 10 RG studija za sljedeće županije: Virovitičko-podravska županija (2009), Požeško-slavonska županija (2009), Zagrebačka županija (2009), Primorsko-goranska županija (2012), Istarska županija (2014), Krapinsko-zagorska županija (2016), Varaždinska županija (2016) Koprivničko-križevačka županija (2016) i Sisačko-moslavačka županija (2016), te je tijekom 2018. godine započeo s izradom RG studije za Bjelovarsko-bilogorsku županiju.

sions can be focused on the policy of sustainable mineral resources management in that particular county.

A MG study is mandatory for each county under the Mining Law (NN 56/13 and NN 14/14), which deals with the definition of mineral resources. During the last ten years, the Department of Mineral Resources (DMR) produced ten MG studies for the following counties: Virovitica-Podravina County (2009), Požega-Slavonia County (2009), Zagreb County (2009), Primorje-Gorski Kotar County (2012), Istra County (2014), Krapina-Zagorje County (2016), Varaždin County (2016), Koprivnica-Križevci County (2016), and Sisak-Moslavina County (2016). In 2018, the DMR started with the MG study development for Bjelovar-Bilogora County.

# Pregled Obzor2020 projekata vezanih za mineralne sirovine – MICA, GeoCradle, ProSUM, FORAM, MINLAND i programa GeoERA

## Overview of the Horizon2020 Projects Connected to Mineral Resource – MICA, Geocradle, ProSUM, FORAM, MINLAND i GeoERA

Koordinatori za HGI-CGS / Coordinators for HGI-CGS: dr. sc. **Slobodan MIKO**, dr. sc. **Željko DEDIĆ**

Suradnici / Collaborators: dr. sc. Ozren HASAN, dr. sc. Nikolina ILIJANIĆ, mr. sc. Boris KRUJK, dr. sc. Vlatko BRČIĆ, dr. sc. Marija HORVAT, Ljiljana KRUK, Erli KOVAČEVIĆ GALOVIĆ, Nikola GIZDAVEC

<http://www.prosumproject.eu/>; <http://www.mica-project.eu/>; <http://geocradle.eu/en/>; <http://www.foramproject.net/>;  
<http://minland.eu/project/>

Tijekom desetogodišnjeg razdoblja istraživači u Zavodu za mineralne sirovine aktivno su sudjelovali i sudjeluju u realizaciji nekoliko Obzor2020 projekata vezanih za mineralne sirovine: ProSUM – *Prospecting Secondary raw materials in the Urban Mine and mining waste*; MICA-Mineral Intelligence Capacity Analysis; GEO-CRADLE- *Coordinating and integRating state-of-the-art Earth Observation Activities in the regions of North Africa, Middle East, and Balkans and Developing Links with GEO related initiatives towards GEOSS*; FORAM – *Towards a World Forum on Raw Materials*; MINLAND – *Mineral resources in sustainable land-use planning*; projekti programa GeoERA – *Establishing the European Geological Surveys Research Area to deliver a Geological Service for Europe*.

U većini Obzor2020 projekta istraživači su sudjelovali u svojstvu povezanih trećih partnera. U okviru projekta ProSUM izrađena je strukturirana baza podataka o boksitnim jalovištima u Dalmaciji koja su nastala 1970-ih godina eksploatacijom boksitne rudače.

U realizaciji projekta MICA sudjelovalo se kroz razvoj platforme znanja o mineralnim sirovinama, u sklopu koje su identificirane grupe dionika kod kojih postoji potreba za pridobivanjem provjerjenih i točnih informacija o mineralnim sirovinama kao podloge za donošenje odluka. Projekt GEO-CRADLE uključivao je sudjelovanje u izgradnji platforme mreže dionika te uspo-

During the ten year period, researchers from the DMR actively participated, and still participate, in the implementation of several Horizon2020 projects related to mineral resources: ProSUM – *Prospecting Secondary raw materials in the Urban Mine and mining waste*; MICA-Mineral Intelligence Capacity Analysis; GEO-CRADLE- *Coordinating and integRating state-of-the-art Earth Observation Activities in the regions of North Africa, Middle East, and Balkans and Developing Links with GEO related initiatives towards GEOSS*; FORAM – *Towards a World Forum on Raw Materials*; MINLAND – *Mineral resources in sustainable land-use planning*; projects of the GeoERA programme – *Establishing the European Geological Surveys Research Area to deliver a Geological Service for Europe*.

In most of the Horizon2020 projects, researchers were involved as associated third-party partners. Within the ProSUM project, a structured database was created for Dalmatia's bauxite tailings, which originate from the 1970s bauxite ore extraction.

In the implementation of the MICA project, researchers participated through the development of the knowledge base on mineral resources, where groups of stakeholders, that require verified and accurate information on mineral resources as a basis for decision making, were identified. Work on the GEO-CRADLE project included participation in the development of the network platform for stakeholders and the establishment of a multiregional coordination network to enhance the use of the existing EO ca-



Prikaz boksitnih jalovišta u Dalmaciji (Obzor2020– ProSUM)  
Bauxite tailings in Dalmatia (Horizon2020– ProSUM)

stavljanja multiregionalne koordinacijske mreže, sa ciljem jačanja korištenja postojećih podataka EO kapaciteta. U sklopu projekta FORAM rad se sastojao od razvoja i uspostavljanja EU platforme međunarodnih stručnjaka i dionika koji će ojačati ideju Svjetskog foruma o mineralnim sirovinama i unaprijediti međunarodnu suradnju na temu politike mineralnih sirovina i ulaganja. Projekt MINLAND radi na izradi smjernica za pristup ležištima mineralnih sirovina.

U projektima programa GeoERA, istraživači će sudjelovati u nekoliko projekata koji se bave uspostavljenjem informacijske platforme o mineralnim sirovinama (Mintell4EU), arhitektonsko-građevnim kamenom (klasifikacije i atlas) (Eurolithos) te kritičnim mineralnim sirovinama (FRAME).

facilities. The work on the FORAM project consisted of development and establishment of an EU platform of international experts and stakeholders, with the purpose to foster the idea of the World Forum on Raw Materials and to improve international cooperation on the topic of mineral resources and investment politics. The MINLAND project concerned the development of guidelines for granting access to mineral resources deposits.

Within the GeoERA programme projects, researchers will participate in several projects concerning the establishment of an information platform on mineral resources (Mintell4EU), architectural-construction stone (classifications and atlas; Eurolithos) and critical mineral resources (FRAME).



Boksitno jalovište uz ležišta boksite Mratovo (Horizon2020– ProSum) (foto Ž. Dedić)  
The bauxite tailings with bauxite deposit Mratovo (Horizon2020– ProSUM)

# Geotermalna karta Republike Hrvatske

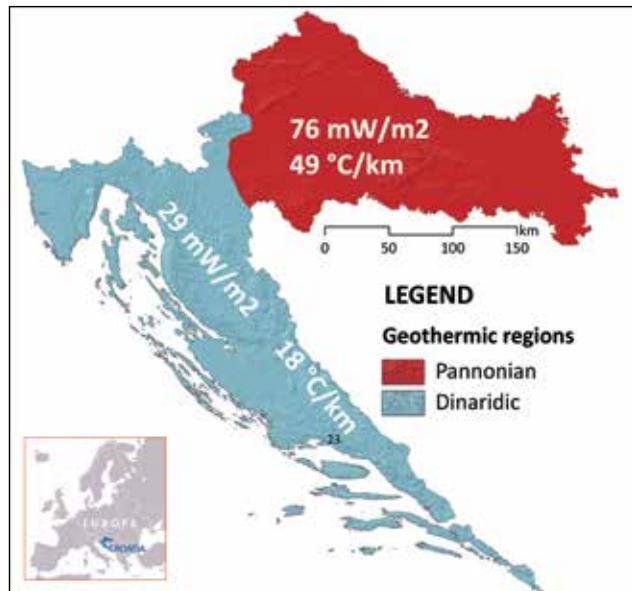
## Geothermal Map of the Republic of Croatia

Glavni istraživač / Principal investigator: dr. sc. **Miron KOVAČIĆ**  
 Autorica teksta / Author of the text: dr. sc. **Staša BOROVIĆ**

Geotermalna karta RH (GTM) je jedan od temeljnih projekata HGI-CGS-a koji se provodio desetljećima, da bi, nakon nekoliko faza smanjenja financiranja, bio ukinut zajedno s ostalim zProjektima 2013. godine.

Projekt se provodio od 1970-ih godina prema uputama koje je izradio Milan Šušnjar. 1990. godine Miron Kovačić predlaže novu metodologiju izrade GTK koja biva prihvaćena od strane rukovodstva HGI-CGS-a te preuzima i ulogu glavnog istraživača, na kojoj je ostao sve do ukidanja financiranja i svojeg umirovljenja 2013. godine.

Svrha projekta bila je dobivanje cjelovite slike o geotermijskim značajkama područja RH. Do sada provedena istraživanja ukazuju na veliku geotermijsku raznolikost prostora RH i postojanje geotermalnih anomalija. Geotermalne anomalije



Geotermijske regije RH  
 Geothermal regions of the RH

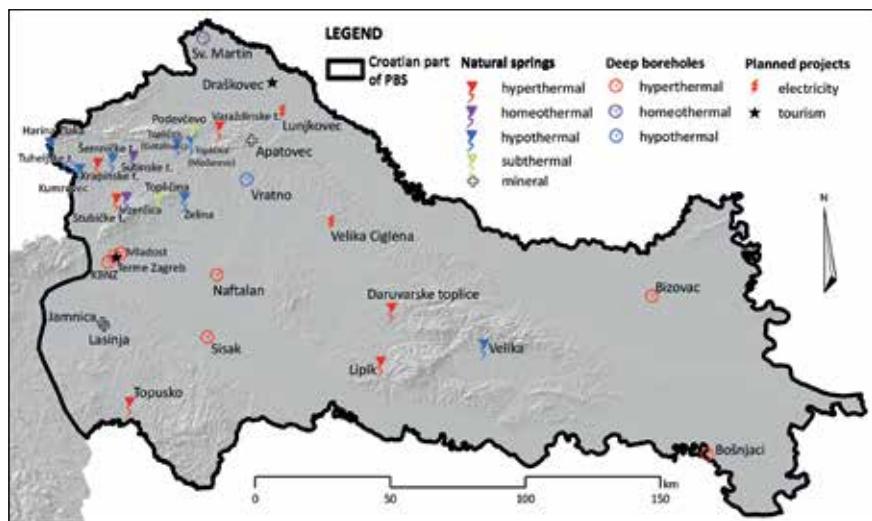
The Geothermal map (GTM) of the Republic of Croatia (RH) was one of the fundamental projects of the HGI-CGS, carried out for decades. However, after several phases of decline in funding, this project was terminated together with other zProjects in 2013.

The project was carried out since the 1970s under the guidance of Milan Šušnjar. In 1990, Miron Kovačić proposed a new methodology of GTM construction, which was accepted by HGI-CGS management, and also took over the role of the principal researcher, which he held all until the termination of funding and his retirement in 2013.

The purpose of the project was to gain a complete picture of geothermal characteristics of the area of the RH. Studies carried out so far indicate high variability of geothermal features across the RH territory and the existence of geothermal anomalies. Geothermal anomalies are manifested as areas of different heat flow density from the Earth's interior towards the surface. The basic objective of the project was to define the size and distribution of geothermal anomalies and collect data on all geothermal phenomena in the study area, presenting them on a map with descriptions in the accompanying explanatory notes. Based on previous research, the RH can be divided into two geothermally different regions, characterised by different geothermal parameters. In the Dinaric karst area, the average geothermal gradient is ca. 18 °C/km, and in the Pannonian area it is 49 °C/km, while the global average is 30 °C/km. It can be inferred that the Pannonian part of the RH possesses favourable geothermal parameters and, accordingly, the majority of natural thermal water springs, as well as boreholes for thermal water exploitation are located there.

This research has unfortunately never been published in the form of either map sheets or explanatory notes.

Although GTM project was formally terminated, geothermal research has continued within the Basic Hydrogeological Map of



Pojave termalnih voda u panonskom dijelu RH  
Thermal water localities in the Pannonian part of the RH

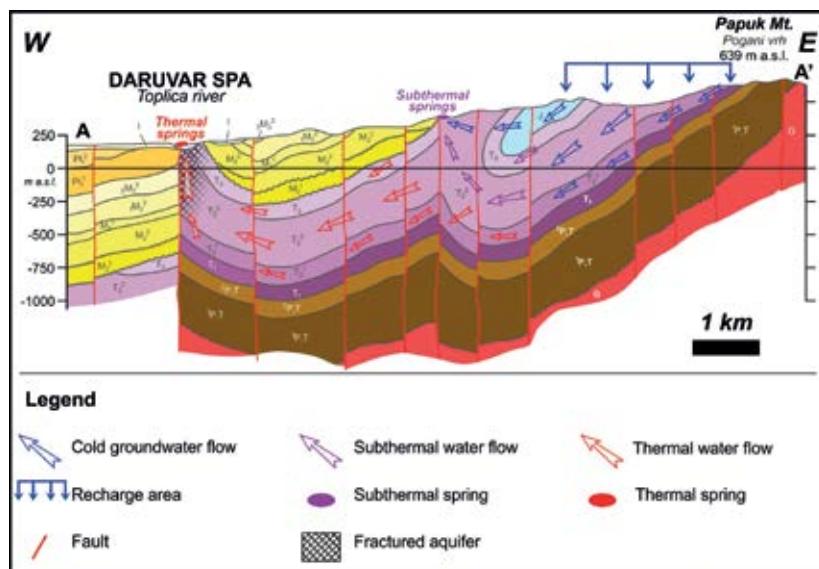
the RH and other competitive projects funded by different investors and EU funds. The work resulted in one PhD dissertation and the publication of a dozen scientific papers dealing with the subject of research and the use of shallow and deep geothermal resources in the RH.

The restoration of the GTM as a fundamental project of the HGI-CGS is envisaged in the strategic documentation. Since the project lacks human and financial resources, the primary goal in the following period shall be procurement of these through project and/or programme funding.

se manifestiraju kao područja različite gustoće toplinskog toka iz Zemljine unutrašnjosti prema površini. Temeljni cilj projekta bio je definirati veličine i raspored geotermalnih anomalija i prikupiti podatke o svim geotermalnim pojavama u istraživanom području te ih prikazati na karti i opisati u tumaču. Na temelju dosadašnjih istraživanja poznato je da se RH može podijeliti na dva geotermijski različita prostora, karakterizirana različitim geotermijskim parametrima. U dinaridskom krškom području prosječni geotermalni gradijent je oko  $18\text{ }^{\circ}\text{C}/\text{km}$ , a u panonskom području  $49\text{ }^{\circ}\text{C}/\text{km}$ , dok je prosjek na svjetskoj



Prirodno izvorište termalne vode Ivanovo vrelo u središtu Daruvara  
The Ivanovo vrelo natural thermal water spring in the centre of Daruvar



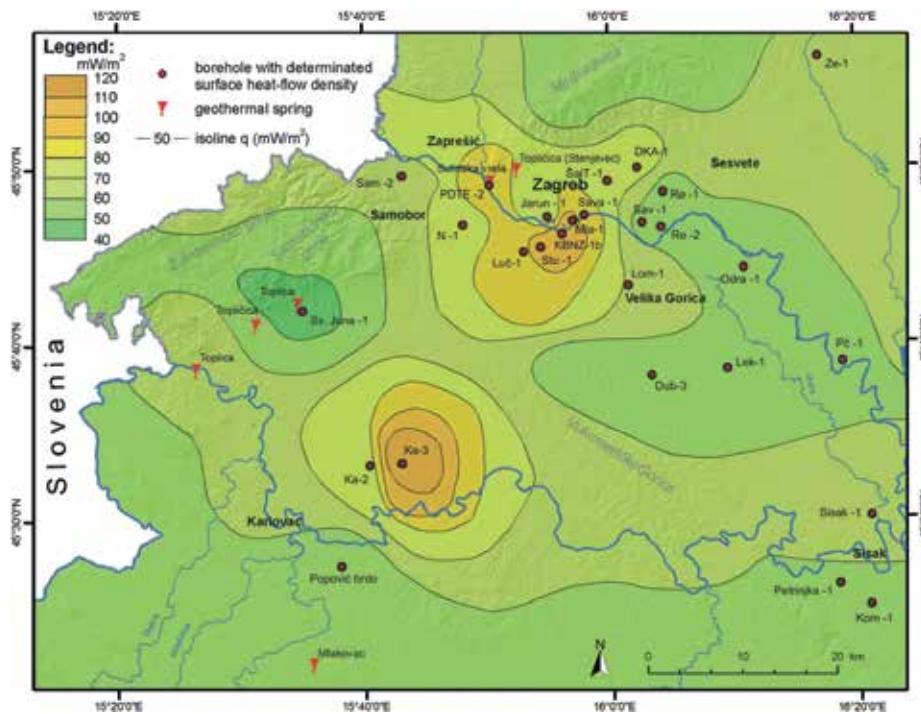
Konceptualni model daruvarskog hidrotermalnog sustava  
Conceptual model of the Daruvar hydrothermal system

razini  $30^{\circ}\text{C}/\text{km}$ . Iz toga slijedi da panonski dio RH ima povoljne geotermijske parametre, a u skladu s time, tamo se nalazi i najveći broj prirodnih izvorišta termalne vode, kao i bušotina iz kojih se ona crpi.

Ova istraživanja nažalost nikad nisu publicirana u formi listova karta niti je izdan tumač.

Iako je karta formalno ukinuta, geotermijska su istraživanja nastavljena u sklopu OHGK i drugih kompetitivnih projekata financiranih od strane različitih investitora i EU fondova, što je rezultiralo izradom jedne doktorske disertacije te objavlјivanjem desetak znanstvenih radova koji se bave tematikom istraživanja i korištenja plitkih i dubokih geotermalnih resursa u RH.

Ponovno uspostavljanje GTK kao temeljnog projekta HGI-CGS-a predviđeno je u strateškoj dokumentaciji. Budući da projekt nema kadrovskih ni finansijskih resursa, primarni će cilj u narednom razdoblju biti njihovo pribavljanje kroz projektno i/ili programsko financiranje različitih instanci.



Karta gustoće toplinskog toka područja Zagreb-Karlovac – dio istražnog područja projekta GTK (Kovačić, 2014)  
Heat flow density map of the Zagreb-Karlovac area – part of the GTM project research area (Kovačić, 2014)

# Istraživanje i promocija korištenja plitkog geotermalnog potencijala Republike Hrvatske

## Research and Promotion of Use of Shallow Geothermal Potential in the Republic of Croatia

Koordinator za HGI-CGS / Coordinator for HGI-CGS: dr. sc. **Josip TERZIĆ**

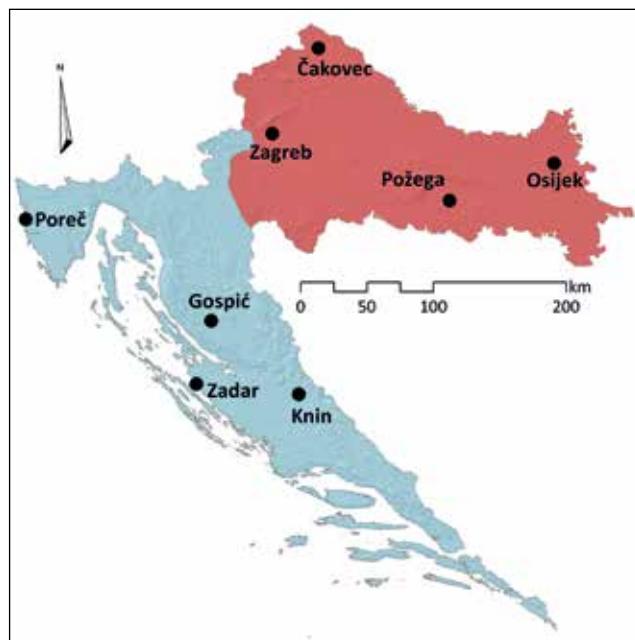
Autorica teksta / Author of the text: dr. sc. **Staša BOROVIĆ**

<http://geothermalmapping.fsb.hr>

Projekt akronima GeoMapping financiran je od 2013. do 2015. godine iz IPA fonda EU za regionalni razvoj. Nositelj projekta bio je Fakultet strojarstva i brodogradnje Sveučilišta u Zagrebu, HGI-CGS je bio partner, a suradnici šest škola i jedan znanstveni institut, na čijim su se zemljиштima provodili istražni radovi.

Glavni su elementi projekta bili istraživanje toplinskih svojstava podzemlja do 100 m (gdje se najčešće smještaju bušotinski

From 2013 to 2015, the project under the acronym "GeoMapping" was funded by the EU IPA fund for regional development. The lead partner was the Faculty of Mechanical Engineering and



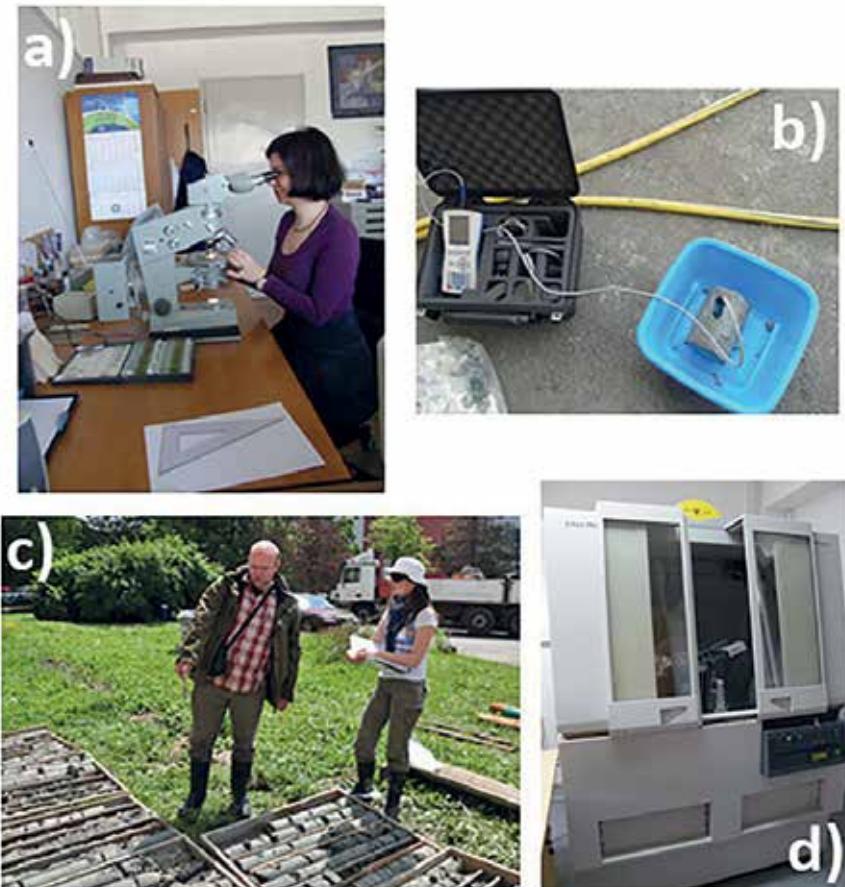
Lokacije istražnih bušotina u panonskom (crveno) i dinaridskom (plavo) dijelu Hrvatske

Locations of exploration boreholes in the Pannonian (red) and the Dinaric (blue) parts of Croatia



Različiti sedimenti i stijene u plitkom podzemlju značajno utječu na izbor tehnologije bušenja i vrste dizalice topline, kao i na učinkovitost sustava tijekom radnog vijeka (gore-panonski dio; dolje-dinaridski dio)

Different sediments and rocks in the shallow subsurface significantly affect the selection of drilling technology and the type of heat pump to be installed (top row – Pannonian part; bottom row – Dinaric part)



Metode terenskog i laboratorijskog rada: a) određivanje mineralnog sastava i strukture polarizacijskom mikroskopijom; b) *in situ* mjerjenje toplinske vodljivosti; c) terenska determinacija jezgre i uzorkovanje; d) određivanje mineralnog sastava rendgenskom difraktometrijom

Methods of fieldwork and laboratory analyses: a) mineralogical analysis using polarizing microscope; b) *in situ* thermal conductivity measurement; c) core determination and sampling; d) mineralogical analysis using X-ray diffractometer

izmenjivači topline za dizalice topline) te promocija grijanja i hlađenja tom tehnologijom. Važno je napomenuti da se radi o korištenju obnovljivog izvora energije koje je moguće u gotovo svim geološkim okolišima.

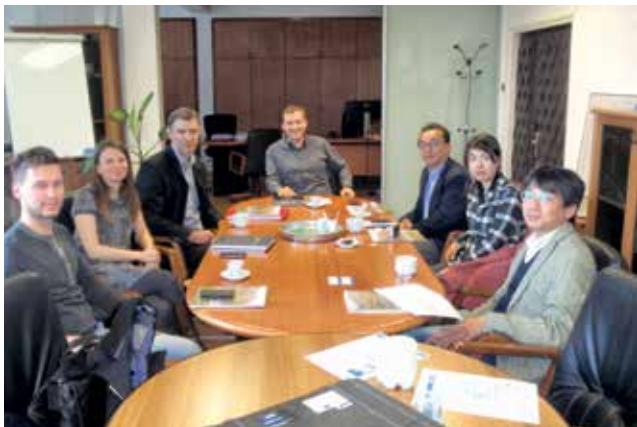
Budući da se na teritoriju RH jasno razlikuju dvije geološki različite cjeline – panonski i dinarski dio – u svakome od njih su odabранe po četiri lokacije. Na svakoj je izbušena bušotina dubine 100 m uz jezgrovanje te su ugrađeni bušotinski izmjenjivači topline u koje su postavljeni optički kablovi za distribuirano mjerjenje temperature.

Istraživanje toplinskih svojstava provedeno je direktnim mjeranjem na uzorcima jezgre te klasičnim i distribuiranim testom toplinskog odziva. Prikupljeni podatci o toplinskim svojstvima plitkog podzemlja mogu se koristiti u planiranju instalacija. Naime, učinkovitost sustava dizalica topline izrazito zavisi od ispravnog dimenzioniranja izmenjivača topline, čija duljina se može ispravno odrediti samo uz poznavanje toplinskih parametara podzemlja koje će se koristiti kao izvor i ponor topline.



Rasprrava tijekom radionice u Institutu za obnovljivu energiju u Fukušimi, FREIA (Japan)

Discussion during a workshop at the Fukushima Renewable Energy Institute, FREIA (Japan)



Radni posjet kolega s Fakulteta strojarstva i brodogradnje, sa Sveučilišta u Akiti, te iz FREA-e i tvrtke Japan Groundwater Development Zavod za hidrogeologiju i inženjersku geologiju HGI-CGS-a

Working visit of the colleagues from FMENA, University of Akita, FREA and Japan Groundwater Development to the Department of Hydrogeology and Engineering Geology of the HGI-CGS

Na izvedenim pilot sustavima provode se i daljnja znanstvena istraživanja praćenjem sezonske učinkovitosti.

Rezultati istraživanja u sklopu projekta objavljeni su u četiri originalna znanstvena rada, te u većem broju radova i sažetaka prezentiranih na nacionalnim i međunarodnim skupovima. Održano je ukupno šest radionica u RH, a uspostavljena je i suradnja s eminentnim institucijama za ovu problematiku u Švedskoj, Švicarskoj i Japanu, koja je rezultirala trima radionicama razmjene iskustava s vrhunskim znanstvenicima, od čega su dvije održane u Hrvatskoj i jedna u Japanu.

Naval Architecture of the University of Zagreb (FMENA), and HGI-CGS was a partner. The project also included seven associate institutions (six technical high schools and one research institute), and pilot sites were established on their premises.

The main elements of the project were the exploration of subsurface thermal properties up to 100 m (where borehole heat exchangers for heat pumps are usually placed) and the promotion of heating and cooling using this technology. It is important to note that the use of this renewable energy source is possible in almost all geological environments.

Since the territory of the Republic of Croatia (RH) can be divided into two geologically diverse regions, the Pannonian and the Dinaric, four locations were selected in each of them. The boreholes were core drilled to a depth of 100 m, cores were analysed, and the heat exchangers with optical cables for distributed temperature measurements were installed.

The study of thermal properties was conducted by direct measurement on core samples and by standard and distributed thermal response testing. The collected data on thermal properties of the shallow subsurface can be used in installations planning. Specifically, the efficiency of the heat pump systems is highly dependent on the correct dimensioning of the heat exchangers, whose length can only be calculated correctly if thermal parameters of the subsurface, which will be used as the heat source and sink, are known. Further scientific studies on developed pilot systems are being carried out by monitoring seasonal performance.

The research results of the project were published in four original scientific papers and in a number of papers and abstracts presented at national and international conferences. A total of six workshops were held in the RH, and collaboration with eminent institutions from Sweden, Switzerland, and Japan was established on this topic. The collaboration resulted in three experience transfer workshops including top scientists in the field of shallow geothermal research, two of which were held in Croatia and one in Japan.

# Istraživanje Baćinskih jezera

## Research of Baćina Lakes

Autori teksta / Authors of the text: dr. sc. **Nikolina ILIJANIĆ**, dr. sc. **Josip TERZIĆ**

Projekt je izvođen od 2013. do 2015. godine, financirale su ga Hrvatske vode, a sastojao se od dvije cjeline. Hidrogeološka istraživanja vodio je Josip Terzić (12 suradnika), a paleolimnološka Slobodan Miko (13 suradnika). Baćinska jezera su jedinstven krški ekosustav od sedam jezera, koji je u velikoj mjeri poremećen ljudskim intervencijama, te je za njihovo istraživanje važan pristup s hidrogeološke (odnosi površinskih i podzemnih voda, te prodori mora kroz podzemlje) i paleolimnološke (evolucija jezera i promjene u taložnom okolišu) strane.

Hidrogeološka istraživanja zahvatila su cijeli slijev koji zalazi duboko u susjednu Bosnu i Hercegovinu, a naglasak je bio na mjesečnom monitoringu hidrokemijskih pokazatelja uz mjerenja protoka, simultanom trasiranju dvama traserima, odjeljivanju sljevova i podsljevova te njihovog međuodnosa, uz izradu vodne bilance. Tako je u konačnici konceptualiziran ovaj krški sustav u čijoj bilanci sudjeluju podzemne i površinske vode (ponornice) i čija je veza s važnim izvorima u sustavu, osobito

This project was carried out in the period from 2013 to 2015 and was funded by Hrvatske vode. The Baćina Lakes are a unique karst ecosystem of seven lakes, highly disrupted by human intervention. Hence, this research required a dual approach: hydrogeological (groundwater and surface water relationship and underground seawater intrusion) and paleolimnological (evolution of lakes and changes in depositional environments). The hydrogeological part of the research was led by Josip Terzić (12 associates) and the paleolimnological part by Slobodan Miko (13 associates).

The hydrogeological research covered the entire catchment, which extends deeply into the neighbouring Bosnia and Herzegovina. The accent was put on monthly monitoring of hydrochemical parameters, along with flow measurements, simultaneous tracing using two tracers, catchment and sub-catchment delineation and correlation, and water balance calculation. Thus, in the end, this karst system was conceptualised. Its water balance consists of groundwater and surface water (intermittent rivers) and the connection to important springs, especially to the Klokuš water supply spring situated within the Baćina Lakes area, has only been partly revealed.

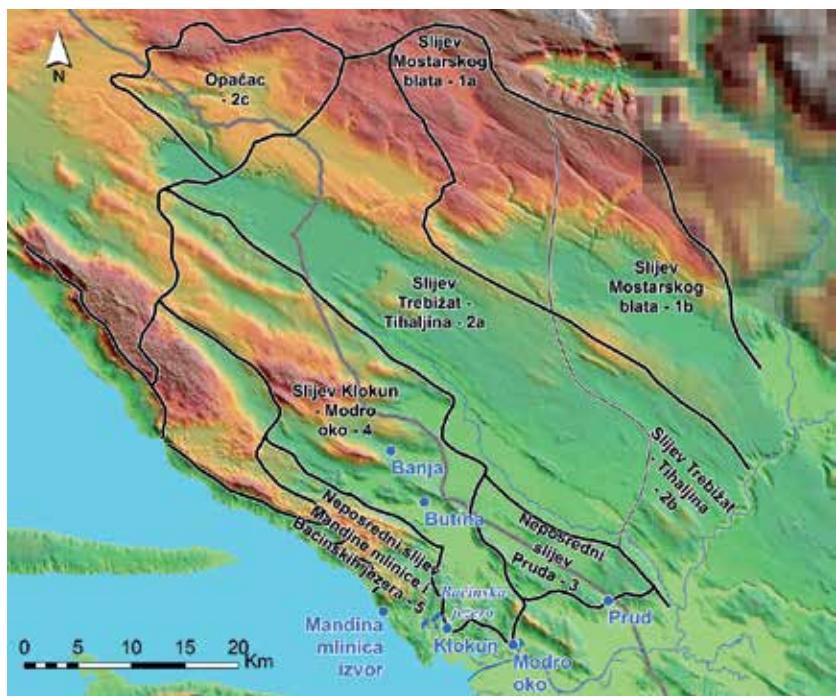
Paleolimnological considerations showed that during the early Holocene period, the level of the Crnišovo Lake was lower because water could leak out of the lake through swallow holes due to a lower sea level, while the higher proportion of siliciclastic detrital material indicates a humid period and erosion. The sea level rise brought about the formation of a deeper lake (up to +9 m a.s.l.) in the period from 7500 to 4500 BCE, dominated by the endogenous calcite precipitation. From 4500 to 2500 BCE, changes in deposition of predominantly carbonate and siliciclastic material suggest intense climate change, i.e. transitions between humid and dry periods. From 2500 BCE until today, homogeneous carbonate sedimentation has been dominant, but with a gradual increase in the portion of siliciclastic material, indicating erosion due to deforestation. The recent anoxia, visible in the last



Uzorkovanje i *in situ* mjerjenja na Baćinskim jezerima  
Sampling and *in situ* measurements at Baćina Lakes

to s vodoopskrbnim izvorom Klokun koji se nalazi u sklopu jezera, tek dijelom rasvjetljena.

Paleolimnološka razmatranja pokazala su da je tijekom ranog holocena razina jezera Crniševa bila niža jer je voda mogla otjecati iz jezera kroz prisutne ponore zbog niže razine mora, dok viši udio siliciklastičnog detritičnog materijala ukazuje na vlažniji period i eroziju. Izdizanje razine mora omogućilo je formiranje dubljeg jezera (do +9 m nm) u periodu od 7500 do 4500 godina prije sadašnjosti, u kojem se dominantno taložio endogeni kalcit. Od 4500 do 2500 godina promjene u sedimentaciji dominantno karbonatnog i siliciklastičnog materijala ukazuju na intenzivne klimatske promjene odnosno izmjenu vlažnijih i suših perioda. Od 2500 godine do danas dominira homogena karbonatna sedimentacija, s postepenim povećanjem udjela siliciklastičnog materijala, što ukazuje na

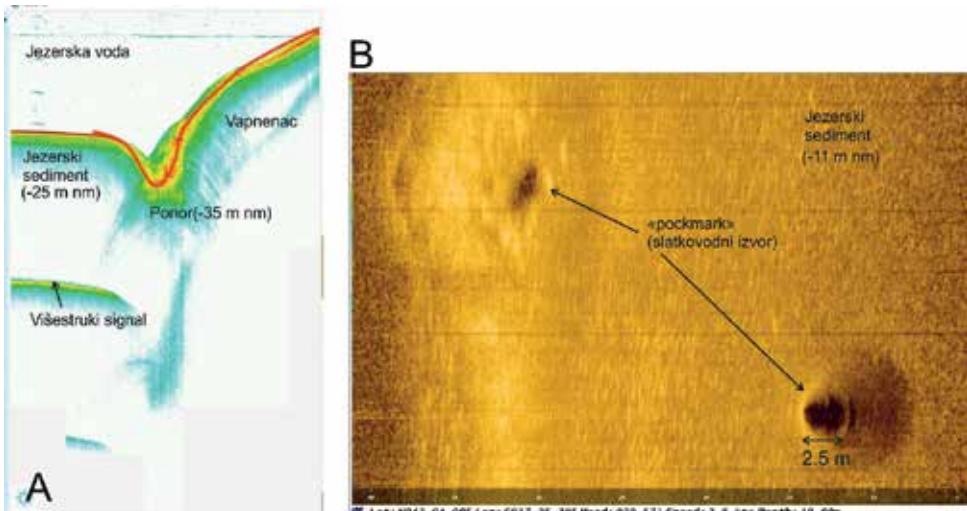


Konceptualizacija sljevova krškog sustava od desne obale doline Neretve (Prud, Modro oko), preko Bačinskih jezera i Klokuna, do Mandine mlinice

Conceptualisation of karst system catchments from the right bank of the Neretva River (Prud, Modro oko), through Bačina Lakes and Klokun, to Mandina Mlinica



Prostirjanje Bačinskih jezera danas (plavo) i prije 100 godina (žuto)  
Bačina Lakes surface area today (blue) and 100 years ago (yellow)



Slike ponora dobivene panoramskim dubinomjerom u jezeru Crniško (A) i podvodnih izvora (pockmarka) u jezeru Očuša (B)

Swallow hole photos acquired by the panoramic echo sounder in the Crniško Lake (A), and underwater springs (pockmarks) in the Očuša Lake (B)

erosiju uslijed deforestacije. Recentna anoksija, vidljiva u posljednjih 55 godina, uzrokovana je povećanom jezerskom produktivnošću i eutrofikacijom te izolacijom jezera Crniško. Prokopavanje odvodnog tunela 1913. godine iz jezera Sladinac u more uzrokovalo je značajno sniženje razine vode u Baćinskim jezerima i predstavljaju jednu od značajnijih ljudskih intervencija u funkciranju jezerskih ekosustava u RH.

55 years, is caused by increased lake productivity and eutrophication, as well as the isolation of the Crniško Lake. In 1913, the drainage tunnel connecting the Sladinac Lake and the sea was constructed, causing a significant reduction in the water level of Baćina Lakes. This represents one of the most significant human interventions in the functioning of lake ecosystems in the Republic of Croatia.



Laminirani sedimenti – varve u jezeru Crniško, sastavljeni od crnih organskih laminationi i bijelih laminationi endogenih karbonata, kao rezultat izmjene oksičnih/anoksičnih uvjeta u jezeru zbog povećane produktivnosti i eutrofikacije u posljednjih 5 godina

Laminated sediments – varves in the Crniško Lake, composed of black organic laminas and white laminas of endogenous carbonates, as a result of transitions between oxic and anoxic conditions in the lake due to increased productivity and eutrophication during the last 5 years

# Dunavska regija kao predvodnik u geotermalnoj energiji

## Danube Region Leading Geothermal Energy

Koordinatorica za HGI-CGS / Coordinator for HGI-CGS: dr. sc. **Tamara MARKOVIĆ**  
<http://www.interreg-danube.eu/approved-projects/darlinge>

Projekt akronima DARLINGe financiran je u okviru prvog poziva iz Programa transnacionalne suradnje Interreg Dunav 2014.–2020., u ukupnom iznosu od 2,52 milijuna €. Sufinanciran je od strane Europskog fonda za regionalni razvoj u iznosu od 1,61 milijun € te iz IPA II fonda u iznosu od 534,64 tisuće €. Implementacija je započela u siječnju 2017. te traje do lipnja 2019. godine. Projekt ima specifični cilj – poboljšati energetsku sigurnost i energetsku učinkovitost unutar tematskog prioriteta – bolje povezana i energetski učinkovita dunavska regija. Cilj projekta je doprinijeti energetskoj sigurnosti i učinkovitosti dunavske regije podizanjem svijesti o dubokim geotermalnim izvorima energije i poboljšanjem učinkovitog korištenja čitavog raspona temperatura eksploriranih geotermalnih vodonošnika. U provedbi projekta sudjeluje 10 ERDF i 5 IPA partnera iz 6 država (Mađarske, Slovenije, Hrvatske, Srbije, Bosne i Hercegovine te Rumunjske) koji su predstavljeni geološkim institutima, sveučilištem, industrijom, regionalnim energetskim i

The project under the acronym DARLINGe is funded within the first call of the Interreg Danube 2014–2020 Transnational Co-operation Programme, totalling € 2.52 million. It is co-financed by the European Regional Development Fund with € 1.61 million and the IPA II with € 534.64 thousand. Implementation started in January 2017 and will last until June 2019. The project has a specific goal – to improve energy security and energy efficiency within thematic priority – a better-connected and energy-efficient Danube region. The goal of the project is to contribute to energy security and efficiency of the Danube region by raising awareness on deep geothermal energy sources and by improving efficient use of the entire range of temperatures of exploited geothermal aquifers. Ten ERDF and five IPA partners from six countries are participating in the implementation of this project (Hungary, Slovenia, Croatia, Serbia, Bosnia and Herzegovina, and Romania). They are represented by geological institutes, a university, the industry, regional energy and development agencies, a ministry



Izvor u Velikom bazenu, Tuheljske Toplice (foto I. Bobovečki)  
 Spring in Veliki bazen, Tuheljske Toplice (photo by I. Bobovečki)



Izvorište u Sutinskim Toplicama (foto I. Bobovečki)  
 Spring in Sutinske Toplice (photo by I. Bobovečki)



Projektno područje DARLINGe projekta s naznačenim pilot područjima  
Project area of the DARLINGe project with marked pilot areas

razvojnim agencijama, ministarstvom i općinom. Isto tako, sudjeluje i sedam pridruženih partnera iz gore navedenih zemalja. Vodeći partner je Geološki i geofizički institut Mađarske. Područje projekta DARLINGe obuhvaća oko 95.000 km<sup>2</sup> na kojem postoje dvije vrste geotermalnih vodonosnika: (i) vodonosnici međuzrnske poroznosti; (ii) karbonatni vodonosnici. Temperature variraju između 20 °C i 90-110 °C. Unutar projektnog područja, odabrana su tri prekogranična pilot područja gdje će se provesti detaljnija ispitivanja, kako bi se testirale razvijene metodologije. Najzapadnije pilot područje obuhvaća područje između Hrvatske, Mađarske i Slovenije, južno pilot područje nalazi se između Bosne i Hercegovine i Srbije, dok se treće nalazi između Mađarske, Rumunjske i Srbije.



Sudionici radionice za dionike u vodenom parku Aquae Vivae u Krapinskim Toplicama  
(foto D. Šolaja)

Participants of the stakeholders' workshop in the Aquae Vivae water park in Krapinske Toplice  
(photo by D. Šolaja)

and a municipality. Seven associated partners from the above-mentioned countries are also taking part. The lead partner is the Geological and Geophysical Institute of Hungary. The DARLINGe project area covers approximately 95,000 km<sup>2</sup>, where there are two types of geothermal aquifers: (i) aquifers with intergranular porosity and (ii) carbonate aquifers. The temperatures vary between 20 °C and 90–110 °C. Within the project area, three cross-border pilot areas have been selected for more detailed investigations, and for testing of the developed methodologies. The westernmost pilot area covers the area between Croatia, Hungary, and Slovenia, the southern part is located between Bosnia and Herzegovina and Serbia, while the third part is located between Hungary, Romania, and Serbia.

# Uspostava istraživačkog prostora europskih geoloških službi i stvaranje geološke službe za Evropu

## Establishing the European Geological Surveys Research Area to Deliver a Geological Service for Europe

Koordinator za HGI-CGS / Coordinator for HGI-CGS: dr. sc. **Slobodan MIKO**

Autorica teksta / Author of the text: dr. sc. **Staša BOROVIĆ**

Program akronima GeoERA sufinancira Europska unija kroz ERA-NET Co-fund shemu u sklopu programa Obzor 2020 (više o programu GeoERA: <http://geoera.eu/about-geoera/>). Program obuhvaća četiri teme iz područja primijenjenih geoznanosti: geoenergija, podzemna voda, mineralne sirovine i informacijska platforma (<http://geoera.eu/themes/>).

Financiranje je odobreno za ukupno petnaest projekata, od čega šest iz teme geoenergija, po četiri iz tema podzemne vode i mineralne sirovine te jedan iz teme informacijska platforma (<http://geoera.eu/projects/>). HGI-CGS je uključen u tri projekta iz tema geoenergija (GeoConnect<sup>3</sup>d – koordinator Marko Šepelić, HotLime i MUSE – koordinatorica dr. sc. Staša Borović), podzemne vode (HOVER – koordinator dr. sc. Ozren Larva, RE-

The GeoERA program is co-funded by the European Union through the ERA-NET Co-fund scheme under the Horizon2020 program (more about GeoERA: <http://geoera.eu/about-geoera/>). The program encompasses four themes in the area of applied geosciences: geoenergy, groundwater, mineral resources and information platform (<http://geoera.eu/themes/>).

Funding has been approved for a total of fifteen projects, of which six are from the theme of geoenergy, four from groundwater and raw materials themes, and one on the information platform (<http://geoera.eu/projects/>).

HGI-CGS is involved in three geoenergy (GeoConnect<sup>3</sup>d – coordinator Marko Šepelić, HotLime and MUSE – coordinator Staša Boro-



Uvodni govor koordinatorice programa GeoERA Yvonne Schavemaker na početnom sastanku u Briselu (foto: M. Šepelić)

Introductory speech of GeoERA coordinator Yvonne Schavemaker at the kick-off meeting in Brussels (photo by M. Šepelić)



Sastanak projekta MUSE u ugodnim vanjskim prostorima kongresnog centra (foto: G. Götzl)

Meeting of the MUSE project team in pleasant outdoor environment of the congress centre in Brussels (photo by G. Goetzl)



Ekskurzija u sklopu sastanka projekta HotLime – lokacija bušenja triju geotermalnih dubleta za sustav grijanja u Minhenu (foto G. Diepolder)

Excursion in the scope of HotLime project: drilling site of three geothermal doublets for the heating system of the City of Munich (photo by G. Diepolder)

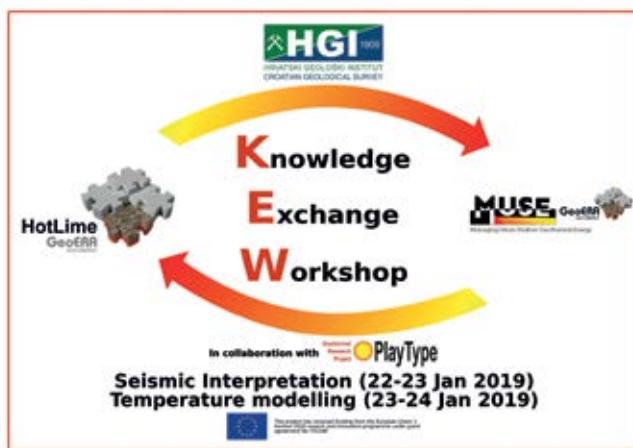
SOURCE i TACTIC – koordinator dr. sc. Andrej Stroj) i mineralne sirovine (EuroLithos, FRAME i Mintell4EU – koordinator dr. sc. Željko Dedić te u informacijsku platformu (GIP-P – koordinatorica dr. sc. Ajka Šorša) koja bi trebala servisirati potrebe svih ostalih projekata, kao i korisnika rezultata.

Početni sastanak programa GeoERA, kao i projektni sastanci pojedinačnih projekata, održani su od 3. do 5. srpnja 2018. godine u Briselu. Predstavljeni su odabrani projekti, a sudionici su se upoznali s projektnim partnerima iz drugih država te zainteresiranim dionicima. Raspravljalo se o očekivanjima od programa GeoERA te su prihvачene preporuke Europske komisije i Vijeća dionika. Također se razgovaralo o zadatcima, događajima, sinergiji među projektima i utjecaju cijelog programa. Projekti će se fokusirati na usklađivanje podataka, informacija i struke izvan granica država te usavršavanje postojećih metoda i tehniku modeliranja. Program GeoERA će zakonodavnim tijelima, donositeljima odluka te krajnjim korisnicima ge-

vić), groundwater (HOVER – coordinator Ozren Larva, RESOURCE and TACTIC – coordinator Andrej Stroj), and mineral resources (EuroLithos, FRAME and Mintell4EU – coordinator Željko Dedić) projects, as well as in information platform (GIP-P – coordinator Ajka Šorša) which should serve the needs of all other projects, as well as the stakeholders.

The kick-off meetings of the GeoERA program, and of some of the individual projects, were held in Brussels from 3 to 5 July 2018. Selected projects were presented, and participants met with project partners from other countries and interested stakeholders. The expectations from the GeoERA were discussed and the recommendations of the European Commission and the Stakeholders Council were presented. Tasks, events, and synergies between projects and the impact of the whole program were also discussed. The projects will focus on harmonizing data, information and expertise beyond national borders and improving the existing methods and modelling techniques. The GeoERA program will provide valuable and publicly available information to legislators, decision-makers and end users of geological data and information in Europe. These meetings were attended by six HGI-CGS staff members who are coordinators for individual projects.

During December 2018, the first reporting period of these projects was due and all reports were submitted to the lead partners of individual projects on time. In addition, planned activities took



Najava radionice razmjene znanja između projekata HotLime i MUSE na teme seizmičke interpretacije i modeliranja temperatura u primjeni za duboku i plitku geotermiju, održane u organizaciji HGI-CGS-a (izradio T. Frangen)

Announcement of Knowledge Exchange Workshop between HotLime and MUSE projects on the topic of seismic interpretation and temperature modelling in deep and shallow geothermal applications, organized by HGI-CGS (prepared by T. Frangen)

oloških podataka i informacija u Europi pružiti vrijedne i javno dostupne podatke. Sastancima je prisustvovalo i šestero dje-latnika HGI-CGS-a koji su koordinatori za pojedine projekte u svojoj instituciji.

Tijekom prosinca 2018. godine završilo je i prvo izvještajno razdoblje ovih projekata te su sva izvješća na vrijeme uručena vodećim partnerima pojedinih projekata. Osim toga, aktivnosti se odvijaju zadanim tijekom, te su djelatnici do sad sudjelovali na desetak sastanaka, radionica i radnih posjeta, a mnoga su događanja u pripremi.

Sudionici radionice razmjene znanja  
u večernjem turističkom obilasku  
Zagreba (foto L. Urumović)  
Participants of knowledge exchange  
workshop during Zagreb city tour  
(photo by L. Urumović)

place during the given period, and colleagues have so far participated in dozens of meetings, workshops and work visits, and more events are in preparation.



# Jačanje istraživanja u Hrvatskom geološkom institutu: geoznanstveni twinning za razvoj sposobnosti svremenog modeliranja podzemlja i znanstvenog odjeka

## Strengthening Research in the Croatian Geological Survey: Geoscience-Twinning to Develop State-of-the-Art Subsurface Modelling Capability and Scientific Impact

Voditelj projekta / Project coordinator: dr. sc. **Davor POLLAK**

Početkom listopada 2018. godine s radom je započeo Horizon 2020 projekt GeoTwinne kojeg vodi i koordinira HGI-CGS. Tijekom provedbe projekta u trajanju od tri godine istraživači HGI-CGS-a će imati prilike surađivati s eminentnim znanstvenicima partnerskih institucija koje sudjeluju u projektu: Geological Survey of Denmark and Greenland (GEUS) i British Geological Survey of the United Kingdom Research and Innovation (BGS-UKRI). Osnovni ciljevi ovog projekta su: značajno osnaživanje istraživačkog potencijala i sposobnosti HGI-CGS-a, umrežava-



Ioannis Abatzis, suvoditelj GeoTwinne projekta (GEUS)  
Ioannis Abatzis, GeoTwinne coordinator for GEUS



Corinna Abesser, suvoditeljica GeoTwinne projekta (BGS-UKRI)  
Corinna Abesser, GeoTwinne coordinator for BGS-UKRI

The Horizon 2020 GeoTwinne project is led and coordinated by the HGI-CGS, starting from the beginning of October 2018. During three years of implementation, HGI-CGS experts will have opportunity to collaborate with eminent scientists from other two partner institutions: the Geological Survey of Denmark and Greenland (GEUS) and the British Geological Survey of the United Kingdom Research and Innovation (BGS-UKRI). The major aims of the project are: to significantly strengthen research potential and capabilities of the HGI-CGS, enable networking between scientists

nje i suradnja znanstvenika i institucija te razrada ideja i prijava novih zajedničkih projekata. Provođenje projekta omogućit će znanstvenicima HGI-CGS-a usvajanje i korištenje najnaprednijih i inovativnih alata, tehnologija, programskih paketa i metoda za izradu geoloških modela kojima raspolažu GEUS i BGS-UKRI. Gotovo trideset znanstvenika HGI-CGS-a sudjelovat će u edukacijskom programu koji uključuje provođenje intenzivnog treninga, konzultacija i primjenu stečenog znanja na konkretnim testnim područjima/primjerima. Programom su predviđene kratkotrajne edukacijske posjete, razmjene i radionice koje će omogućiti HGI-CGS-u znanstveni napredak i poboljšanje sposobnosti u četiri važna područja geoznanosti i geološkog inženjerstva:

1. 3D geološka istraživanja i modeliranja;
2. napredno modeliranje podzemnog toka i transporta zagađivača;
3. geološki hazardi;
4. geotermalna energija.

and institutions, and develop ideas and new project proposals. HGI-CGS will benefit from a range of research tools, technologies, software, and methods at the disposal of GEUS and BGS-UKRI. Almost thirty scientists from HGI-CGS will participate in the training programmes, which includes intensive training, consultations, and application of gained knowledge on test areas and data. The program involves short term visits, two-way scientific exchanges, and workshops, which will support HGI-CGS to strengthen research potential and capabilities in four important geoscientific subject areas:

- (1) 3D geological surveying and modelling;
- (2) advanced groundwater flow and contaminant transport modelling;
- (3) geological hazards;
- (4) geothermal energy.



Sudionici kick-off radionice projekta GeoTwin (HGI-CGS, Zagreb)  
Participants of the kick-off workshop of the GeoTwin project at HGI-CGS, Zagreb



Dio prve GeoTwin radionice održao se na terenu u Istri  
Part of the kick-off workshop was organized as fieldwork in Istria



Spilja Manita peć (foto T. Frangen) / Manita peć cave  
(photo by T. Frangen)

5

**Publikacije**  
*Publications*

# Publicirani listovi OGK RH 1:50.000

## Published Sheets of BGM RH 1:50,000

Glavni istraživač / Principal Investigator: dr. sc. **Tvrtko KORBAR**

U proteklom 10-godišnjem razdoblju objavljeno je 19 standardiziranih listova OGK RH 1:50.000, izrađenih prema Uputama za izradu Osnovne geološke karte Republike Hrvatske u mjerilu 1:50.000 (Korbar et al., 2012). 16 listova objavljeno je u projektnom području „Dinaridi“, a 3 u projektnom području „Panon“. U suradnji s informatičkim odjelom HGI-CGS-a, od početka 2017. godine omogućen je pregled svih objavljenih listova (na zahtjev) putem GEOPORTALA HGI-CGS-a, a prodaja digitalnih i papirnatih inačica objavljenih listova radi se na zahtjev, također putem spomenutog portala.

In the past ten-year period, 19 standardised sheets of the basic geological map (BGM) of the Republic of Croatia (RH) at the scale of 1 : 50,000 have been published, according to the Guidelines for compilation of the BGM of the RH at the scale 1 : 50,000 (Korbar et al., 2012). Sixteen sheets were published of the *Dinarides* and three of the *Pannonian* project area. From the beginning of 2017, the published sheets can be viewed (on request) through the GeoPortal of the HGI-CGS, as a result of the collaboration of the Department of Geology and the IT department of the HGI-CGS. The purchase of digital and printed versions of the published sheets is also possible on demand, and via the specified portal.

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OŠTRIĆ, N., JELASKA, V., FUČEK, L., PRTOLJAN, B., KOROLIJA, B., GUŠIĆ, I., MARINČIĆ, S., ŠPARICA, M., KORBAR, T. & HUSINEC, A (2015c): Osnovna geološka karta Republike Hrvatske M 1:50 000 – list Otok Hvar.- Hrvatski geološki institut, Zavod za geologiju, 1 list, Zagreb, ISBN: 978-953-6907-49-6.

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HUSINEC, A., PRTOLJAN B., FUČEK, L., KORBAR, T., (2016): Osnovna geološka karta Republike Hrvatske mjerila 1:50 000 – list Otok Mljet.- Hrvatski geološki institut, Zavod za geologiju, Zagreb, 1 list, ISBN: 978-953-6907-57-1.

FILJAK, R., PIKIJA, M.; AVANIĆ, R.; BAKRAČ, K.; MIKNIĆ, M., PAVELIĆ, D.; BRKIĆ, M.; BELAK, M. (2016): Osnovna geološka karta Republike Hrvatske mjerila 1 : 50 000 – list Slavonska Požega 3, Hrvatski geološki institut, Zavod za geologiju, ISBN: 978-953-6907-46-5.

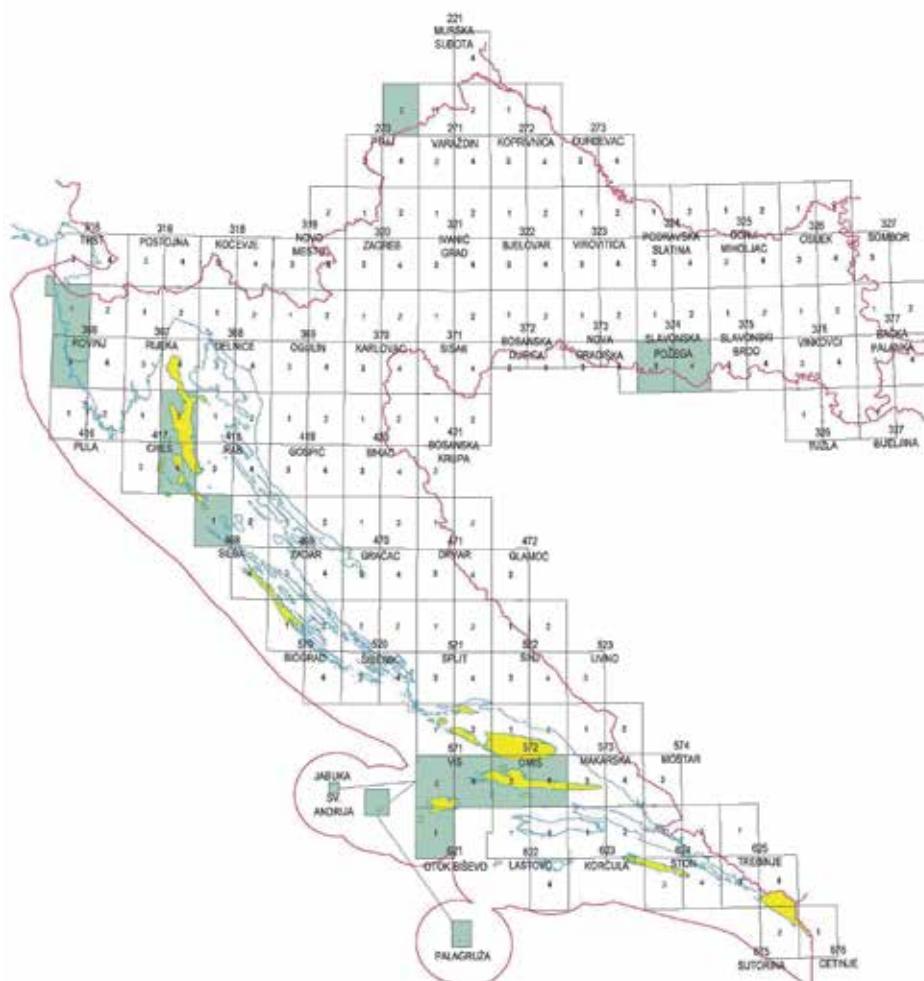
FILJAK, R., PIKIJA, M., AVANIĆ, R., BAKRAČ, K., MIKNIĆ, M. (2016): Osnovna geološka karta Republike Hrvatske mjerila 1 : 50 000 – list Slavonska Požega 4, Hrvatski geološki institut, Zavod za geologiju, ISBN: 978-953-6907-46-2.

FUČEK, L., JELASKA, V., PRTOLJAN, B., KOROLIJA, B., OŠTRIĆ, N., GUŠIĆ, I. (2016): Osnovna geološka karta Republike Hrvatske mjerila 1:50 000 – list Dugi otok . Zagreb : Hrvatski geološki institut, Zavod za geologiju, ISBN: 978-953-6907-58-8.

KORBAR, T., FUČEK, L., BRČIĆ, V., PALENIK, D. (2017): Osnovna geološka karta Republike Hrvatske M 1:50 000: list: Šolta, Čiovo, Drvenik.- Hrvatski geološki institut, Zavod za geologiju, 1 list, Zagreb, ISBN: 978-953-6907-59-5.

MATIČEC, D., BERGANT, S., FUČEK, L., PALENIK, D., KORBAR, T., VLAHOVIĆ, I., ŠPARICA, M., KOCH, G., PRTOLJAN, B., GALOVIĆ, I., VELIĆ, I., TIŠLJAR, J. (2017): Osnovna geološka karta Republike Hrvatske mjerila 1:50 000 – list Rovinj 1., Zagreb: Hrvatski geološki institut (Zavod za geologiju), 1 list, Zagreb, ISBN: 978-953-6907-56-4.

FUČEK, L., KORBAR, T., PALENIK, D., MATIČEC, D. (2018): Osnovna geološka karta Republike Hrvatske M 1:50 000: list Silba 1.- Hrvatski geološki institut (Zavod za geologiju), 1 list, Zagreb, ISBN: 978-953-6907-69-4.



Shema objavljenih listova OGK RH (označeni sivo i žuto), koji su dostupni na [www.hgi-cgs.hr](http://www.hgi-cgs.hr)  
Scheme of the published sheets of the BGM of the RH (marked grey and yellow), available at [www.hgi-cgs.hr](http://www.hgi-cgs.hr)

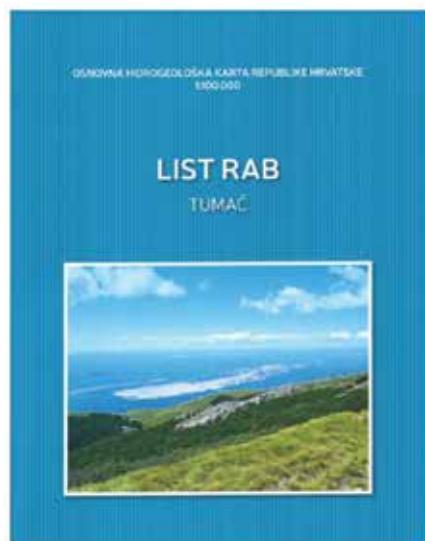
# Publikacije OHGK RH 1:100.000

## Published Materials of BHGM RH 1:100,000

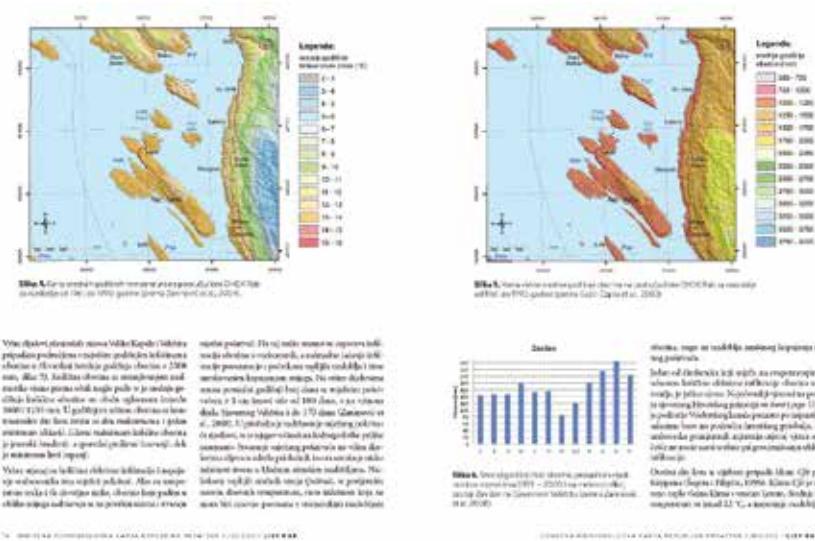
Glavni istraživač / Principal Investigator: dr. sc. **Josip TERZIĆ**

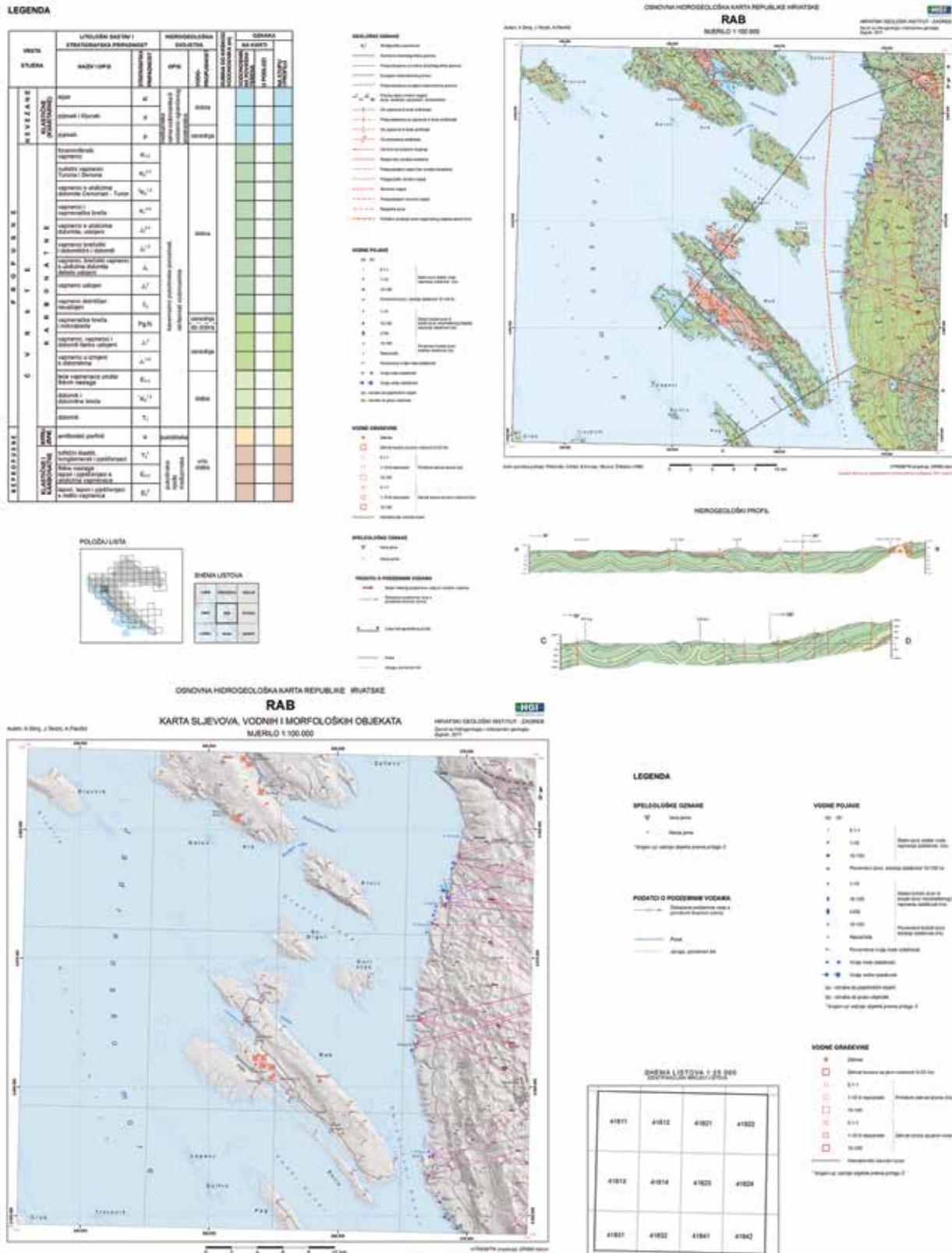
Prva službena publikacija načinjena u sklopu projekta Osnovne hidrogeološke karte objavljena je 2017. godine. Riječ je o karti i tumaču – List Rab. Autori publikacije su Andrej Stroj, Josip Terzić i Ante Pavičić, a sastoji se od knjige – tumača, u kojem su opisana sva poglavja važna za hidrogeološka istraživanja i projektiranja u ovom dijelu terena, te kartografskih priloga od kojih je najvažnija hidrogeološka karta M 1:100.000. Ova publikacija ujedno predstavlja primjer prema kojem će se u budućnosti sadržajno i tehnički uređivati ostale osnovne hidrogeološke karte. Razmatrani teren je u hidrogeološkom smislu veoma heterogen jer zahvaća vrleti Velebita s izraženim speleološkim objektima i jakim izvorima u podnožju, ali i male izvore i fliške vodonosnike otoka Raba. Radi nepostojanja odgovarajućih podloga, posebno je tehnički zahtjevan bio posao pripreme topografskih podloga, kako bi bile informativne, a ne bi negativno utjecale na hidrogeološke boje i simbole.

The first official publication within the Basic Hydrogeological Map (BHGM) project was published in 2017. It includes maps and explanatory notes for the sheet Rab. The authors of the publication are Andrej Stroj, Josip Terzić, and Ante Pavičić. The explanatory notes are provided in the form of a book, containing chapters on important hydrogeological research and projects in this part of the terrain, while the hydrogeological map at the scale of 1 : 100,000 is the most important cartographic supplement. This publication is also an example of content and technical specifications for future BHGM publications. The investigated terrain is very heterogeneous from a hydrogeological aspect, because it comprises a part of the Velebit Mt. with distinct speleological objects and strong springs at the foothills, but also small springs and flysch aquifers on the island of Rab. Because of the lack of appropriate base maps, it was a technically demanding work to prepare topographic base maps, in order for them to be informative, but not to adversely affect the hydrogeological colours and symbols.



Tumač OHGK list Rab  
Explanatory notes of BHGM sheet Rab





Grafički prilozi OHGK list Rab

Graphical supplements to the BHGM sheet Rab

# Geološka karta Republike Hrvatske M 1:300.000

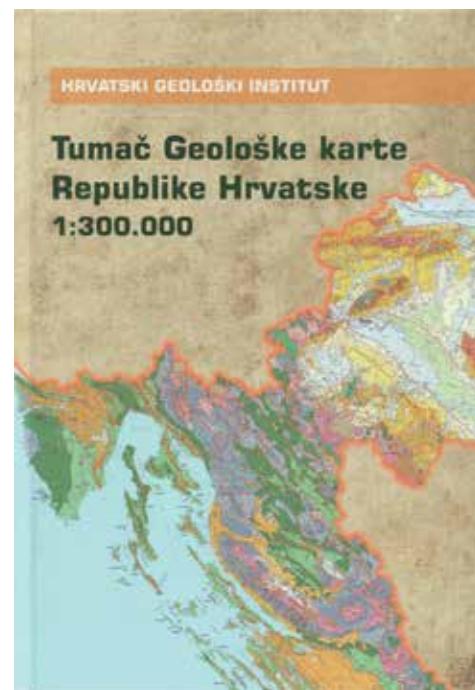
## Geological Map of the Republic of Croatia M 1:300,000

Autor teksta / Author of the text: dr. sc. **Josip HALAMIĆ**

Geološka karta RH 1:300.000, koja predstavlja ogromno znanstveno dostignuće i kulturno dobro geološke struke u RH, je prva cijelovita pregledna geološka karta države na kojoj je prikazana geološka građa i povijest stvaranja terena od pretkambrija do kvartara, kroz vremenski period od preko 600 milijuna godina. Izrađena je kompilacijom 74 lista OGK 1:100.000 područja RH, u čijoj je izradi sudjelovalo sedamdesetak kartirajućih geologa, najvećim dijelom iz današnjeg HG-CGS-a, a manjim dijelom s Prirodoslovno-matematičkog i Rudarsko-geološko-naftnog fakulteta Sveučilišta u Zagrebu, Hrvatskog prirodoslovnog muzeja, Zavoda za geologiju kvartara JAZU (današnja HAZU) i INA-Naftaplina. Osim kartirajućih geologa, u taj je projekt bio uključen i velik broj specijalista različitih geoloških disciplina (paleontologa, mineraloga, petrografa, geokemičara i dr.), te brojno tehničko i drugo prateće osoblje. Uz kartu je tiskan i tumač, u čijem je pisanju sudjelovalo 20 geologa, od kojih je većina radila na izradi OGK 1:100.000. Radi upoznavanja mlađih naraštaja s geološkim značajkama domovine, po jedan primjerak karte s tumačem poklonjen je svim osnovnim i srednjim školama u RH te hrvatskim školama diljem svijeta.

Velić, I., Vlahović, I. (ur.) (2009): Geološka karta Republike Hrvatske 1:300.000 – karta i tumač, Hrvatski geološki institut, Zagreb.

The geological map of the Republic of Croatia (RH) at the scale 1 : 300,000 represents a tremendous scientific achievement and a cultural heritage of the geological profession in the RH. It is the first complete review geological map of the country showing the geological structure and terrain evolution from the Precambrian to the Quaternary era, over a period of over 600 million years. This map was made by compiling 74 sheets of the basic geological map (BGM) at the scale of 1 : 100,000 in the territory of the Republic of Croatia (RH). About seventy mapping geologists participated in its construction, most of them from present-day HG-CGS, and to a lesser extent from the Faculty of Science, the Faculty of Mining, Geology and Petroleum Engineering, the Croatian Natural History Museum, the Institute for Quaternary Geology of the Yugoslav Academy of Sciences and Arts (present-day Croatian Academy of Sciences and Arts), and INA-Naftaplin petroleum company. In addition to the mapping geologists, many experts from various geological disciplines (paleontologists, mineralogists, petrographers, geochemists, etc.) were involved in this project, as well as numerous technical and other supporting staff. In addition to the map, explanatory notes were published, involving 20 geologists, most of whom worked on the construction of the BGM at the scale of 1 : 100,000. In order to get the younger generations acquainted with geological features of the RH, one copy of the map with explanatory notes was donated to all primary and secondary schools in the RH and Croatian schools around the world.



Karta i tumač OGK RH 1:300.000  
Map and Explanatory notes BGM RH : 300,000

# Upute za izradu Osnovne geološke karte Republike Hrvatske u mjerilu 1:50.000

## Guidelines for Compilation of the Basic Geological Map of the Republic of Croatia at the Scale of 1:50,000

Autor teksta / Author of the text: dr. sc. **Tvrtko KORBAR**

Krajem 2012. godine došlo je do vidljivog napretka u hrvatskoj geološkoj kartografiji jer su objavljene Upute za izradu OGK RH u mjerilu 1:50.000. U izradi je sudjelovala većina geologa i tehničara Zavoda za geologiju HGI-CGS-a, a recenzirane su od strane pet recenzenata iz RH i susjednih država. U uputama se kroz 11 poglavlja opisuje postupak izrade OGK RH te se određuju standardi za njezinu izradu. Po svom značaju one nisu samo skup pravila za izradu OGK, već i vrlo koristan priročnik drugim geolozima koji obavljaju terenska i kabinetska istraživanja za razne potrebe. Stoga predstavljaju značajan doprinos cijelokupnoj hrvatskoj geološkoj zajednici.

Usporedno s izradom uputa rađena je i geološka karta lista Cres-2, koja je u smanjenom formatu priložena uz upute. Izrada karte predstavlja je izravnu kartografsku provjeru i ocjenu valjanosti postavljenih kartografskih standarda. Na stručnoj kartografskoj recenziji dobila je odličnu ocjenu. Mora se naglasiti kako geološka karta lista Cres-2 predstavlja ogroman iskorak u hrvatskoj geološkoj kartografiji jer je to prva standardizirana geološka karta koja je pripremljena, uređena i otisnuta, ne samo u HGI-CGS-u, nego i u našoj državi.

*Korbar, T., Avanić, R., Bakrač, K. et al.(2012): Upute za izradu Osnovne geološke karte Republike Hrvatske: M 1:50.000, Hrvatski geološki institut, Zagreb.*

Late 2012, a significant progress was achieved in Croatian geological mapping, as the Guidelines for compilation of the basic geological map (BGM) of the Republic of Croatia (RH) at the scale of 1 : 50,000 were published. Most of the geologists and technicians who participated were from the Department of Geology of the HGI-CGS. The guidelines were reviewed by five reviewers from the RH and neighbouring countries. Within the guidelines, the process of construction of the BGM of the RH is described through 11 chapters, along with the definition of standards for its preparation. By their very nature, they are not just a set of rules for the construction of the BGM, but a very useful manual for other geologists who conduct fieldwork and desk research for various purposes. They therefore represent a significant contribution to the entire Croatian geological community.



Naslovica Upute za izradu OGK RH u mjerilu 1:50.000  
Cover of the Guidelines for compilation of the basic geological map of the Republic of Croatia at the scale of 1:50,000

Along with the specification of the guidelines, a geological map of the Cres-2 sheet was constructed, enclosed with the guidelines in a reduced format. The construction of the map was a direct cartographic control and evaluation of proscribed cartographic standards. It was reviewed by experts and obtained an excellent rating. It should be emphasized that the geological map of the Cres-2 sheet is a leap forward in Croatian geological mapping, since it is the first standardised geological map prepared, produced, and published not only at the HGI-CGS, but also in the country.

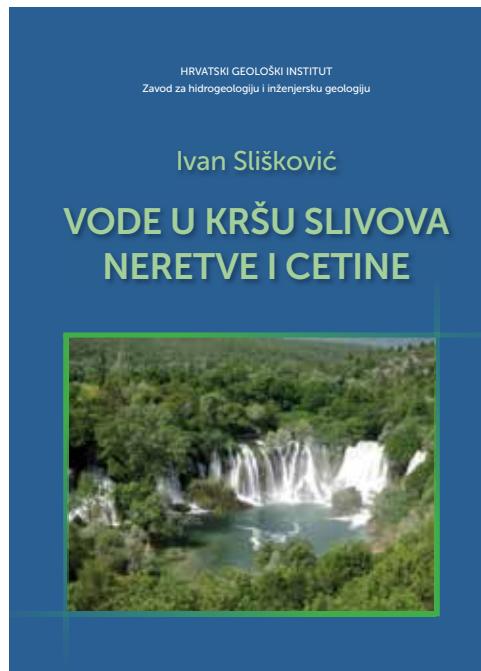
# Vode u kršu slivova Neretve i Cetine

## Waters in the Karst Catchments of Neretva and Cetina Rivers

Autor teksta / Author of the text: dr. sc. **Josip TERZIĆ**

Knjiga „Vode u kršu slivova Neretve i Cetine“ objavljena je 2014. godine i predstavlja krunu karijere našeg umirovljenog znanstvenog savjetnika Ivana Sliškovića. Najveći dio svojeg znanstvenog i stručnog rada on je proveo upravo u ovim krškim terenima iz kojih i potječe (Široki Brrijeg). Knjiga na pregledan i stručan način prikazuje brojne hidrogeološke informacije koje će uzeti u obzir svaki budući istraživač ovog područja. Obiluje podatcima koji postoje u raznim fondovima stručne dokumentacije, a koje je u današnje vrijeme često nemoguće naći iz brojnih razloga. Usprkos određenim tehničkim nedostatcima, može se ustvrditi kako je riječ o veoma vrijednom djelu naše hidrogeologije koje se bavi jednim od najzamršenijih sustava dinarskog krša, područja u kojem do izražaja najviše dolazi upravo terensko iskustvo, kojeg autoru ne manjka.

The book "Water in the Karst Catchments of Neretva and Cetina Rivers" was published in 2014 and represents the pinnacle of the career of our retired scientific advisor Ivan Slišković. He spent most of his scientific and professional work in these karst areas, where he also originates from (Široki Brrijeg). The book provides hydrogeological information in a clear and expert manner, and should be considered by every future researcher of this area. It abounds with data from various archives of professional documentation, which is often impossible to find due to various reasons. Despite some technical drawbacks, it can be concluded that this book is a very valuable work of our hydrogeology. It deals with one of the most complex Dinaric karst systems, an area in which field experience, which the author does not lack, is the most valuable.



Slišković, I. (2014): *Vode u kršu slivova Neretve i Cetine*, Hrvatski geološki institut, Zagreb.

# Geokemijski atlas Republike Hrvatske i Geokemijski atlas Siska

## Geochemical Atlas of the Republic of Croatia and Geochemical Atlas of the City of Sisak

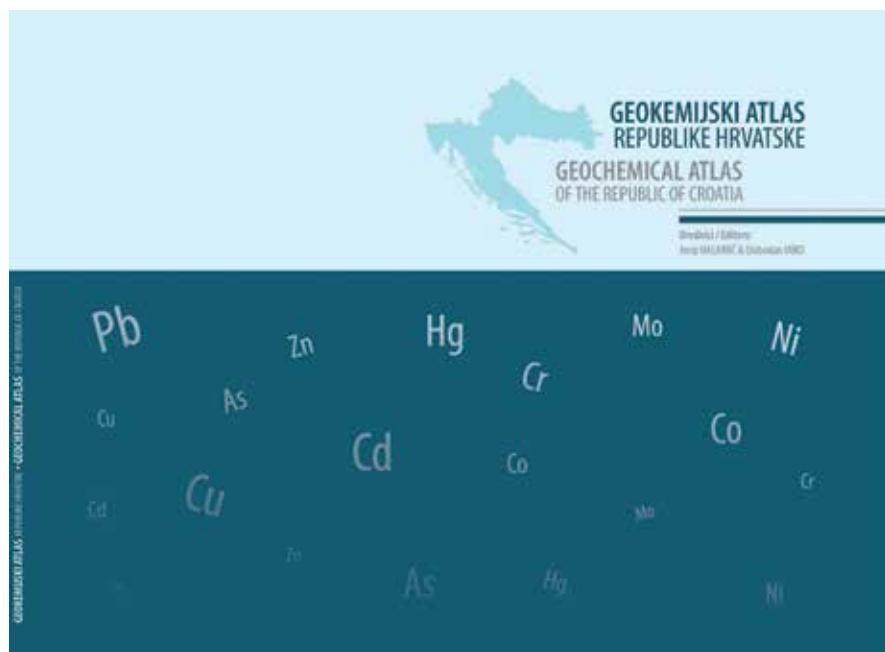
Autori teksta / Authors of the text: dr. sc. Josip HALAMIĆ, dr. sc. Ajka ŠORŠA

U okviru nacionalnog znanstvenog projekta „Osnovna geokemijska karta RH“ Hrvatski geološki institut publicirao je Geokemijski atlas RH koji sadrži karte raspodjele 27 kemijskih elemenata opisanih po geografskim regijama. Atlas predstavlja baseline koncentracije prikazanih kemijskih elemenata u površinskom dijelu tla i nezaobilazan je temelj za sva buduća istraživanja geokemije okoliša regionalnih razmjera.

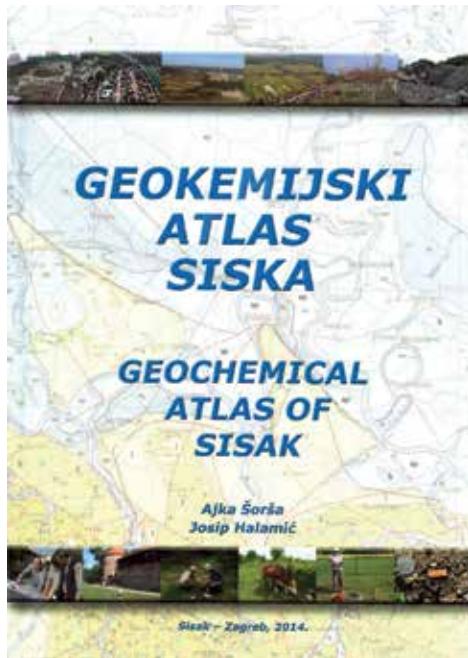
Sisak i njegova ruralna okolica je prvi grad u RH na čijem je teritoriju provedeno sustavno urbano geokemijsko kartiranje u okviru projekta „Urban Geochemistry in Europe (URGE) – soil,

Within the national scientific project "Basic Geochemical Map of the Republic of Croatia", the HGI-CGS published a "Geochemical Atlas of the Republic of Croatia", containing distribution maps of 27 chemical elements by geographic regions. The atlas presents baseline concentrations of studied chemical elements in the surface layer of soil and is therefore the foundation for all future environmental geochemical studies at the regional scale.

The first systematic urban geochemical mapping in the Republic of Croatia (RH) was carried out in the City of Sisak and its rural surroundings. The mapping was performed within the "Urban Geo-



Naslovica Geokemijskog atlasa RH  
Cover of the Geochemical atlas of the RH



Naslovica Geokemijskog atlasa Siska  
Cover of the Geochemical atlas of Sisak

children, health". Jedan od rezultata tog istraživanja je i Geokemijski atlas Siska, koji je djelo suradnje HGI-CGS-a, gradske uprave i stanovnika Siska te Geokemijske ekspertne grupe EuroGeoSurveys-a. Atlas prikazuje sadržaj i prostornu raspodjelu koncentracija 44 kemijska elementa u površinskom dijelu tala grada Siska.

chemistry in Europe (URGE) – soil, children, health" project. One of the results of this research is the "Geochemical Atlas of Sisak", which is the result of collaboration between the HGI-CGS, the city administration, inhabitants of the City of Sisak, and the Geochemical Expert Group of EuroGeoSurveys. The atlas shows the content and spatial distribution of concentrations of 44 chemical elements in the surface layer of soil in the City of Sisak.

*Halamić, J., Miko, S. (ur.) (2009): Geokemijski atlas Republike Hrvatske, Hrvatski geološki institut, Zagreb.*

*Šorša, A., Halamić, J. (2014): Geokemijski atlas Siska, Narodna knjižnica i čitaonica Vlado Gotovac Sisak, Gradski muzej Sisak i Hrvatski geološki institut, Sisak – Zagreb.*

# Geološka zbirka Zadarske županije u OŠ Bartula Kašića

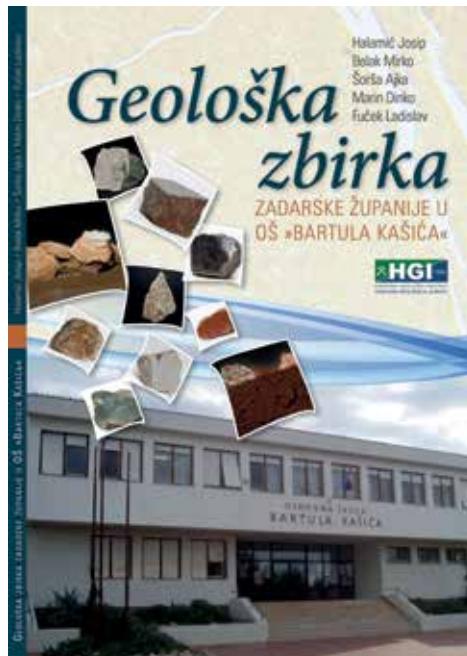
## Geological Sample Collection of the Zadar County in the Bartul Kašić Elementary School

Autor teksta / Author of the text: dr. sc. **Mirko BELAK**

Ova je knjiga plod rada grupe autora. U uvodu je objašnjeno značenje geologije kao grane prirodnih znanosti, opisano je kako je nastala zbirka, a zatim su predstavljeni OŠ Bartula Kašića i HGI-CGS. U drugom poglavlju opisana su geološka razdoblja planeta Zemlje, a u trećem petrologija magmatskih, sedimentnih i metamorfnih stijena. Kratak pregled geologije RH podijeljen u dva potpoglavlja (Panonski i Dinaridsko-primorski prostor) predstavljen je u četvrtom poglavlju. U petom poglavljiju opisana je geologija Zadarske županije, gdje se škola nalazi. Slijedi detaljan opis 43 izloška Geološke zbirke. Manji dio izložaka su najzanimljivije stijene s područja cijele Hrvatske, a veći dio su stijene s područja Zadarske županije.

Knjiga je bogato ilustrirana grafičkim prilozima i fotografijama u boji, a tekst je napisan vrlo stručno. Zbog složenosti opisivane materije bilo bi korisno da se na kraju nalazi objašnjenje manje poznatih pojmljiva, ovako će čitatelji ponekad morati posegnuti za rječnikom stranih riječi ili pak kakvim udžbenikom geologije. Po svom sadržaju i kvaliteti ova knjiga može biti dopuna nastavnom materijalu za osnovne škole kao i nastavnom materijalu za srednje škole koje su usmjerenе prema prirodnim ili tehničkim znanostima.

*Halamić, J., Belak, M., Šorša, A., Marin, D., Fuček, L. (2012): Geološka zbirka Zadarske županije u OŠ Bartula Kašića, Hrvatski geološki institut, Osnovna škola Bartul Kašić, Zagreb – Zadar.*



Naslovica knjige  
Book cover

This book is the work of a group of authors: Josip Halamić, Mirko Belak, Ajka Šorša, and Ladislav Fuček from the HGI-CGS, and Marin Dinko from Bartul Kašić elementary school in Zadar.

The introduction describes the meaning of geology as a branch of natural sciences, explains how the sample collection was created, and then presents the Bartul Kašić elementary school and the HGI-CGS. The second chapter describes the geological periods of planet Earth and the third chapter describes the petrology of magmatic, sedimentary and metamorphic rocks. A brief overview of the geology of the Republic of Croatia, divided into two subchapters (Pannonian and Dinaric-coastal areas), is presented in the fourth chapter. The fifth chapter describes the geology of the Zadar County, where the school is located. The chapters are followed by a detailed description of 43 samples of the geological sample collection. A smaller number of samples represent the most interesting rocks from the whole territory of Croatia, while a larger number of samples are rocks from the Zadar County area.

The book is rich in illustrated graphic supplements and colour photographs, and the text is written in an expert manner. Due to the complexity of the described material, it would be useful to find glossary at the end of the book. Without it, the readers will sometimes have to consult the foreign words dictionary or geology textbook. By its content and quality, this book can complement teaching materials for elementary schools, as well as high schools oriented towards natural or technical sciences.

# Znanstveni časopis Geologia Croatica

## Scientific Journal Geologia Croatica

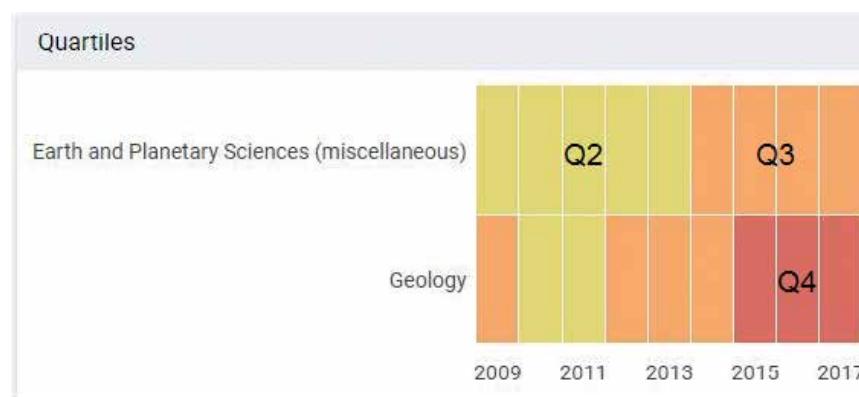
Glavna urednica / *Editor in chief:* dr. sc. **Lidija GALOVIĆ**  
 Tehnička urednica / *Technical editor:* dr. sc. **Marija HORVAT**  
[www.geologia-croatica.hr](http://www.geologia-croatica.hr)

Geologia Croatica je znanstveni časopis Hrvatskog geološkog instituta i Hrvatskog geološkog društva kojeg izdaje HGI-CGS. Tri puta godišnje objavljuje međunarodno recenzirane članke na engleskom jeziku iz svih područja geoznanosti, s naglaskom na Panonski bazen i Sredozemlje.

Glavni urednik je od 2009. do 2014. godine bio Mladen Juračić, tijekom 2015. godine u suuredništvu s Lidijom Galović, koja je glavna urednica od 2016. godine. Tajnica časopisa je Alisa Martek, a od 2016. povremeno Tea Fluksi i Marija Bošnjak. Tehnička urednica časopisa tijekom zadnjih deset godina je Marija Horvat. Tiskano je 30 redovnih sveščića koji su sadržavali 193 izvorna znanstvena rada, tri pregledna rada, šest prethodnih priopćenja, jedan stručni rad, deset *In Memoriam*, te jedno specijalno izdanje posvećeno akademiku Milanu Heraku. U sedam tematskih brojeva prethodio je Uvodnik, a radovi su bili vezani za važnija događanja u geološkoj znanstvenoj zajednici RH. Od značajnih baza, časopis citiraju Web of Science (od 2009.) i Scopus (od 1999.).

*Geologia Croatica* is a scientific journal of the Croatian Geological Survey (HGI-CGS) and the Croatian Geological Society, published by the HGI-CGS. The journal is published three times a year and contains internationally reviewed articles in English from all fields of geosciences, with an emphasis on the Pannonian Basin and the Mediterranean.

From 2009 to 2014, the editor-in-chief was Mladen Juračić, and during 2015 Lidija Galović joined him as the editor-in-chief. Since 2016, Lidija Galović was the sole editor-in-chief. The secretary of the journal is Alisa Martek, and since 2016, this function was performed occasionally by Tea Fluksi and Marija Bošnjak. During the past ten years, the technical editor of the journal has been Marija Horvat. Thirty regular volumes were published, containing 193 original scientific papers, three review papers, six preliminary communications, one professional paper, ten *In Memoriam* texts, and one special edition dedicated to academician Milan Herak. Seven thematic issues with introductory editorials were published, containing papers related to important events in the geological scientific community of the Republic of Croatia. The journal is indexed in the Web of Science (since 2009) and Scopus (since 1999).



Vidljivost časopisa Geologia Croatica u bazi Scopus u kategorijama „Geologija“ i „Zemlja i planetarne znanosti (razno)“ tijekom prošlog desetljeća

Visibility of the *Geologia Croatica* journal during the past decade within the Scopus database in the categories "Geology" and "Earth and Planetary Sciences (miscellaneous)"

# Kongresne publikacije

## Congressional Publications

Priredila / Prepared by: **Tea FLUKSI**

Hrvatski geološki institut je sudjelovao u organizaciji kongresa iz kojih su proizašla sljedeća izdanja:

The Croatian Geological Survey participated in the organisation of conferences, from which the following publications emerged:

4. Hrvatski geološki kongres s međunarodnim sudjelovanjem, Šibenik 14.–15.10.2010. Knjiga sažetaka / **Horvat, Marija** (ur.). Zagreb : Hrvatski geološki institut, 2010.

4. Hrvatski geološki kongres s međunarodnim sudjelovanjem, Šibenik 14.–15.10.2010. Vodič ekskurzija / **Horvat, Marija** (ur.). Zagreb : Hrvatski geološki institut, 2010.

5. Hrvatski geološki kongres s međunarodnim sudjelovanjem, Osijek 23.–25.09.2015. Knjiga sažetaka / **Marija Horvat & Lara Wacha** (ur.). Zagreb : Hrvatski geološki institut, 2015.

5. Hrvatski geološki kongres s međunarodnim sudjelovanjem, Osijek 23.–25.09.2015. Vodič ekskurzija / **Marija Horvat & Lidija Galović** (ur.). Zagreb : Hrvatski geološki institut, 2015.

44th Annual Congress of the International Association of Hydrogeologists (IAH) "Groundwater Heritage and Sustainability" Dubrovnik, Croatia, September 25th to 29th 2017. Book of Abstracts / Kristijan Posavec & **Tamara Marković** (ur.). Zagreb: Hrvatski geološki institut, 2017.

44th Annual Congress of the International Association of Hydrogeologists (IAH) "Groundwater Heritage and Sustainability" Dubrovnik, Croatia, September 25th to 29th 2017. Excursion guidebook: Arboretum Trsteno – Koločep Bay -Ston/ **Tamara Marković, Jasmina Martinjak, Nataša Pomper** (ur.). Zagreb: Hrvatski geološki institut, 2017.

44th Annual Congress of the International Association of Hydrogeologists (IAH) "Groundwater Heritage and Sustainability" Dubrovnik, Croatia, September 25th to 29th 2017. Excursion guidebook: Dubrovnik (Ombla) – Blue and Red Lakes (Imotski) – Gacka River – Plitvička Lakes – Zagreb – Ljubljana / **Tamara Marković, Jasmina Martinjak, Nataša Pomper** (ur.). Zagreb: Hrvatski geološki institut, 2017.

44th Annual Congress of the International Association of Hydrogeologists (IAH) "Groundwater Heritage and Sustainability" Dubrovnik, Croatia, September 25th to 29th 2017. Excursion guidebook: Ombla – Robinzon – HE Dubrovnik – Konavle / **Tamara Marković, Jasmina Martinjak, Nataša Pomper** (ur.). Zagreb: Hrvatski geološki institut, 2017.

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44th Annual Congress of the International Association of Hydrogeologists (IAH) "Groundwater Heritage and Sustainability" Dubrovnik, Croatia, September 25th to 29th 2017. Excursion guidebook: Ston – Pelješac peninsula – Korčula Island / **Tamara Marković, Jasmina Martinjak, Nataša Pomper** (ur.). Zagreb: Hrvatski geološki institut, 2017.

44th Annual Congress of the International Association of Hydrogeologists (IAH) "Groundwater Heritage and Sustainability" Dubrovnik, Croatia, September 25th to 29th 2017. Excursion guidebook: The Island of Mljet / **Tamara Marković, Jasmina Martinjak, Nataša Pomper** (ur.). Zagreb: Hrvatski geološki institut, 2017.

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7th International Workshop Neogene of Central and South-Eastern Europe, Field Trip Guidebook / Kovačić, Marijan; **Wacha, Lara; Horvat, Marija** (ur.). Zagreb : Hrvatsko geološko društvo, 2017.

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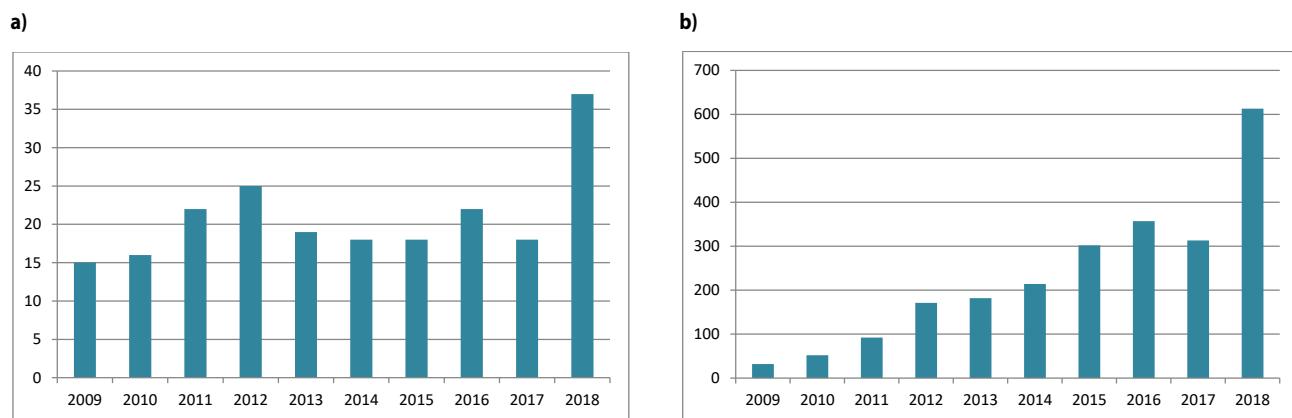


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# Znanstveni radovi djelatnika

## Scientific Papers by Employees

Priredila / Prepared by: **Tea FLUKSI**



**2018.**

**Bakrač, K., Ilijanić, N., Miko, S., Hasan, O.** Evidence of sapropel S1 formation from Holocene lacustrine sequences in Lake Vrana in Dalmatia (Croatia). / Quaternary International, 494, 5–18.

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Geološka pozadina i spomen-obilježja na mjestu stradavanja vatrogasaca (otok Kornat) (foto T. Korbar) /  
Geological background and memorials on the site of the firefighters' tragedy (the island of Kornat) (photo by T. Korbar)



6.

Događanja  
*Events*

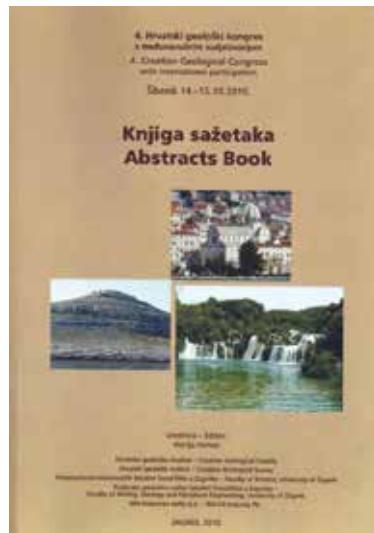
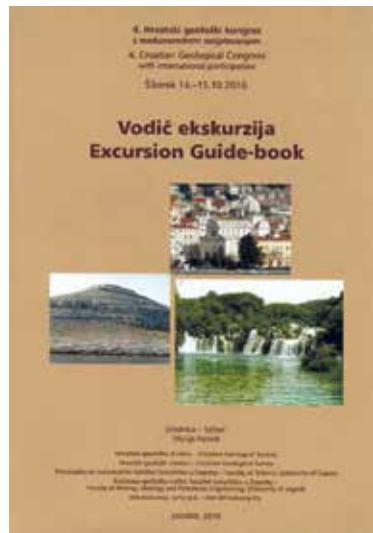
# 4. hrvatski geološki kongres

## 4. Croatian Geological Congress

Autor teksta / Author of the text: dr. sc. **Josip HALAMIĆ**

U Šibeniku je 14. i 15. listopada 2010. godine u organizaciji Hrvatskog geološkog instituta, Hrvatskog geološkog društva, Prirodoslovno-matematičkog fakulteta Sveučilišta u Zagrebu, Rudarsko-geološko-naftnog fakulteta Sveučilišta u Zagrebu i INA – industrije nafte d.d., uz potporu Ministarstva znanosti, obrazovanja i sporta održan, 4. hrvatski geološki kongres s međunarodnim sudjelovanjem. Kongresu je nazočilo oko 300 znanstvenika iz Hrvatske, Austrije, Bosne i Hercegovine, Mađarske, Makedonije, Njemačke, Slovenije, Švicarske i Velike Britanije. Tijekom kongresa predstavljena su ukupno 222 znanstvena rada, koji su tiskani u Knjizi sažetaka. U okviru kongresa organizirane su tri predkongresne i tri postkongresne ekskurzije koje su popraćene tiskanim Vodičem ekskurzija. U njemu su objavljena dodatna 32 znanstvena rada. Tijekom kongresa održana je i radionica Europske federacije geologa na temu Geolozi u Europi – stručni, zakonodavni i regulatorni rad.

On the 14<sup>th</sup> and 15<sup>th</sup> of October 2010, the 4<sup>th</sup> Croatian geological congress with international participation was organised in the City of Šibenik. It was organised by the Croatian Geological Survey, the Croatian Geological Society, the Faculty of Science of the University of Zagreb, the Faculty of Mining, Geology, and Petroleum Engineering of the University of Zagreb, and INA – Petroleum Industry plc, with the support of the Ministry of Science, Education and Sports. About 300 scientists attended the congress, from Croatia, Austria, Bosnia and Herzegovina, Germany, Hungary, Macedonia, Slovenia, Switzerland, and the United Kingdom. During the Congress, a total of 222 scientific papers were presented, and printed in the book of abstracts. Within the scope of the congress, three pre-congress and three post-congress excursions were organised, accompanied by a printed excursion guide, which included additional 32 scientific papers. During the congress, a workshop by the European Federation of Geologists was held, on the topic "Geologists in Europe – the professional, legislative and regulatory work".



Naslovnice kongresnih publikacija  
Covers of congressional publications

# 5. hrvatski geološki kongres

## 5. Croatian Geological Congress

Autor teksta / Author of the text: dr. sc. **Josip HALAMIĆ**

Nakon dvadeset godina održavanja kongresa u obalnim gradovima (Opatija dva puta, Cavtat i Šibenik), 5. hrvatski geološki kongres održan je u Slavoniji, u Osijeku, od 23. do 25. rujna 2015. godine. Organizatori kongresa bili su Hrvatski geološki institut, Hrvatsko geološko društvo, Zavod za mineralogiju i petrologiju i Zavod za geologiju Prirodoslovno matematičkog fakulteta Sveučilišta u Zagrebu i Rudarsko-geološko-naftni fakultet Sveučilišta u Zagrebu, INA Industrija nafte d.d. i Hrvatski prirodoslovni muzej. U radu kongresa sudjelovao je 171 znanstvenik iz Hrvatske, Austrije, Njemačke, Slovenije, Srbije i Velike Britanije. Kongres je otvoren s 5 pozvanih predavanja, a tijekom dva dana održana su sveukupno 84 usmena izlaganja. Na poster sekcijama prezentirano je 70 postera. U knjizi sažetaka objavljeno je ukupno 160 znanstvenih radova. Prije održavanja kongresa organizirane su dvije, a poslije održavanja tri znanstvene geološke ekskurzije. Kao publikacija kongresa tiskan je i vodič ekskurzija.

Tijekom ceremonije zatvaranja kongresa odlučeno je da će se sljedeći kongres održati za četiri godine, tj. 2019. godine u Zagrebu, kada će se ujedno obilježiti i 110. obljetnica postojanja HGI-CGS-a.

After twenty years of organising the national congress in coastal cities (twice in Opatija, once in Cavtat and Šibenik), the 5<sup>th</sup> Croatian geological congress was held in Slavonia, in Osijek, from the 23<sup>rd</sup> to the 25<sup>th</sup> of September 2015. The organisers of the Congress were the Croatian Geological Survey (HGI-CGS), the Croatian Geological Society, the Department of Mineralogy and Petrology and the Department of Geology at the Faculty of Science of the University of Zagreb, the Faculty of Mining, Geology and Petroleum Engineering of the University of Zagreb, INA – Petroleum Industry plc, and the Croatian Natural History Museum. 171 scientists participated in the congress, from Croatia, Austria, Germany, Serbia, Slovenia, and the United Kingdom. The congress was opened by invited lecturers, and during the two days, a total of 84 oral presentations were delivered and 70 posters were presented at poster sessions. A total of 160 scientific papers were published in the book of abstracts. Two scientific geological excursions were organised prior to the congress, and three after. Moreover, an excursion guide was printed as a congress publication.

During the closing ceremony, it was decided that the next congress will be held in four years, i.e. in 2019, in Zagreb, to honour the 110<sup>th</sup> anniversary of the HGI-CGS.



Naslovnice kongresnih publikacija  
Covers of congressional publications

# 44. godišnji kongres Međunarodnog udruženja hidrogeologa

## 44<sup>th</sup> Annual Congress of the International Association of Hydrogeologists

Autorica teksta / Author of the text: dr. sc. Tamara MARKOVIĆ

Od 25. do 29.09.2017. održan je 44. kongres Međunarodnog udruženja hidrogeologa (IAH) "Groundwater Heritage and Sustainability" u Dubrovniku, kojeg su organizirali Hrvatski geološki institut i Hrvatska nacionalna grupa Međunarodnog udruženje hidrogeologa (IAH). Kongres je održan pod pokroviteljstvom Predsjednice Republike Hrvatske, Hrvatskog povjerenstva za UNESCO, Ministarstva zaštite okoliša i energetike i Turističke zajednice Grada Dubrovnika. U okviru osam kongresnih tema (Podzemna voda kao baština – očuvanje za sadašnje i buduće generacije; Održivo upravljanje podzemnim vodama; Modeliranje vodonosnih sustava; Praćenje podzemnih voda – novi pristupi; Podzemna voda u kršu; Hidrogeologija otočnih i priobalnih vodonosnika; Podzemna voda i ekosustavi; Mineralne i geotermalne vode) 549 sudionika je održalo 271 oralnih prezentacija i 167 poster prezentacija. Sudionici su pristigli iz 57 država svijeta. Tijekom kongresa održano je 6 pozvanih predavanja, 3 radionice, 6 stručnih jednodnevnih ekskurzija i 1 trodnevna postkongresna ekskurzija.



Svečano otvorenje kongresa (foto M. Dolić)  
Congress opening ceremony (photo by M. Dolić)



Logotip kongresa  
Logo of the Congress

The 44<sup>th</sup> Annual Congress of the International Association of Hydrogeologists (IAH), "Groundwater – Heritage and Sustainability" was held in Dubrovnik from the 25<sup>th</sup> to the 29<sup>th</sup> of September 2017. It was organised by the HGI-CGS and the Croatian National Chapter of the IAH. The congress was held under the patronage of the President of the Republic of Croatia, the Croatian Commission for UNESCO, the Ministry of Environment and Energy, and the Dubrovnik Tourist Board. Within the eight congress topics (Groundwater heritage – passing benefits to current and future generations; Sustainable management of groundwater resources; Groundwater modelling; Groundwater monitoring – new approaches; Groundwater in karst systems; Coastal and island hydrogeology; Groundwater and dependent ecosystems; Mineral and geothermal waters), 549 participants delivered 271 oral and 167 poster presentations. The participants came from 57 countries around the world. During the congress, six invited lectures were delivered, and three workshops and six professional single-day excursions were held. A three-day excursion was organised after the congress.

# Sedma međunarodna radionica „Neogen centralne i jugoistočne Europe“ The 7<sup>th</sup> International Workshop on the Neogene of Central and South Eastern Europe

Autorica teksta / Author of the text: dr. sc. **Valentina HAJEK – TADESSE**



Logotip radionice  
Logo of the Workshop

Više od osamdeset sudionika iz Europe, Rusije i Turske sudjelovalo je na sedmoj radionici neogena centralne i jugoistočne Europe u Velikoj od 28. do 31. svibnja 2017. godine. Na otvorenju skupa pozvana predavanja održali su Jasenka Sremac (Zagreb), Michal Kováč (Bratislava) i László Csontos (Budimpešta). Na međunarodnoj radionici održano

je dvadeset i pet predavanja, a u poster sekciji prezentirano je dvadeset znanstvenih radova. Drugi dan radionice bio je rezerviran za terenski obilazak šest najreprezentativnijih neogenih lokaliteta Papuka, Požeške gore, Krndije i Dilj gore.

Prije zatvaranja radionice Barbara Studencka predstavila je poljsku kandididaturu za organizaciju slijedeće osme radionice koja će se održati 2019. godine u Chęciny, Poljska. U okviru skupa izdane su dvije publikacije: Knjiga sažetaka i Vodič ekskurzije; a za vrijeme trajanja radionice u Velikoj je u Gradskom muzeju Požege održana izložba pod naslovom „Tajne mikrosvišta Zlatne doline“.

More than 80 participants from Europe, Russia, and Turkey participated in the 7<sup>th</sup> International Workshop "Neogene of Central and South-Eastern Europe". The workshop was held in the town of Velika, from the 28<sup>th</sup> to the 31<sup>st</sup> of May 2017. At the opening of the workshop, Jasenka Sremac (Zagreb), Michal Kováč (Bratislava), and László Csontos (Budapest) delivered the invited lectures. Twenty-five regular lectures were delivered, and 20 scientific papers were presented in the poster session. The second day of the workshop was reserved for a field trip to the six most representative Neogene localities of Papuk Mt., the city of Požega, and Krndija and Dilj Mts.

Before the closing ceremony, Barbara Studencka presented the Polish candidacy for the organisation of the next, 8<sup>th</sup> workshop, to be held in 2019 in the city of Chęciny, Poland. Two publications were published within the workshop: the abstracts book and the excursion guide. Moreover, during the workshop, an exhibition titled "The Micro-World Secrets of the Golden Valley" was held in the Požega City Museum.



Zajednička fotografija sudionika radionice u kamenolomu Radlovac (foto M. Hernitz-Kučenjak)

Group photo of the participants of the Workshop at Radlovac quarry (photo by M. Hernitz-Kučenjak)

# 9. skup srednjoeuropskih grupa za gline

## 9<sup>th</sup> Mid-European Clay Conference

Autorica teksta / Author of the text: dr. sc. **Anita GRIZELJ**

9<sup>th</sup> Mid-European Clay Conference (MECC 2018) održan je od 17. do 21. rujna 2018. godine u Hotelu Dubrovnik u Zagrebu. Glavni cilj ove međunarodno priznate konferencije bio je okupiti istraživače, studente i industrijske partnerne, te raspravljati o različitim područjima istraživanja i primjene povezanim s mineralima glina, zeolitima i drugim silikatnim prirodnim i sintetiziranim materijalima.

Zajednički skupovi nacionalnih grupa za gline iz Austrije, Češke, Hrvatske, Mađarske, Njemačke, Poljske, Slovačke i Švicarske održavaju se redovito svake dvije godine. Na konferenciji u Zagrebu bilo je 123 sudionika iz 28 država.

U sklopu konferencije održana su četiri pozvana predavanja, završna radionica projekta HRZZ – NanoMin, stručna ekskurzija u Hrvatsko zagorje i turističko razgledavanje Zagreba. Organizatori skupa bili su: Hrvatsko geološko društvo, Hrvatski geološki institut te Rudarsko-geološko-naftni i Prirodoslovno matematički fakultet – Sveučilišta u Zagrebu.

The 9<sup>th</sup> Mid-European Clay Conference (MECC 2018) was held from the 17<sup>th</sup> to the 21<sup>st</sup> of September 2018 at Hotel Dubrovnik in Zagreb. The main purpose of this internationally recognised conference was to bring together researchers, students, and industry partners, and discuss different areas of research and application related to clay minerals, zeolites and other natural and synthetic silicate materials.

Joint meetings of the national clay groups from Austria, Croatia, Czech Republic, Germany, Hungary, Poland, Slovakia, and Switzerland are held regularly, every two years. 123 participants from 28 countries participated in the conference in Zagreb.

Within the conference, four invited lectures were delivered and the final workshop of the NanoMin project (funded by Croatian Science Foundation), was held. In addition, a professional excursion to Hrvatsko zagorje and tourist sightseeing of the City of Zagreb were organised. The organisers of the conference were the Croatian Geological Society, the Croatian Geological Survey, the Faculty of Mining, Geology and Petroleum Engineering of the University of Zagreb, and the Faculty of Science of the University of Zagreb.



Stručna ekskurzija u Hrvatsko zagorje – kamenolom zeolitiziranih piroklasta u Donjem Jesenju

Expert excursion to Hrvatsko zagorje – Donje Jesenje quarry of zeolitised pyroclastic rocks

# 60. obljetnica Međunarodnog udruženja hidrogeologa

## 60. Anniversary of the International Association of Hydrogeologists

Autorica teksta / Author of the text: dr. sc. Tamara MARKOVIĆ

Povodom obilježavanja šezdeset godina postojanja Međunarodnog udruženja hidrogeologa (IAH) i dvadeset tri godine postojanja Hrvatske nacionalne grupe pri Odsjeku za hidrogeologiju Hrvatskog geološkog društva, 30. studenog 2016. godine u HGI-CGS-u je održan Okrugli stol. Okruglom stolu prisustvovale su 24 osobe. Održano je predavanje *Dosadašnja postignuća, sadašnje aktivnosti i budući izazovi IAH-a i Nacionalne grupe*, autora Tamare Marković, Johna Chiltona, Staše Borović, Willija Struckmeiera i Željka Miklina. Dodijeljena su priznanja Anti Šarinu, Božidaru Biondiću, Pavlu Miletiću, Darku Mayeru i Kostu Urumoviću za uspješno dugogodišnje djelovanje u sklopu nacionalne grupe Međunarodnog udruženja hidrogeologa pri Odsjeku za hidrogeologiju Hrvatskog geološkog društva.

A round table event was organized on the 30<sup>th</sup> of November 2016 at the Croatian Geological Survey to honour 60 years of the International Association of Hydrogeologists (IAH) and 23 years of the Croatian National Group of the IAH in the Hydrogeology section of the Croatian Geological Society. Twenty-four people attended the round table. Lectures on the achievements, current activities and future challenges of the IAH and the National Group were delivered by Tamara Marković, John Chilton, Staša Borović, Willi Struckmeier and Željko Miklin. Moreover, awards were presented to Ante Šarin, Božidar Biondić, Pavao Miletić, Darko Mayer, and Kosta Urumović Sr., for long-term successful work within the National Group of the IAH in the Hydrogeology section of the Croatian Geological Society.



Otvorenje skupa (foto V. Sučić)  
Opening ceremony of the meeting (photo by V. Sučić)

# Geoznanstveni sat

## Geoscientific Hour

Autorica teksta / Author of the text: dr. sc. **Željka BRKIĆ**

Čime je predstavljena baza badenskih transgresija na podlogu Medvednice? Što nam govore multi-proksi rekonstrukcije? Što se od nas očekuje u projektima vezanim za mineralne sirovine, hidrogeologiju i geotermiju u okviru GeoERA-e? Što mi očekujemo od GeoERA-e? Kakve su mogućnosti primjene georadar-a u geološkim istraživanjima? Kako napisati znanstveni rad i prezentirati ga? Na sva ta, ali i mnoga druga pitanja, odgovaraju istraživači HGI-CGS-a i njihovi gosti.

Cilj Geoznanstvenog sata je upoznati djelatnike HGI-CGS-a s istraživanjima kojima se bave ostali djelatnici, te omogućiti razmjenu istraživačkih spoznaja. Osim istraživača HGI-CGS-a, predavači su domaći i inozemni stručnjaci i znanstvenici. Održavanje Geoznanstvenog sata uspostavljeno je 2018. godine. Zamišljen je kao sat druženja u okviru kojega će se otvoriti rasprave o aktualnim i novim područjima istraživanja i donijeti ideje o novim projektima i suradnjama.

What represents the base of the Badenian transgressions onto basement rocks of Medvednica Mt.? What can multi-proxy reconstructions tell us? What is expected from us in projects related to mineral resources, hydrogeology and geoenergy within the GeoERA? What do we expect from GeoERA? What are the possibilities of ground penetrating radar applications in geological exploration? How to write a scientific paper and present it? All these and many other questions will be answered by the researchers of the HGI-CGS and their guests.

The aim of the "Geoscientific hour" is to familiarise the staff of the HGI-CGS with other employees' research and facilitate the exchange of research results. In addition to the researchers of the HGI-CGS, the lecturers are also domestic and foreign experts and scientists. The "Geoscientific hour" was established in 2018. It is conceived as a social gathering session, where discussions of current and new areas of research are conducted and ideas on new projects and collaborations are introduced.



Predavanje na Geoznanstvenom satu  
A lecture at the Geoscientific hour

# 85. rođendan akademika Branka Sokača

## 85. Birthday of Academician Branko Sokač

Autor teksta / Author of the text: dr. sc. **Tonći GRGASOVIĆ**

Dana 15. lipnja 2018. godine održana je svečanost povodom 85. rođendana akademika Branka Sokača, posvećena njegovom doprinosu hrvatskoj geologiji i HGI-CGS-u. Skupu su se odazvali brojni umirovljeni i aktivni djelatnici HGI-CGS-a kao i članovi Hrvatske akademije znanosti i umjetnosti, te kolege i kolege s Prirodoslovno-matematičkog i Rudarsko-geološko-naftnog fakulteta Sveučilišta u Zagrebu, Hrvatskog prirodoslovnog muzeja i Hrvatskog geološkog društva.

Pozdravne govore održali su ravnatelj HGI-CGS-a i predstojnica Zavoda za geologiju, prezentirajući bogato ilustriranu knjižicu izdanu u povodu ovog skupa. Biografiju akademika Sokača, ilustriranu povijesnim fotografijama, prezentirao je Tonći Grgasović. O doprinosu akademika Sokača izradi OGK govorio je Tvrtko Korbar, naglasivši važnost ovog projekta za RH. O doprinosu akademika Sokača istraživanju fosilnih vapnenačkih algi, u čemu je zasluzio svjetsko priznanje, govorio je Tonći Grgasović.

Kao rođendanski poklon akademiku je uručena knjiga s popisom preprata rodova i vrsta koje je do sada opisao, uz ilustracije svih novih taksa fosilnih algi. Radi se o 78 novih taksa, od toga 12 rodova, 62 vrste i 4 varijeteta, što je izuzetan broj.

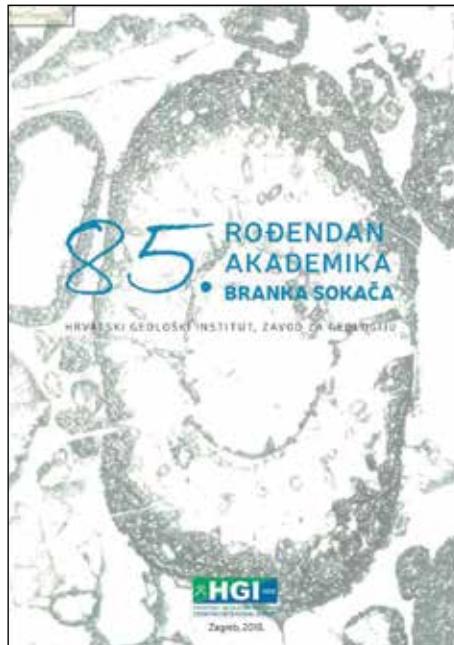
Skupu se obratili i akademik Ivan Gušić i predsjednik Hrvatskog geološkog društva Davor Pavelić. Na kraju je zahvalnost svima izrazio i slavljenik.

On the 15<sup>th</sup> of June 2018, a celebration was held on the occasion of the 85<sup>th</sup> birthday of academician Branko Sokač, and devoted to his contribution to Croatian geology and the HGI-CGS. Numerous retired and active employees of the HGI-CGS attended the ceremony, as well as members of the Croatian Academy of Sciences and Arts, colleagues from the Faculty of Science and Faculty of Mining, Geology and Petroleum Engineering of the University of Zagreb, and colleagues from the Croatian Natural History Museum and the Croatian Geological Society.

Introductory speeches were delivered by the director of the HGI-CGS and by the head of the Department of Geology. They presented a richly illustrated booklet issued in the scope of this ceremony. The biography of academician Sokač, illustrated by historical photographs, was presented by Tonći Grgasović. He also gave a speech on the contribution of academician Sokač to the research of fossilised limestone algae, which is recognised worldwide. Tvrtko Korbar delivered a speech on the contribution of academician Sokač to the production of the basic geological map, emphasizing the importance of this project for the Republic of Croatia.

As a birthday gift, a book was presented to the academician, with a list of genera and species he described so far, along with illustrations of all new taxa of fossil algae. This constitutes 78 new taxa, among which 12 genera, 62 species and 4 varieties, which is a remarkable number.

Academician Ivan Gušić and the president of the Croatian Geological Society Davor Pavelić also delivered speeches. In the end, academician Sokač expressed his gratitude to everyone.



Naslovница prigodne publikacije  
Cover of the honorary publication

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