

Atti e Memorie della Commissione Grotte “E. Boegan”	Vol. 54 (2025)	pp. 3-24	Trieste 2025
--	----------------	----------	--------------

JOHANNES MATTES*

THE MAKING OF “CLASSICAL” KARST: SERBIAN GEOGRAPHER JOVAN CVIJIĆ, (INTER) NATIONALISM, AND THE EMERGENCE OF KARST SCIENCES, 1870–1914

This article examines the development of geomorphological and hydrological research on karst landscapes in Central and Southeast Europe in the period before 1914. It provides novel insights into the introduction of the term “karst,” originally the name of a cavernous limestone plateau east of the Adriatic city of Trieste, as a universal model for comparing and understanding dissolutional features in soluble rocks. Based on a critical reappraisal of the seminal work “The Karst Phenomenon” (1893) by the Serbian geoscientist Jovan Cvijić (1865–1928), submitted as a Ph.D. thesis at the University of Vienna, my essay argues for a reassessment of the beginnings of karst sciences. It gives more attention to research as a cooperative enterprise and to the interplay between the internationalization of geoscientific knowledge and the emerging national claims to the Balkan Peninsula and its inhabitants. Approaching the topic from a history of science perspective, I will analyze the epistemic, political, and social dimensions of early karst research at three different stages, namely, its emergence as an imperial undertaking in the Habsburg Monarchy, its synthesis and systematization through Cvijić’s “Karst Phenomenon,” and the final establishment of the Dinarides’ northwestern part as the “Classical” Karst.

INTRODUCTION

“The Karst is a living picture of desolation, transcending all imagination. An area of at least two by three [German] miles in extent, bordered by sheer naked karst rocks, contains nothing but a million stones left over from receding flood” (HERMANN, 1781: 48). There might be few comparable cases in which such a limited area, with its wealth of geomorphological features, has become representative of many global phenomena, and its study a distinct specialty, namely, karstology (karst sciences). According to FORD AND WILLIAMS (2007), karst terrains cover approximately 20% of the Earth’s dry ice-free surface and contribute up to 25% of the total drinking water supply of the world. Karst scientists consider them as a type of landscape with distinctive hydrology where the dissolution of soluble bedrocks, such as limestone, dolomite, marble, or gypsum, has created sinkholes, underground streams, caves, springs, and other features (KRANJC, 1997; KNEZ et al., 2020). The name originates from a barren plateau in the hinterland of the Bay of Trieste (Adriatic Sea), which in Slovenian is called “Kras”, in Italian “Carso”, and in German “Karst” (KRANJC, 1994). From the eighteenth century onward, naturalists and travelers, including the aforementioned BENEDICT

¹ Institute of Culture Studies, Austrian Academy of Sciences, 1010 Vienna, Austria.

* Corresponding author: E-mail: johannes.mattes@oeaw.ac.at

FRANZ HERMANN (1755–1815), traversing the area along ancient trade routes between Trieste and Vienna, compared its features with landscapes in Southeast Europe. This gradually extended the geographical scope of the toponym beyond the traditionally defined or “classical” karst area. Until 1918, this plateau formed part of the multinational Habsburg Monarchy, and the study of karst landforms and hydrology at the end of the nineteenth century was supported by the government because of large-scale public undertakings for water supply and reforestation.

The Serbian geoscientist JOVAN CVJIĆ (1865–1927; Fig. 1a) was the first to classify karst features and to propose a unified typology that is still widely in use to this day (GÈZE, 1983). His notable Ph.D. thesis “Das Karstphänomen” (The Karst Phenomenon, 1893; Fig. 1b), which he completed as a student of the world-renowned geographer ALBRECHT PENCK (1858–1945) and geologist EDUARD SUSS (1831–1914) at the University of Vienna, is considered the starting point of “proper karst studies in the Western world” (DE WAELE AND GUTIERREZ, 2022: 2). Cvjić’s thesis synthesized the international literature, discussed the variety of large- and small-scale features in sequence, and provided an overview of the worldwide distribution of karst terrains. Soon recognized as a standard reference, over time, his study significantly contributed to establishing the Dinaric Karst as the world reference site for dissolutional landforms and aquifers. The thesis also introduced Slavic terms, such as “polje” (karst plain), “doline” (enclosed depression), or “ponor” (swallow hole) to the international scientific community (STEVANOVIĆ AND MIJATOVIĆ, 2005). On the occasion of the 130th anniversary of the publication of Cvjić’s influential book, a critical review of its genesis, sources, and impact is timely.

The history of karstology has so far been researched mainly by eminent members of the specialty, often to mark anniversaries of founding figures or scientific societies. Particularly valuable are studies by GAMS (1973) and KRANJC (2011) on the origin of the term “karst,”

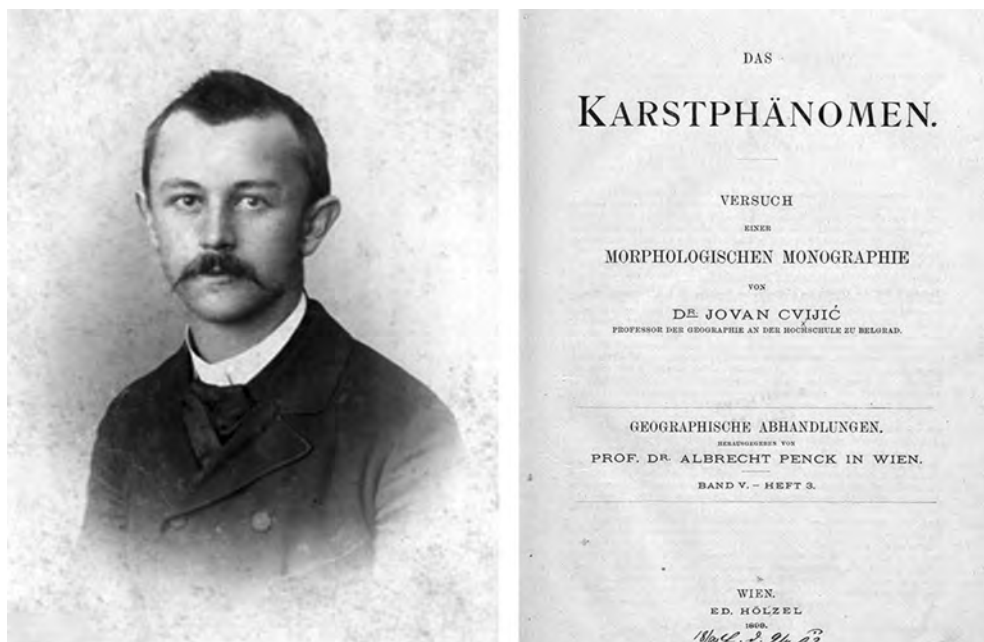


Figure 1a-b. (left) Jovan Cvjić as a doctoral student, c. 1893, photographer: Milan Jovanović (Belgrade); (right) Title page of Cvjić’s printed dissertation “The Karst Phenomenon” (1893).

FORD (2007) and STEVANOVIĆ (2013) on Cvijić's geomorphological and hydrological works, and SHAW (1992) and MATTES (2015) on early karst research and its overlap with speleology (cave and karst studies). JOVIĆ AND KOSTIĆ (2015) and JOVIĆ AND PETROVIĆ (2015), among others, published comprehensive surveys of Cvijić's life and scientific legacy. Historical geographers, in turn, dealt with his ethnographical studies and the political influence he gained in the aftermath of WWI as an advisor to the Paris Peace Conference and the border demarcations on the Balkan Peninsula (CRAMPTON, 2006; SEEGL, 2018; GÓRNY, 2019). Noteworthy are the contributions of GINSBURGER (2015; 2016) to transnational networks and conceptual exchanges between Serbian, French, and American geographers. FORD AND WILLIAMS (2007) and TRUDGILL (2008) situated Cvijić's work within the broader field of geomorphology, as did a comprehensive book on his mentor Penck and the "Viennese School" of physical geography by HENNIGES (2017a). However, with a few welcome exceptions, such as MAIS (1989), GAUCHON (1999), ČALIĆ (2007), and VOGEL (2019), we know much less about research activities before the "Karst Phenomenon," especially when it comes to independent researchers without university affiliations. More remarkably, although scholars, such as MISHKOVA (2018) and DEMETER AND BOTTLIK (2021), have examined Cvijić's ethnological studies and maps of the Balkans within the context of pre-WWI Serbian territorial claims and Yugoslav state-building, his geomorphological work, usually seen as "purely scientific," has rarely been analyzed from this perspective.

This article argues for a reappraisal of the "Karst Phenomenon" and thus of the beginnings of karst sciences as a specialty. My essay also seeks to shift the understanding of these early steps from an individual achievement of one or a few "professional" geoscientists to a collaborative endeavor by a range of local, regional, and (trans)national practitioners driven by public benefit and the hope of personal gain. I also argue for a better consideration of the political dimensions involved in making the "Classical" Karst a model for dissolutional phenomena, and for understanding this development as a power-related interaction process supported by a close (trans)national community of academic geographers. While KLIMCHOUK (2015), referring to the science theorist Thomas Kuhn, used the term "karst paradigm" (a set of thought models) to describe the shift from a "traditional understanding of karst" to current research trends, my article is inspired by LUDWIK FLECK'S (1935) concept of "thought collective" (Denkkollektiv) and "thought style" (Denkstil). By explaining what and how individuals within a collective (must) think at a given moment, this theory—similar to Kuhn's notion of paradigm—highlights the influence of communities on knowledge production. However, this theory goes further in recognizing that knowledge is the result of social interaction and that transformations in scientific thought are often not abrupt but involve divergent developments.

Based on a (re)evaluation of historical sources on early karst research in Central and Southeast Europe, I will ask: Under which changing conditions, goals, and profit expectations did different stakeholders engage in karst research, which resources did they tap, and which (collaborative) practices did they develop? To what extent did Cvijić's "Karst Phenomenon," through literature review and synthesis, influence the accreditation of existing knowledge, and what role did his fieldwork play? What does this mean for the establishment of the "Classical" Karst as a world reference site, and how did discipline formation in the geosciences and competing concepts affect this process? Therefore, I will not deal with the historical breadth of naturalists studying various phenomena in soluble rocks. Rather, I will analyze the emergence of a scientific community sharing the same theories, methods, and visions of karst at three key stages: the origin of karst research as a cooperative undertaking in the late Habsburg Monarchy, its synthesis and systematization in Cvijić's "Karst Phenomenon," and the final establishment of the "Classical" Karst as a type area.

“KARST KNOWLEDGE” IN THE MAKING: AN IMPERIAL ENTERPRISE?

In the late 1880s, as Cvijić was earning his spurs in field research by exploring the mountains and caves of Serbia, karst and its understanding as a phenomenon affecting many territories across Southeast Europe was already a hot topic in the Habsburg Monarchy. This concerned not only geological and hydrological issues but also paleontological and prehistoric findings made at karst sites, and especially the practical applicability of such knowledge. Railroads linking the capital Vienna with the Adriatic, the Alps, and the Balkans had brought karst environments within reach, and along with them, public and private interests in their exploitation to the fore: as tourist sites, as sources of drinking water, or as forestry and agricultural lands. However, “karst knowledge” relied not only on field studies by “experts” but also on indigenous knowledge of (subsurface) topography, hydrographical conditions, or cultivation practices, which was evaluated by them and then, in accredited form, compared with other karst regions. Given that karst landscapes, with their multilingual populations, were often borderlands or the focus of Habsburg’s expansive claims, knowledge about these areas also had geopolitical significance and was even used for military operations.

In the first half of the nineteenth century, traveling and resident scholars, accompanied by local guides, studied karst features as part of their natural, historical, and/or cultural interests in individual regions. Accounts of discoveries in Postojna Cave (Carniola), visited by the imperial family, and their development for touristic purposes shifted the attention of visitors from the barren surface of karst terrains to their subterranean beauty. An illustrated guidebook published to this end by the naturalist FRANZ VON HOHENWART (1830) already indicated the extent of the Karst southward to the Ionian Islands. Possibly the first to discuss the “type of karst formation” with sites outside the Dinarides was FRIEDRICH SIMONY (1813–1896), later the founding professor of geography at the University of Vienna. Based on his excursions on the Dachstein Mountains (Northern Alps), SIMONY (1847: 56–58) compared its “surface” and the “closely related cave formation” with similar features in the limestone area around Brno. According to him, the “shape of the terrain” with “basins, crater-like depressions, and deeply carved gorges” was the outcome of erosion-caused “collapses of cavities.” Although Simony soon turned his attention back to glacial phenomena, his paper, given before the Friends of Natural Sciences in Vienna, the capital’s first scientific society, stimulated the sharing of knowledge from other karst areas. This included, for example, an account of the spectacular attempt by Trieste engineers to solve the water shortage of the city by locating and tapping the Reka River, running 330 m below the surface (LINDNER, 1841; MORLOT, 1848).

After the political upheavals of 1848/49, the karst-related issues raised among the dissolved “Friends” were further researched by individual scholars, with an emphasis on describing, comparing, and classifying the diversity of topographical features. ADOLF SCHMIDL (1858), an official of the Imperial Academy of Sciences, toured the Monarchy’s main limestone areas and documented their peculiarities and similarities through his observations, measurements taken by technicians, and interviews with local naturalists and indigenous peoples. However, he still used “Karst” as a regional toponym and, in keeping with his primary interest in subterranean features, coined the term “Höhlenkunde” (cave study) (SCHMIDL, 1854). Travelers to the then Ottoman-ruled Bosnia, Montenegro, and Serbia, such as the German writer JOHANN KOHL (1851) and the French–Austrian geologist AMI BOUÉ (1856), related the landforms they encountered to those of Carniola but still switched between the toponymical and geomorphological meanings of the word “karst.” BOUÉ (1861) was also the author of the first systematic study of sinkholes (or dolines), attributing their formation in limestone, salt beds, gypsum, or sandstone to the action of surface and subsurface water. By noting that karst features also occur in Greece, Minor Asia, and Syria, Boué finally detached the term from its local reference.

Apart from the aforementioned individual ventures, the founding of empire-wide scientific

institutions in 1850s Vienna, especially the Geological Survey and the Geographical Society, made the karst areas of the Habsburg Monarchy the object of collaborative work. To increase the efficiency of governance and scholarship, this new type of research relied on the Habsburg central administration and its intellectual agenda to preserve the statehood of the empire in the face of internal and external crises (ASH AND SURMAN, 2012; COEN, 2018). Large-scale data-collecting undertakings, such as topographical, agricultural, or meteorological surveys, herbaria, and recordings of antiquaries, sought to determine and dismantle disparities within the Monarchy and legitimize its territorial framework as a natural and cultural unit. While some of these campaigns aimed to accumulate and accredit (geographical) knowledge of volunteering contributors across the empire (MATTES, 2024), others were planned and funded collaboratively but conducted by a few experts, such as the geological survey of all Habsburg territories (KLEMUN, 2012).

The latter venture resulted in a unifying map published in 1867 that, among others, indicated the type, age, and distribution of limestone formations based on measurements and samples taken in the field. In particular, the survey of Carniola in the course of the Ljubljana–Trieste railroad construction had led the geologists in charge to the generalizing hypothesis that the “internal and external character of karst” manifests itself “in various limestones” (STUR, 1858) and that their features are due to “chemical erosion” (LIPOLD, 1858). The sources and experiences gathered in these intra-imperial projects became a common reference for later state-run (military) geoscientific surveys extending beyond the Habsburg Monarchy, either at the invitation of the Ottoman Empire and independent Balkan states or as a follow-up to the occupation of Bosnia (1878) by Habsburg forces. Notably, EMIL TIETZE (1873) elaborated on the early understanding of karst as a geomorphological type and applied it to many of the landforms he studied as a fellow of the Geological Survey in Southeast Europe, Asia Minor, and Persia. Overall, the development of the term “karst” as a model of thought unifying different Habsburg territories contributed to the creation of a scientific framework for imperial identity. Subsequent mapping of karst areas throughout the Balkans and the Middle East was a precursor to the internationalization of the model (DIENER, 1886).



Figure 2. “Cultural-geographical map of the Liburnian (Croatian) coastal karst”, indicating the terrain, geognosy, natural and cultivated vegetation, author: Lorenz (1860, Tab. III).

With the ecological studies of the Rijeka teacher and naturalist, and later a senior official of the Ministry of Agriculture, Joseph Lorenz (1860), the notion of karst as an environment threatened by deforestation and water scarcity gained prominence. Noting that the lack of vegetation in the “Croatian coastal karst” is the result of historical overexploitation and that the “karst plateau” “descends toward the sea, becoming drier from top to bottom,” Lorenz developed a vision of karst terrains as a landscape type where hydrological, soil, and climatic conditions are interdependent (Fig. 2). Inspired by his work, the authorities of several crownlands, in partnership with Viennese ministries and forestry research institutions, engaged in the “reforestation and cultivation” of the Dinaric Karst. To this end, forestry officials first tested possible measures in limited areas and then, if successful, transferred them as a model to other territories at risk of “karstification” (*Verkarstung*), which, according to the influential forestry scientist JOSEPH WESSELY (1876: 88), could thus be raised to the “cultural level” of the Habsburg Monarchy. Behind these cross-regional efforts to transform entire landscapes from their “neglected state” to a “more humane” one were not only economic motives but also stereotypical images of the Balkan Peninsula as the “European Orient,” embodying Habsburg policymakers’ notion of the empire as a “cultural state” and its civilizing mission toward the “East.” According to the idea of “cultural work” (*Kulturarbeit*) – as it was adopted and further elaborated by Penck – Germans and other “civilized nations” were entitled to cultivate (karst) environments inhabited by indigenous Slavic-speaking populations and thereby acquire a territorial claim to these areas (JUREIT, 2012). The attribution of the term “karst” to areas beyond the Monarchy thus promoted the notion of their potential for “civilization” and integration and ultimately underpinned Habsburg’s expansive claims.

In the 1870s, with the opening of the Eastern Alps to tourism and the construction of pipelines to supply the cities of Vienna and Salzburg with water from karst aquifers, considerable public interest in the surface and subsurface of karst environments arose. The first Society for Cave Study (1879), established in the Habsburg capital, followed previous imperial efforts to pool data, sources, and specimens from all karst areas of the Monarchy and to centralize them in a register (*Kataster*). Relying on public engagement, non-expert observation, and knowledge based on expert-lay communication, research in this Society was a holistic and inclusive endeavor (FRUWIRTH, 1883/85). However, its contributors worked closely with the Vienna Natural History Museum and the Imperial Academy of Sciences, providing them with paleontological and prehistoric findings. Reports of periodic flooding in the poljes of Carniola led to the establishment of the Karst Committee (1881) as a private-public partnership, composed of Society members, ministry officials, and eminent geoscientists (HAUER, 1880). The purpose of the Karst Committee was to manage the monitoring and melioration (e.g., the opening of blocked sinkholes) of various karst areas initially by private individuals on behalf of the government and then by forestry officials (MATTES, 2012). Over the following years, karst research societies emerged in several crownlands, such as the Littoral, Moravia, and the Carpathians, often associated with Alpine clubs and separated according to nationality. Following the empire-wide Society for Cave Study, these societies created registers of karst features at the regional level; however, their activities focused more on exploration and recreational aspects, and some of them also engaged in the development of karst areas for touristic purposes.

This leads us to two preliminary conclusions: First, the making of “karst knowledge” hinged on the territoriality of Habsburg imperial rule and the way research was organized to serve both state and civil society interests. Originally a tool for scholars to compare topographical and geological features across regions, the term “karst” evolved into a versatile model of thought for systematizing and applying large bodies of earth (scientific) knowledge gathered through empire-wide ventures and public engagement. The potential applications of this knowledge, spanning tourism, environmental engineering, and geoscientific pursuits, are

exemplified by three interpretations of the term in the public discourse of the 1880s, namely, a local place name, a geographical landscape type, and a geologically determined “formation of the ground” (KARRER, 1884). Second, the idea of karst formation, similar to many other contemporary geographical or geological thoughts, was embedded in power-political contexts, implying stereotypical notions of center and periphery, culture and wasteland, and Europe and the “Orient.” Until the 1880s, the discussion on karst remained predominantly confined to the German-speaking (scientific) communities within and beyond the Monarchy. Building on a shared framework of concepts, practices, and values, scientific institutions in the Habsburg capital and their counterparts in the crownlands constituted a “thought collective” that, in response to socio-political challenges, advocated for the development of models and typologies to address natural and cultural diversity. While scientists investigated karst formations to enhance understanding and generalize processes related to earth and the environment, for the bureaucracy, it became a governance tool, facilitating the transfer of forestry, land, and water management projects tested in one karst area to others.

DRAFTING THE “KARST PHENOMENON”: LITERATURE SYNTHESIS AND FIELD OBSERVATIONS

Although the history of geology scholarship widely considers the “Karst Phenomenon” thesis as a forceful breakthrough that led to the establishment of a new field of research, Cvijić did not start his studies from scratch. It is difficult to imagine his success without mentors, the fieldwork experience gained as a student, and the sources of the aforementioned researchers, sometimes forgotten today, whose fundamental work served as a springboard for his career. Having graduated in natural sciences from the Velika Škola (Great School) in Belgrade and having worked as a teacher for a year, Cvijić moved to Vienna in 1889 on a scholarship from the Serbian Ministry and attended lectures at the University of Vienna for six semesters (MATTES, 2018). Back then, the capital of the Habsburg Monarchy was one of the geoscientific centers in Europe, attracting promising Ph.D. candidates from the southeast of the continent and beyond (COHEN, 2015; KLEMUN, 2018). The Leipzig-born geographer Albrecht Penck, just a few years older than Cvijić, was appointed professor at the University of Vienna in 1885. He introduced excursions and practical fieldwork to the regular curriculum and, at that time, was working on geomorphology and karst landforms (PENCK, 1894; HENNIGES, 2017a). Cvijić’s second mentor, the Viennese geologist Eduard Suess, a leading member of the Imperial Academy of Sciences, was already world-famous for his work “Das Antlitz der Erde” (The Face of the Earth, 1883–1909). In this multivolume book, he created a worldwide synthesis of the empirical work done over the previous decades (mostly on regional rock strata), thus “globalizing” his tectonic concepts originally based on fieldwork in the Alps (Westermann, 2010).

Cvijić (1893: 219) similarly aimed to synthesize all existing research on karst landforms in a “summarizing monograph” drawing on both “personal observations and literary sources.” Although this was not his initial intention upon arriving in Vienna, Cvijić’s (1887/88) earlier work in Belgrade, which focused on establishing precise geographical terms in Serbian for international standardization purposes, laid the groundwork for his subsequent endeavors. Participation in Penck’s excursions to the Dachstein Mountains and the Moravian Karst likely played a pivotal role in shaping the focus of his thesis. In the field, Penck’s students learned to “adopt a geographical gaze” and to identify, analyze, and reinterpret landscape features through joint observation and mapping exercises (HENNIGES, 2014). In addition, Cvijić undertook extensive self-guided trips throughout the Dinarides, not least to the “classical” karst areas of Carniola and Istria, where he applied and refined his visual expertise. In exploring the more remote mountain ranges of eastern Serbia and Montenegro, he benefited from his

language skills and the support of his former teacher, JOVAN ŽUJOVIĆ (1856–1936). The observations Cvijić made there led to his first publications (1889; 1891), including two essays on Prekonoška Cave and Kučaj Karst (Serbian Carpathians). Another source of inspiration for Cvijić's work was the wealth of papers on hydrology and cave formation presented in Viennese associations, such as the Geographical Society, the University Club of Geographers, and various Alpine clubs. Particularly noteworthy is an article published on behalf of the Habsburg General Staff, following the topographical survey of Bosnia by the Vienna Military Geographical Institute, as it already outlined a typology of karst phenomena, encompassing "poljes," "dolines," and "ponors," and delineated four intensity "levels of karstification" (L.B.B., 1889).

In developing his nomenclature of karst phenomena, Cvijić encountered methodological challenges similar to those confronted by Suess, particularly in validating, comparing, and generalizing research data gathered from literature studies and personal fieldwork. On the one hand, a significant portion of publications on karst features did not stem from university or survey-affiliated scientists, but rather from local and "non-professional" researchers with varying observation and interpretation methods. On the other hand, the results needed to be contextualized within the international research landscape – a dimension often overlooked in the intra-Habsburg discourse. However, the endeavor to link and globalize these diverse bodies of karst knowledge also raised epistemological issues, such as the accuracy and objectivity of research outcomes. This proved essential for the credibility of the geosciences as they became increasingly specialized and professionalized in the late nineteenth century (HENNIGES, 2017a). The need for credibility was particularly pronounced in the controversial field of geomorphology, which emerged as a new sub-discipline during the "geologization" of geography in the 1880s (BÖTTCHER, 1979). Under the influence of Penck, who focused on exogenous processes like weathering, erosion, and denudation, and the Berlin geographer FERDINAND VON RICHTHOFEN (1886), geomorphology gained prominence, especially within the German-speaking scholarship (WARDENGA, 1995). As such, geomorphology provided a new empirical basis for the diverse field of university geography, which was previously molded by a range of historical, statistical, and topographical approaches.

To successfully meet these challenges, Cvijić (1893: 220) adopted two strategies that added reliability to the "elaboration of all observational material from the literature" he examined in the library of the Vienna Natural History Museum: First, by restricting his scope to surface landforms, he set his research apart from the study of caves, a field that was increasingly seen as "amateurish" as other branches of the geosciences gained recognition as academic disciplines. Nevertheless, Cvijić eagerly made use of the rich sources provided by the speleological community. These sources included, for example, the expedition reports (*Grottenbücher*) of the Alpine Club in Trieste, whose representatives, following Penck's advice (1891: 202), had "entrusted to his student the scientific material ... probably worthy of publication in its entirety." Second, Cvijić accentuated the importance of his fieldwork, even though numerous arguments in his thesis were derived from the selection, analysis, and systematization of (published) observations made by other researchers. This emphasis served to highlight his practical skills and the empirical foundation of his findings. Furthermore, he portrayed himself as a geographer dedicated to on site research – a professional identity cultivated by Penck in his teaching, exemplified on excursions, and ultimately internalized by his students (HENNIGES, 2014). Later on, however, Cvijić applied many of the observational methods learned during these trips, such as identifying, documenting, and comparing visual patterns in landscape morphology (WARDENGA, 1995), to his literary analysis. For instance, by examining the topographical maps collected in the *Grottenbücher*, he was able to identify new types of depressions.

When organizing this knowledge into chapters with descriptions and examples of typical landforms (or groups of them), including "karren," "dolines," "karst rivers," "karst valleys,"

“poljes,” and “the Adriatic karst coast,” Cvijić drew inspiration from earlier studies of individual karst regions. Discussing these features from the smallest to the largest, he adhered to didactic conventions and considered the prevalent interest in, and extensive literature on, small and mid-sized structures. Accordingly, the “Karst Phenomenon” was not a balanced work. Karst rivers and coastal karst landforms occupied only six pages each, whereas the chapter on dolines alone, which included many vertical caves, took up nearly half of the 112 pages. For Cvijić (1893: 226), dolines were the “characteristic feature of karst formations” and indicative of other dissolutional phenomena (FORD, 2007). In the polarized discourse on doline formation, a debate unfolded between two senior fellows of the Vienna Geological Survey, EDMUND VON MOJSISOVICS (1880) and Penck’s rival, EMIL TIETZE (1880), Cvijić (1893: 272) unsurprisingly supported the former’s hypothesis. Similarly, he argued that “true dolines” result from “chemical erosion,” that is, dissolution initiated by “penetrating [rain]water” and its associated “carbon dioxide,” progressing downward from the surface. Nevertheless, out of respect for Tietze and numerous Habsburg speleologists (KRAUS, 1887; PUTICK, 1889), who held the opposite view that dolines are formed by mechanical collapse of an underlying cave, Cvijić did not question their field observations. Instead, he drew different conclusions from them and, in a few cases, acknowledged a collapse origin (today both hypotheses are accepted).

Particularly remarkable is Cvijić’s concluding chapter on the worldwide distribution of karst terrains. In this section, he aimed to systematically organize all of the knowledge on limestone landforms published in German, French, and English, categorizing it based on geological periods. Recent hydrographical studies conducted by the geologists JOSEPH FOURNET (1858) and GABRIEL DAUBRÉE (1887) in central southern France, as well as speleological explorations led by the lawyer ÉDOUARD-ALFRED MARTEL (1889), prompted Cvijić (1893: 218) to regard these karst areas as “a side piece to ... Carniola.” Extracting these and other international sources from Indiana (COX, 1874), South Australia (WOODS, 1862), and Syria (DIENER, 1886), he identified variations in karstification types and intensities attributed to the age, composition, and tectonics of different limestones. Another noteworthy contribution by Cvijić is his promotion of terms borrowed from South Slavic languages, such as “doline,” “polje,” or “ponor.” Although these terms had been introduced in earlier studies on regional karst areas, authors, such as REYER (1881), still employed them with varying meanings or alongside synonyms in other languages. To standardize their use, Cvijić provided names of typical landforms in other European languages or dialects, as well as uniform definitions based on morphological criteria, while considering geological and hydrological conditions. For instance, Cvijić distinguished poljes from sinkholes by their size, longitudinal extension, and flat bottom and from karst valleys by their wide trough shape and water drainage.

In presenting his findings, Cvijić adopted a more scholarly approach than many of Penck’s other Ph.D. students, which involved employing a sober, descriptive writing style, free of political or cultural judgments. In addition, he used content-related tools to gain the trust of his academic audience, including an extensive footnote apparatus and tables with detailed quantitative data on individual landforms, albeit, to some extent, extracted from maps and literature. In doing so, Cvijić not only demonstrated the richness and in-depth study of his material but also deliberately distanced himself from the perceived “amateurish” origins of some of the sources he interpreted. The few illustrations included in the thesis, particularly two of alluvial dolines (sinkholes in sedimentary deposits) taken during Cvijić’s travels in Serbia, reinforced his self-image as a skilled field researcher and conveyed a sense of authenticity (Fig. 3a). Although these two figures were not actively integrated into his argument, they depicted the characteristics of the corresponding landforms, aiding potential users in recognizing them in the field. A notable exception is Cvijić’s diagram illustrating a section of a doline exposed in a railway cut at Logatec train station in Carniola (Fig. 3b). Without evidence of a cavity beneath the depression, the diagram refuted the idea of doline formation by collapse and thus served

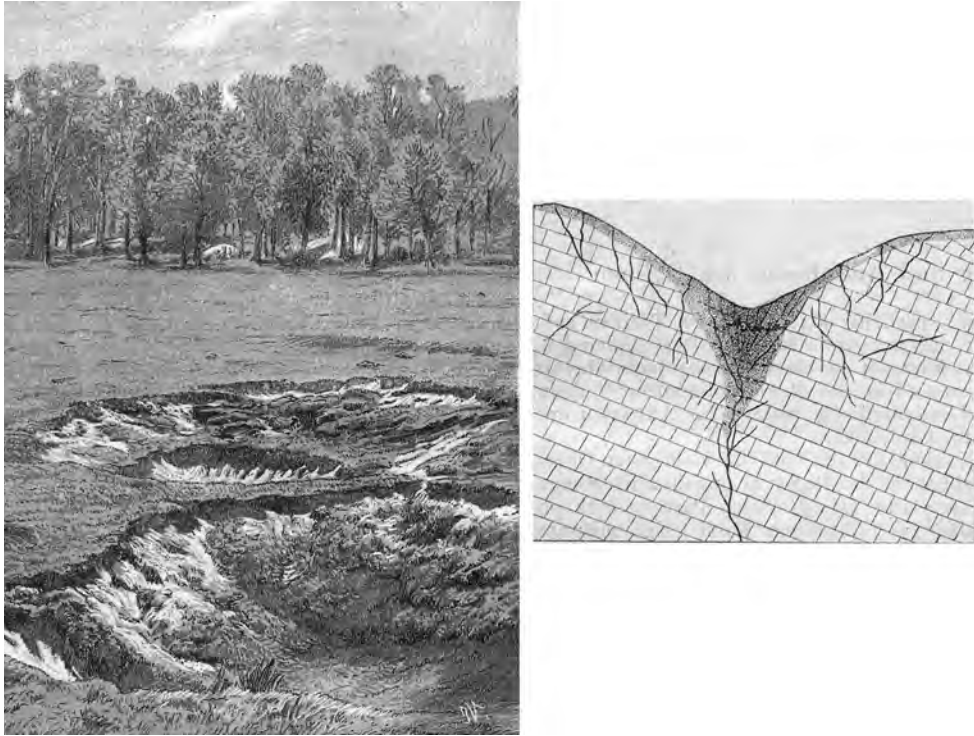


Figure 3a-b. (left) Depiction of an alluvial doline in the Kučaj mountains (eastern Serbia); (right) Cross-section of a 3 m deep dissolution doline at Dolenji Logatec (Slovenia), author: Cvijić (1893: 259).

Cvijić as an explanatory model for his hypothesis (FORD, 2007). In the subsequent years, the Logatec railway cut even became the holotype for dissolution dolines and was persistently reproduced in textbooks. However, recent research (ŠUŠTERŠIČ, 1994; STEPIŠNIK, 2015) re-examining the site has cast doubt on Cvijić's observations and disproved its dissolutional origin.

In summary, the "Karst Phenomenon" thesis relied on accumulating sources about landforms in soluble rocks to compare, (re)organize, and apply this empirical knowledge based on consistent morphogenetic criteria. In terms of concepts, terminology, and repositories, Cvijić largely built on earlier Habsburg undertakings and their popular scientific communities. However, the elevation of the comparative framework to an international level and the professionalization of research, marked by its delimitation as a specific occupational profile, posed novel challenges to the reliability and validation of the sources examined. This demand was particularly evident in the study of landforms and landform evolution, a burgeoning branch of physical geography grounded on uniform methods of observation. However, in the case of (subsurface) karst features, university scientists still relied heavily on the reports of "non-professional" researchers. The visual knowledge and practices gained in the field, including the (joint) description, drawing, or measurement of landforms, furnished the analytical tools with which academics later evaluated the observations of others in their offices. Nevertheless, in Cvijić's case, the emphasis on field expertise also proved to be a potent tool of persuasion, effectively addressing the epistemic uncertainties associated with the globalization of geoscientific concepts and communicating credibility to his professional audience.

MAKING THE KARST (INTER)NATIONAL: THE AFTERMATH OF THE “KARST PHENOMENON”

Shortly after Cvijić defended his thesis around the turn of 1892, the “Karst Phenomenon” was published together with other dissertations in Penck’s series “Geographische Abhandlungen” (Geographical Treatises) and distributed to fellow researchers abroad. By this time, Cvijić had already left Vienna for Belgrade, where the then 27-year-old had been appointed full professor at Velika Škola (from 1905 known as the University of Belgrade). There, Cvijić was surprised by the encouraging letters he received from eminent scholars, such as Archibald Geikie (1835–1924), director of the British Geological Survey, who shared a keen interest in valley erosion by flowing water. Decisive for the attention that the “Karst Phenomenon” attracted were the networks of Cvijić’s supervisor, the recognition of the geosciences then being taught at Vienna, and the significance of German as a language of science. Most reviewers agreed that the thesis was the first survey (though not a proper monograph) of karst landforms; however, the more detailed comments, especially from field geologists and local researchers, raised several concerns, not least about geomorphology per se: For Weigand (1894: 801–802), the use of “such primitive means of categorization” as the “external [morphological] form” impeded the understanding of formation processes and, in the case of Cvijić’s thesis, led to an “inappropriate terminology.” Meanwhile, Trampler (1894: 329) recommended a “more careful examination” of the sources, and Kraus (1894a: 21–22), whom Cvijić himself had attacked, scornfully countered that the thesis, rooted in “long-disproved schools of thought,” is only suitable as a repository for the “otherwise inaccessible Slavic literature.”

The reason for this criticism, apart from (personal) reservations about Penck and his teaching at the Vienna University, may lie in Cvijić’s firm rejection of the dolines’ collapse origin, which earned him opponents among its Habsburg supporters. The Serbian origins of Penck’s protégé may also have played a role, which, given the national tensions of the 1890s, must have caused resentment among colleagues with a German nationalist mindset. However, Cvijić did receive support from his teacher’s former Ph.D. students, who used their networks to place favorable reviews, and most importantly, from Penck himself. In his two-volume “Morphologie der Erdoberfläche” (MORPHOLOGY OF THE EARTH’S SURFACE, 1894), he dealt extensively with “karst landscapes” and, by adopting many of Cvijić’s findings, endorsed their relevance and reliability. By this time, karst phenomena had evolved into one of the most researched and debated landforms, and their study, conducted for decades by Habsburg scholars, became worldwide in scope. For the growing circle of Penck’s students, gaining a foothold in the promising but largely “amateurish” karst research was an opportunity to establish a reputation in the developing field of geomorphology. For their teacher, in turn, it was a chance to raise the profile of the Vienna chair of physical geography, especially in the French- and English-speaking world.

Simultaneously with the release of the “Karst Phenomenon,” speleological monographs gained attention. Despite originating in non-university contexts, these works underwent joint review with Cvijić’s thesis. Notable among them are Franz Kraus’ comprehensive “Höhlenkunde” (CAVE STUDY, 1894b) and Édouard-Alfred Martel’s “Les Abîmes” (THE ABYSSES, 1894), both lavishly illustrated with sketches, maps, and photographs. In the geographical journal “Petermanns Mittheilungen,” Martel’s 580-page book was even hailed as the “standard work on karst phenomena,” surpassing the “little piece” (Werkchen) of Penck’s student (SUPAN, 1894: 136). The self-taught researchers Kraus and Martel, with extensive experience in the exploration of pit caves, karst streams, and springs, were not simply willing to accept Cvijić’s arguments and paid more attention to hydrological processes (SCHUT AND DELALAN-DRE, 2015). Based on diagrams of exemplary features, they developed individual landform typologies, using German or French terms. For example, Kraus introduced an alternative no-

menclature for “surface erosion phenomena” (mainly dolines), whereas Martel argued against the internationalization of the “Austrian” term “karst” (GAUCHON, 1999). Referring to recent investigations in the south of France, comparable to that in the “classical land” of karst research, Martel proposed the more neutral term “limestone phenomena” (*phénomènes du calcaire*) to designate landscapes characterized by “subterranean water circulation”:

Locally, the name Karst seems to be limited to ... Istria and western Carniola; ... so arid in places that it has been nicknamed Austria's Arabia Petraea [Roman province in Arabia]. ... All that the Karst proper can claim is to have been the first ground, where subterranean hydrology was ... scientifically studied, and, to possess caves and underground rivers that, for beauty and power, rank first among their counterparts. (Martel, 1894: 432–33)

The reception of the “Karst Phenomenon” thus proved to be more controversial than its current status as the founding work of karst geomorphology suggests. The thesis divided not only geographers and geologists, academics, and “non-professionals”, but also scholarly communities that, driven by different concepts and methods, favored research based on global synthesis or local fieldwork. At the national level, Cvijić's thesis and its supporters had painfully exposed discrepancies within the “thought collective” once uniting the Monarchy's karst research. In its place, Penck's close-knit network of young and ambitious geographers took over the reins, no longer committed to shared bodies of knowledge and culture, such as a holistic approach, (trans)regional focus, and public engagement in science. At the international level, the discussion of Cvijić's thesis, despite competing proposals, stimulated the use of the term “karst” in English- and French-speaking academia. Although there was no translation of these languages, Cvijić had a revised version of his thesis published in Serbian Cyrillic under the title “Карст: географска монографија” (KARST: GEOGRAPHICAL MONOGRAPH, 1895). Thus, he contributed to the growth of an independent, language- and nation-oriented geoscientific community in Serbia, whose publications were embraced by colleagues, especially of the Orthodox denomination, throughout the Balkan Peninsula. However, for the vast majority of Viennese scholars, these works remained unreadable due to a language barrier. Furthermore, by introducing a terminology derived from South Slavic languages (while disregarding terms in Czech, Italian, or French), Cvijić unintentionally fueled nationalistic tendencies in karst research. The increasing use of the term “(Austrian) karst countries” (Karstländer) in the (school) literature of the Habsburg Monarchy, spurred by the growth of comparative regional geography (Länderkunde), was a response to these tensions (KREBS, 1907; SCHULTZ, 2012; KINDER, 2020). With subsequent authors proposing modifications or new terms in their (national) languages, inconsistencies flourished well into the twentieth century.

Beyond these scholarly debates, novel media such as postcards, photographs, and dioramas, with their compelling landscape images, brought karst areas to public attention. Whereas Cvijić's thesis referred more to the Dinaric Karst as a whole, popular representations highlighted the “Classical” Karst, both as a geographically unique region and as a landscape holo-type (SHAW AND ČUK, 2012). Moreover, the developing tourist infrastructure, especially in Carniola, familiarized a growing number of visitors with karst landforms (SHAW AND ČUK, 2015). The worldwide dissemination of this imagery was facilitated by a booming geographic book market and innovations in printing technology. Atlases and (school) wall maps, exhibited at international fairs and used in classrooms, influenced the “worldviews” of broad segments of society (HENNIGES, 2017b). Especially favored were representations of iconic landscape types like Alpine glaciers, the Pannonian Steppe, or the Dinaric Karst. These visually captivating images, distilled to a few “characteristic” landform elements (CHAVANNE, 1881), also became popular in bourgeois households due to their quality, exotic appeal, and affordability. The “Geographische Charakterbilder” (Geographical Character Pictures) reproduced in large numbers

by the Viennese publisher Hölzel, with depictions of Postojna Cave (Carniola) and the coastal karst of Kotor (Montenegro), are examples of this trend (JOVANOVIĆ-KRUSPEL, 2019). Artists often created sketches for these images on site, with scientists contributing to the initial motif selection and providing didactic texts for the accompanying materials (CHAVANNE et al., 1886). The representations in the 24-volume opus “Die österreichisch-ungarische Monarchie in Wort und Bild” (THE AUSTRO-HUNGARIAN MONARCHY IN WORDS AND PICTURES, 1886–1902) wielded significant influence. Initiated by Crown Prince Rudolph, this ambitious project aimed at compiling the natural-historical and cultural knowledge of all Habsburg territories. The widely circulated landscape images, including those “portraying” the “Classical” Karst (Fig. 4), had a high recognition value (KRAUS, 1891). Together with other images of landscape types representative of the Monarchy, they symbolized its unity in diversity and, eventually, underpinned the integrity of Habsburg imperial rule.



Figure 4. Depiction of a typical “karst landscape with dolines between Sessana [Sežana] and Lippitza [Lipica, Slovenia]” in the 24-volume encyclopedia “The Austro-Hungarian Monarchy in Words and Pictures” (Sonklar, 1886: 37), artist: Eduard von Lichtenfels (Vienna).

Apart from this popular discourse, the elevation of “The Karst Phenomenon” to a foundational work in karst geomorphology took place in the 1900s, propelled by the influential network centered around Penck. Scientists from across Southeast Europe, including Cvijić, commonly used Viennese communities to exchange knowledge, foster bilateral cooperation, and advance careers. This relationship, in turn, created a loyal educated class on the peripheries of the Habsburg Monarchy, facilitating the absorption of scientific concepts, methods, and literature alongside a shared political consensus affirming the empire’s integrity and cultural claim to supremacy. In Cvijić’s case, his loyalty bore fruit when WILLIAM MORRIS DAVIS (1850–1934), a prominent Harvard geographer, encountered the “Karst Phenomenon” during his trip to Europe in 1899. Joining Penck and his students on an excursion to Bosnia and Herzegovina to investigate karst phenomena (KREBS AND LEX, 1899; PENCK, 1900), DAVIS (1901)

later incorporated many of Cvijić's findings into his framework, notably within his prominent cycle of erosion theory. This model, reflecting contemporary evolutionary thinking, left a profound impact on fluvial geomorphologists, particularly within Anglo-American academia, enduring well into the 1940s (GINSBURGER, 2015). Inspired by Davis, CVJIĆ (1918) developed a similar theory for karst landform evolution, contextualizing three-dimensional typological representations of karst terrains within causal, time-related frameworks (Fig. 5). Moreover, Penck's continuous excursions to karst areas stimulated further research by his Ph.D. students and other Habsburg geoscientists, including Alfred Grund's "Karsthydrographie" (KARST HYDROGRAPHY, 1903) and Friedrich Katzer's "Karst und Karsthydrographie" (KARST AND KARST HYDROGRAPHY, 1909) (FORD, 2015). These efforts not only established Vienna as the international hub of karst research until WWI but also solidified Cvijić's thesis as a key reference in the burgeoning field of geomorphology (HILPERT, 1907; KREBS, 1910; BECKINSALE AND CHORLEY, 1991).

The acceptance of Cvijić's work by French scholars can be attributed to the geopolitical shifts following the Serbian coup d'état of 1903, notably the assassination of the pro-Habsburg King Alexander Obrenović. Initially ambivalent, Cvijić solidified his position by declining his appointment to the Prague chair of physical geography, later filled by Grund (STANKOVIĆ, 2015). While his academic training and shared scientific concepts initially bridged tensions with Vienna, Cvijić's convictions shifted with the growth of the Yugoslavist movement, Serbian nationalism, and his close friendship with Foreign Minister MILOVAN MILOVANOVIC (1863–1912). The latter advocated an alliance with Britain, Bulgaria, and France and even entrusted Cvijić with diplomatic missions abroad (GINSBURGER, 2016). Ironically, Cvijić, whose career had its origins in Vienna and who later served as rector of the University of Belgrade and president of the Serbian Academy of Sciences and Arts, went on to become one of the most prominent critics of Austria-Hungary after the annexation of Bosnia by Habsburg forces in 1908. The Serbian Geographical Society, founded by Cvijić two years later, shifted its focus from geoscientific features to ethnographical and national relations in the Balkans, aiming to collaborate with French and Anglo-American scholars. Cvijić, by then publishing in French, found a new, powerful mentor in Emmanuel de Martonne (1909: 468), who, in his "Traité de géographie physique" (Treatise on Physical Geography), adopted the term "karst" to denote the "entirety of limestone relief features" (GAUCHON, 1999; RENAULT, 1992). The study of karst geomorphology, once a common ground for scholars from Central and Southeast Europe, had finally lost its integrative power. Cvijić's advocacy for a South Slavic state under Serbian leadership, championed while serving as a visiting professor at Sorbonne University throughout the war, finally came true in 1918. As one of the key scientific advisors to the Paris Peace Conference (1919–20), he shared responsibility for border demarcations in Southeast Europe following the upheavals of WWI (GINSBURGER, 2010).

Overall, the impact of Cvijić's thesis can be summarized as follows: First, the establishment of the "Karst Phenomenon" as a standard reference occurred in the years surrounding WWI and depended on the (trans)formation of international thought collectives engaged in karst research. Shared political-cultural convictions, along with the adoption of evolutionary thinking prevalent in Anglo-American scholarship, fostered cohesion among geoscientists of the (future) Entente powers, who recognized Cvijić's thesis as the foundational piece of karst geomorphology. In turn, Habsburg researchers, such as Grund, who perished in the battles with Serbia, and Katzer, who continued his hydrological work at the Bosnian Geological Survey after WWI, were either overlooked or, in the case of their Viennese peers, sidelined from international scientific exchange for political reasons in the 1920s. Second, Cvijić's efforts in internationalizing and nationalizing karst knowledge were instrumental in shaping a more professionalized realm within karst research. Beyond local fieldwork, these new "professionals" relied on the comparison of data collected worldwide, incorporating sources from non-ac-

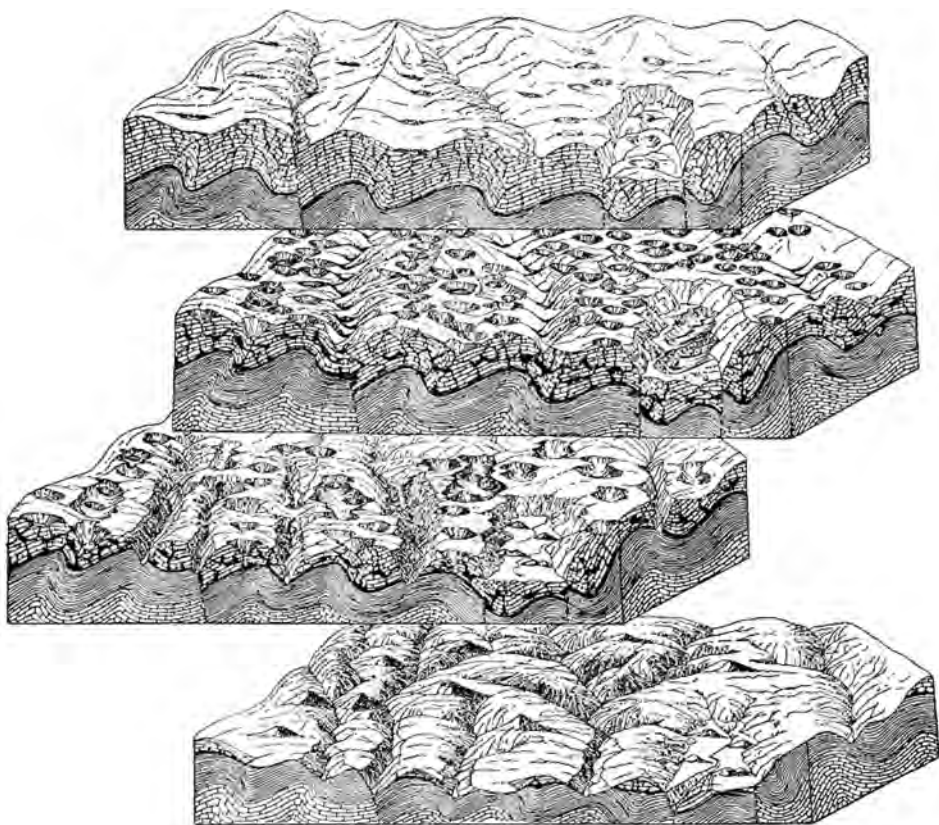


Figure 5. Morphological evolution of the karst terrain in four phases: 1. original karst terrain; 2. maximum level of karstification; 3. beginning of disappearance of karst relief; 4. disappearance of karst relief and hydrography, author: Cvijić (1918: 423).

ademic practitioners but gradually excluding the latter from interpretation. As nation-states (emerging from the Habsburg Monarchy) increasingly employed karst knowledge, novel concerns, such as the significance of karst areas as heritage sites and the ethnic composition or language(s) of their populations, gained prominence. Notably, the allocation of the “Classical” Karst to Italy in 1919 prompted Fascist initiatives to turn the caves around Postojna into a national park and to enforce cultural assimilation policies (BERTARELLI, 1919; KAVREČIĆ, 2020), including the prohibition of the Slovene language.

CONCLUSIONS

This article has examined the foundations of karst sciences as a scholarly community, evolving in the late nineteenth century around a cohesive framework of shared concepts, practices, and political-cultural convictions. While historians, often beginning with Cvijić’s thesis, have thus far studied major advances in geological thought, my article centers on the epistemic, political, and social dimensions involved in the “making” of the “Karst Phenomenon,” providing a more comprehensive understanding of the complex processes around the globalization of this scientific concept. Tracing the origins of karst research within the Habsburg

Monarchy has opened up avenues for investigating how knowledge is produced, mobilized, and exchanged within specific geographical and historical contexts, shedding light on thought styles, imperial agendas, and the interplay between science and society.

In exploring the epistemic dimensions, I have shown that the use of the term “karst” as a versatile model of thought for comparing and transferring knowledge across regions was reliant on (scientific) power dynamics and societal preconceptions that informed understandings of karst phenomena. Cvijić, in formulating his hypotheses, methodology, and terminology, drew upon the teachings of his mentors, prior research, and unpublished materials, systematizing and (inter)nationalizing the scale of his analysis. To address the uncertainties inherent in comparing globally sourced data and enhance credibility with his audience, Cvijić narrowed his thesis to surface landforms, employing a scholarly presentation style with diagrams and tables of (survey) data. New observational methods, hydrological research, and the adoption of evolutionary principles in geomorphology strengthened physical geography, setting it apart from the focus of geology on local phenomena (i.e., outcrops) and from the increasingly “amateurish” realm of speleology.

On the political front, I have demonstrated that the scientific study of karst phenomena emerged within an intra-imperial context, responding to the integrative imperatives and realities of Habsburg rule. This search for coherence across diverse regions was also driven by the practical utility of the gathered knowledge, especially in resource management. As foreign policy shifted to the southeast following the defeat by Prussia and the opening of the Suez Canal in the late 1860s, Habsburg scholars began extending the term “karst” to areas on the peripheries of the Monarchy, setting the stage for future internationalization endeavors. Early ecological thinking about karst environments, influenced by Orientalism, advocated for the cultural “elevation” of Slavic-inhabited areas, thereby indirectly supporting colonial-expansive ambitions. Cvijić’s (trans)national collaboration was also shaped by geopolitical agendas, either by prioritizing research autonomy in the Balkans or by adopting scientific concepts and practices from Vienna or Paris. By integrating the limestone mountains of eastern Serbia into the Dinaric Karst framework and enhancing his fieldwork with ethnographic mapping from the early 1900s onward, he indirectly strengthened arguments for South Slavic unity.

Delving into the social dimensions, I have highlighted the significance of unacknowledged stakeholders, including field researchers, local guides, and science popularizers, in addition to prominent figures, such as Cvijić. Through personal exploration or supporting others, these stakeholders were equally essential to the production, accumulation, and (inter)nationalization of karst knowledge. However, they gradually lost visibility with the professionalization of the geosciences. This was particularly evident for members of local and indigenous communities, whose expertise in topography or hydrological conditions, for instance, was eagerly exploited by “professional” researchers and incorporated into the scientific body of karst knowledge. Boundary work among early karst specialists, including earth scientists, naturalists, and bourgeois “autodidacts,” was influenced not only by differences in concepts, methods, and foci of interest but also, to some extent, by social backgrounds, academic status, and evolving disciplinary identities. Alongside scholarly discourse, popular media, such as landscape imagery, postcards, and wall maps, depicting representative features of the “Classical” Karst have had a lasting impact on public visions of karst areas.

Overall, the pooling of this broad topographical and practical knowledge within a new, scientifically accredited format and the global comparison of dissolutional landforms, distinct from phenomena of fluvial geomorphology, can be considered the essential merit of the “Karst Phenomenon”. This consolidation achieved by Cvijić not only facilitated cross-border exchanges in early geomorphological research but also paved the way for a deeper understanding of evolutionary and hydrological processes in karst landscapes and beyond. His extensive correspondence, field notes, and hand-drawn maps illuminate the development and impact of

Cvijić's and his contemporaries' (visual) knowledge on the observation and collective perception of landforms, offering promising avenues for future research (JOVIĆ AND STANIĆ, 2015; MILANOVIĆ PEŠIĆ et al., 2019). However, today's geomorphologists, such as Ford (2007), consider the Dinaric Karst less suitable for a more general study of the evolution of dissolutional landscapes because of its complex geological structure and the inherent variability among individual karst regions. Despite this limitation, the study of karst phenomena remains essential to unravel the intricate processes that shape both the natural and social fabrics of our world.

ACKNOWLEDGEMENTS

The idea for this article arose during a trip with Ernst Hamm (York University, Toronto) through the South Tyrolean Dolomites in June 2022. I would like to thank Jelena Čalić (Belgrade), Ernest Geyer (Admont), Norman Henniges (Berlin), Walter Klappacher (Salzburg), Sandra Klos, Rudolf Pavuza, Lukas Plan (Vienna), and Nadja Zupan-Hajna (Postojna) for reading and commenting on this essay and/or providing sources. I am also grateful for the constructive and enriching suggestions of the editors and two anonymous reviewers. Last but not least, I especially thank Associate Editor Kathleen Histon for her invitation to submit a manuscript on this topic and her unwavering support and patience throughout the writing process.

REFERENCES

- ASH, M.G., and SURMAN, J. (Eds.), 2012, *The Nationalization of Scientific Knowledge in the Habsburg Empire, 1848–1918*. Palgrave Macmillan, London, 258 p.
- BECKINSALE, R.P., and CHORLEY, R.J., 1991, *The History of the Study of Landforms or the Development of Geomorphology, vol. 3: Historical and Regional Geomorphology*. Routledge, New York, 524 p.
- BERTARELLI, L.V., 1919, *Per un parco nazionale sotterraneo italiano*. Le Vie d'Italia, v. 25(3), pp. 129–35.
- BÖTTCHER, H., 1979, *Zwischen Naturbeschreibung und Ideologie. Versuch einer Rekonstruktion der Wissenschaftsgeschichte der deutschen Geomorphologie*. Gesellschaft zur Förderung regional-wissenschaftlicher Erkenntnisse, Oldenburg, 151 p.
- BOUÉ, A., 1856, *Beiträge zur Geographie Serbiens*. Sitzungsberichte, kaiserliche Akademie der Wissenschaften, math.-nat. Klasse, v. 20, pp. 549–573.
- BOUÉ, A., 1861, *Über die Karst- und Trichterplastik im Allgemeinen*. Sitzungsberichte, kaiserliche Akademie der Wissenschaften, math.-nat. Klasse, v. 43, pp. 283–293.
- ČALIĆ, J., 2007, *Karst Research in Serbia before the Time of Jovan Cvijić*. Acta Carsologica, v. 36(2), pp. 315–319.
- CHAVANNE, J., 1882, *Die geographischen Unterrichtsmittel*. Zeitschrift für Schul-Geographie, v. 3, pp. 1–11.
- CHAVANNE, J., HAARDT, V. V., PRAUSEK, V. et al., 1886, *Hölzel's Geographische Charakterbilder für Schule und Haus*. Textbeilage. Hölzel, Vienna, 226 p.
- COEN, D., 2018, *Climate in Motion: Science, Empire, and the Problem of Scale*. Chicago UP, Chicago, 464 p.
- COHEN, G.B., 2015, *Expansion and the Limits of Inclusion: The Students of the Vienna University, 1860–1914*. In: Ash, M.G., and Ehmer, J. (Eds.), *Universität - Politik – Gesellschaft. 650 Jahre Universität Wien*, vol. 2. V&R unipress, Vienna, pp. 505–528.
- COX, E.T., 1874, *Fifth annual report of the Geological Society of Indiana*. Sentinel Company, Indianapolis, 494 p.

- CRAMPTON, J.W., 2006, *The cartographic calculation of space. Race mapping and the Balkans at the Paris Peace Conference*. Social & Cultural Geography, v. 7, pp. 731–752.
- CVJIĆ, J., 1887/88, *Prilog geografskoj terminologiji našoj* [Contribution to our geographical terminology], 2 parts. Prosветni glasnik, v. 8–9, pp. 903–916, 21–28.
- CVJIĆ, J., 1889, *Ka poznavanju krša Istočne Srbije* [Contribution to the study of karst in eastern Serbia]. Prosветni glasnik, v. 10, pp. 1–14, 62–73, 131–139.
- CVJIĆ, J., 1891, *Prekonoška Pećina* [Prekonoška Cave]. Geološki anali Balkanskoga poluostrva, v. 3, pp. 272–299.
- CVJIĆ, J., 1893, *Das Karstphänomen: Versuch einer morphologischen Monographie*. Hölzel, Vienna, pp. 217–329.
- CVJIĆ, J., 1895, *Kapcm: зеографска монографија* [Karst: Geographical Monograph]. Štamaparija Kraljevine, Belgrade, 176 p.
- CVJIĆ, J., 1918, *Hydrographie souterraine et evolution morphologique du karst*. Recueil des Travaux de l'Institute de Géographie Alpine, v. 6, pp. 375–426.
- DAUBRÉE, A., 1887, *Les eaux souterraines*. 2 vol., Dunod, Paris, 757 p.
- DAVIS, W.M., 1901, *An excursion in Bosnia, Hercegovina and Dalmatia*. Bulletin of the Geographical Society of Philadelphia, v. 3(2), pp. 47–50.
- DE WAELE, J., and GUTIÉRREZ, F., 2022, *Karst Hydrogeology, Geomorphology and Caves*. Wiley-Blackwell, Hoboken and Chichester, 912 p.
- DEMETER, G., and BOTLIK, Z., 2021, *Maps in the Service of the Nation. The Role of Ethnic Mapping in Nation-Building and Its Influence on Political Decision-Making Across the Balkan Peninsula*. Frank & Timme, Berlin, 310 p.
- DIENER, K., 1886, *Libanon. Grundlinien der physischen Geographie und Geologie von Mittel-Syrien*. Hölder, Vienna, 412 p.
- FLECK, L., 1935, *Entstehung und Entwicklung einer wissenschaftlichen Tatsache*. Schwabe, Basel, 150 p.
- FORD, D., 2007, *Jovan Cvijić and the founding of karst geomorphology*. Environmental Geology, v. 51, pp. 675–684.
- FORD, D., 2015, *The science of caves and karst: From the beginning of the Geological Society of America to ca. 1960*. In: Feinberg, J., Gao, Y., and Alexander, E.C. (Eds.), *Caves and Karst Across Time*. Geological Society of America, Boulder, pp. 1–17.
- FORD, D., and WILLIAMS, P., 2007, *Karst Hydrogeology and Geomorphology*. 2nd edition. Wiley, Chichester, 562 p.
- FOURNET, J., 1858, *Hydrographie souterraine. Mémoires de l'Académie des Sciences, Belles-Lettres et Arts de Lyon*, 2e série, v. 8, pp. 221–296.
- FRUWIRTH, C., 1883/85, *Ueber Höhlen*. Zeitschrift des Deutschen und Oesterreichischen Alpenvereins, v. 14/16, pp. 1–37, 108–130.
- GAMS, I., 1973, *Razvoj slovenskih besed kras in dolina* [The evolution of the Slovene words “kras” and “dolina”]. In: Gams, I., Kunaver, J., and Radinja, D. (Eds.), *Slovenska kraska terminologija*. Univ. Press, Ljubljana, pp. 39–53.
- GAUCHON, C., 1999, *L'adoption du terme de « karst » en France*. Karstologia, v. 34(2), pp. 45–51.
- GÈZE, B., 1983, *Karstologie et spéléologie*. Karstologia, v. 1, pp. 2–4.
- GINSBURGER, N., 2010, *« La guerre, la plus terrible des érosions »*. Cultures de guerre et géographes universitaires Allemagne-France-États-Unis. PhD thesis, Université Paris-Nanterre, 1682 p.
- GINSBURGER, N., 2015, *Les Balkans avec ou sans Cvijić. Géographes et géologues universitaires austro-allemands, français et serbes dans un espace européen périphérique*. In: Clerc, P., and Robic, M.-C. (Eds.), *Des géographes hors-les-murs?*. L'Harmattan, Paris, pp. 323–354.
- GINSBURGER, N., 2016, *Réseaux académiques et circulations savantes entre guerres et paix*. Cybergeog, 784 (<http://journals.openedition.org/cybergeog/27690>).

- GÓRNY, M., 2019, *Vaterlandszeichner. Geografen und Grenzen im Zwischenkriegseuropa*. Fibre, Osnabrück, 304 p.
- GRUND, A., 1903, *Die Karsthydrographie: Studien aus Westbosnien*. Hölzel, Vienna, pp. 103–200.
- HAUER, F. V., 1883, *Berichte über die Wasserverhältnisse in den Kesselthälern von Krain*. Österreichische Touristen-Zeitung, v. 3(3–4), pp. 25–31, 37–41.
- HENNIGES, N., 2014, „Sehen lernen“: Die Exkursionen des Wiener Geographischen Instituts und die Formierung der Praxiskultur der geographischen (Feld-)Beobachtung. Mitteilungen der Österreichischen Geographischen Gesellschaft, v. 156, pp. 141–170.
- HENNIGES, N., 2017a, *Die Spur des Eises: eine praxeologische Studie über die wissenschaftlichen Anfänge des Geologen und Geographen Albrecht Penck*. Leibniz-Institut für Länderkunde, Leipzig, 556 p.
- HENNIGES, N., 2017b, *The Rolled World. German school wall maps and their publishers*. IMCOS, v. 151, pp. 45–53.
- HERMANN, B.F., 1781, *Benedikt Franz Hermann's Reisen durch Oesterreich*, vol. 2. Wappler, Vienna, 143 p.
- HILPERT, H., 1907, *Die historische Entwicklung der Frage nach dem Wesen des Karstphänomens*. PhD thesis, Würzburg University, 126 p.
- HOHENWART, F., 1830, *Wegweiser für die Wanderer in der berühmten Adelsberger und Kronprinz Ferdinands-Grotte*, vol. 1. Sollinger, Vienna, 31 p.
- JOVANOVIĆ-KRUSPEL, S., 2019, *Bilder der Welt: Hölzels „Geographische Charakterbilder“*. In: Wiesinger, B. (Ed.), 175 Jahre Verlag Eduard Hölzel. Hölzel, Vienna, pp. 89–95.
- JOVIĆ, V., and KOSTIĆ, A. (Eds.), 2015, *Jovan Cvijić. Life, Work, Times*. Serbian Academy of Sciences & Arts, Belgrade, 286 p.
- JOVIĆ, V., and PETROVIĆ, A.M. (Eds.), 2015, *150th Anniversary of Jovan Cvijić's Birth*. 2 vol. Serbian Academy of Sciences & Arts, Belgrade, 820 p.
- JOVIĆ, V., and STANIĆ, M., 2015, *Jovan Cvijić's correspondence*. In: JOVIĆ, V., and KOSTIĆ, A. (Eds.), *Jovan Cvijić. Life, Work, Times*. Serbian Academy of Sciences & Arts, Belgrade, pp. 213–231.
- JUREIT, U., 2012, *Das Ordnen von Räumen: Territorium und Lebensraum*. Hamburger Edition, Hamburg, 445 p.
- KARRER, F., 1884, *Zur Geologie der Karst-Erscheinungen*. Wiener Allgemeine Zeitung, v. 1462 (March, 24), p. 4.
- KATZER, F., 1909, *Karst und Karsthydrographie. Zur Kunde der Balkanhalbinsel*. Kajon, Sarajevo, 94 p.
- KAVREČIĆ, P., 2020, *Tourism and Fascism. Tourism Development on the Eastern Italian Border*. Prispevki za novejšo zgodovino, v. 60(2), pp. 99–119.
- KINDER, S., 2020, *Die Entwicklung der Geographischen Länderkunde*. In: JOHLER, R., and WOLF, J. (Eds.), *Beschreiben und Vermessen. Raumwissen in der östlichen Habsburgermonarchie im 18. und 19. Jahrhundert*. Frank & Timme, Berlin, pp. 679–703.
- KLEMUN, M., 2012, *National 'Consensus' As Culture and Practice: The Geological Survey*. In: ASH, M.G., and SURMAN, J. (Eds.), *The Nationalization of Scientific Knowledge*. Palgrave Macmillan, London, pp. 83–101.
- KLEMUN, M., 2018, *Spaces and places: an historical overview of the development of geology in Austria*. Geological Society, London, Special Publications 442, pp. 263–270.
- KLIMCHOUK, A.B., 2015, *The Karst Paradigm: Changes, Trends and Perspectives*. Acta Carsologica, v. 44(3), pp. 289–313.
- KNEZ, M., OTONIČAR, B., PETRIČ, M., et al. (Eds.), 2020, *Karstology in the Classical Karst*. Springer, Cham, 236 p.
- KOHL, J.G., 1851, *Der Karst*. Deutsche Vierteljahrsschrift, v. 14(3), pp. 1–62.
- KRANJC, A. (Ed.), 1997, *Kras: Slovene Classical Karst*. ZRC SAZU, Ljubljana, 254 p.
- KRANJC, A., 1994, *About the name and the history of the region Kras*. Acta Carsologica, v. 23, pp. 81–90.

- KRANJC, A., 2011, *The Origin and evolution of the term "Karst"*. *Procedia – Social and Behavioral Sciences*, v. 19, pp. 567–570.
- KRAUS, F., 1887, *Ueber Dolinen*. *Verhandlungen der Geologischen Reichsanstalt*, v. 10(2), pp. 54–62.
- KRAUS, F., 1891, *Der Karst*. In: RUDOLF VON HABSBURG (Ed.), *Die österreichisch-ungarische Monarchie in Wort und Bild*. vol. 8: *Kärnten und Krain*. Hof- und Staatsdruckerei, Vienna, pp. 285–304.
- KRAUS, F., 1894a, *Das Karstphänomen [book review]*. *Globus*, v. 65, pp. 21–22.
- KRAUS, F., 1894b, *Höhlenkunde*. Gerold, Vienna, 308 p.
- KREBS, N., and LEX, F., 1899, *Reisebericht*. *Jahrbuch, Verein der Geographen an der Universität Wien*, v. 25, pp. 81–122.
- KREBS, N., 1907, *Die Halbinsel Istrien: Landeskundliche Studie*. Teubner, Leipzig, 166 p.
- KREBS, N., 1910, *Offene Fragen der Karstkunde*. *Geographische Zeitschrift*, v. 16(3), pp. 134–142.
- L.B.B. [LANDESBESCHREIBUNGSBUREAU DES K.U.K. GENERALSTABS], 1889, *Der westliche Teil des Illyrischen Gebirgslandes*. *Mittheilungen der Geographischen Gesellschaft in Wien*, v. 32, pp. 416–430.
- LINDNER, A.F., 1841, *Corso sotterraneo del fiume Recca, suo ritrovamento presso Trieste e progetto di trarne un canale a beneficio della città*. *Giornale dell'I.R. Istituto Lombardo di Scienze Lettere ed Arti e Biblioteca Italiana*, v. 2(4), pp. 116–121.
- LIPOLD, M.V., 1858, *Bericht über die geologische Aufnahme in Unter-Krain*. *Jahrbuch der Geologischen Reichsanstalt*, v. 9, pp. 257–276.
- LORENZ, J.R., 1860, *Bericht über die Bedingungen der Aufforstung und Cultivierung des croatischen Karstgebirges*. *Mittheilungen der Geographischen Gesellschaft in Wien*, v. 4, pp. 97–140.
- MAIS, K., 1989, *Vom Karst zur Karstkunde: Zum Wandel einer lokalen Bezeichnung zum Fachausdruck*. *Die Höhle*, v. 40, pp. 78–84.
- MARTEL, É.-A., 1889, *Les Cévennes et la région des Causses*. Delagrave, Paris, 407 p.
- MARTEL, É.-A., 1894, *Les Abîmes, les eaux souterraines, les cavernes, les sources, la spéléologie*. Delagrave, Paris, 580 p.
- MARTONNE, E. DE, 1909, *Traité de géographie physique*. Armand Colin, Paris, 910 p.
- MATTES, J., 2012, *Die Eroberung der Tiefe: Mitglieder der k. k. Geologischen Reichsanstalt als Akteure und Förderer der Höhlenforschung*. *Berichte der Geologischen Bundesanstalt*, v. 95, pp. 81–114.
- MATTES, J., 2015, *Reisen ins Unterirdische. Eine Kulturgeschichte der Höhlenforschung*. Böhlau, Vienna, 418 p.
- MATTES, J., 2018, *Coming from abroad. The discourse on scientific centralism and Jovan Cvijić's studies in Vienna*. In: JOVIĆ, V., and PETROVIĆ, A.M. (Eds.), *150th Anniversary of Jovan Cvijić's Birth*. vol. 1. Serbian Academy of Sciences & Arts, Belgrade, pp. 13–28.
- MATTES, J., 2024, *Collaborative Research in Imperial Vienna: Science Organization, Statehood, and Civil Society, 1848–1914*. *Austrian History Yearbook (Cambridge)*, v. 55, 1–28 (first view).
- MILANOVIĆ PEŠIĆ, A., ČALIĆ, J., PETROVIĆ, M.D., TERZIĆ, A., and VUKSANOVIĆ-MACURA, Z. (Eds.), 2019, *From the Notebooks of Jovan Cvijić. Selected Pages and Interpretations*. Serbian Academy of Sciences & Arts, Belgrade, 199 p.
- MISHKOVA, D., 2018, *Beyond Balkanism: the scholarly politics of region making*. Routledge, New York, 282 p.
- MOJSISOVICS, E. v., 1880, *Zur Geologie der Karst-Erscheinungen*. *Zeitschrift des Deutschen und Oesterreichischen Alpenvereins*, v. 11, pp. 111–116.
- MORLOT, A., 1848, *Ueber die geologischen Verhältnisse von Istrien*. *Naturwissenschaftliche Abhandlungen (Vienna)*, v. 2, pp. 257–317.
- PENCK, A., 1891, *Das Grottenbuch der Section Küstenland d. D. u. Oe. A.-V.* *Mittheilungen des Deutschen und Oesterreichischen Alpenvereins*, v. 17, p. 202.
- PENCK, A., 1894, *Morphologie der Erdoberfläche*. vol. 2. Engelhorn, Stuttgart, 696 p.

- PENCK, A., 1900, *Geomorphologische Studien aus der Herzegowina*. Zeitschrift des Deutschen und Oesterreichischen Alpenvereins, v. 31, pp. 25–41.
- PUTICK, W., 1889, *Die unterirdischen Flussläufe von Inner-Krain [Part 3]*. Mittheilungen der Geographischen Gesellschaft in Wien, v. 32, pp. 57–79.
- RENAULT, P., 1992, *La Karstologie française de 1900 à 1992*. In: SALOMON, J.N., and MAIRE, R. (Eds.), *Karsts et évolutions climatiques*. Presses Universitaires, Bordeaux, pp. 17–30.
- REYER, E., 1881, *Studien über das Karstrelief*. Mittheilungen der Geographischen Gesellschaft in Wien, v. 24, pp. 76–87, 101–107.
- RICHTHOFEN, F.V., 1886, *Führer für Forschungsreisende*. Oppenheim, Berlin, 745 p.
- SCHMIDL, A., 1854, *Zur Höhlenkunde des Karstes*. Braumüller, Vienna, 316 p.
- SCHMIDL, A., 1858, *Die österreichischen Höhlen*. Eine geographische Skizze. Emich, Pest, 29 p.
- SCHULTZ, H.-D., 2012, *Völkerkarten im Geografieunterricht des 20. Jahrhunderts*. In: HASLINGER, P., and OSWALT, V. (Eds.), *Kampf der Karten. Propaganda und Geschichtskarten*. Herder-Institut, Marburg, pp. 13–61.
- SCHUT, P.-O., and DELALANDRE, M., 2015, *L'échec d'une discipline: Montée et déclin de la spéléologie en France (1888-1978)*. Revue d'histoire des sciences, v. 68, pp. 81–107.
- SEEGER, S., 2018, *Map Men. Transnational Lives and Deaths of Geographers in the Making of East Central Europe*. Chicago UP, Chicago, 320 p.
- SHAW, T.R., 1992, *History of Cave Science. 2nd edition*. Sydney Speleological Society, Sydney, 338 p.
- SHAW, T.R., and ČUK, A., 2012, *Slovene Caves and Karst Pictured*. ZRC SAZU, Ljubljana, 230 p.
- SHAW, T.R., and ČUK, A., 2015, *Slovene Caves and Karst in the Past*. ZRC SAZU, Ljubljana, 464 p.
- SIMONY, F., 1847, *Höhlen- und Karstbildung in den geschichteten Kalken*. Berichte über die Mittheilungen von Freunden der Naturwissenschaften in Wien, v. 1, pp. 55–59.
- SONKLAR, K. v., 1886, *Orographie und Hydrographie*. In: HABSBURG, R. v. (Ed.), *Österreich-Ungarn in Wort und Bild, vol. 2: Übersichtsband. Naturgeschichtliche Abteilung*. Hof- und Staatsdruckerei, Vienna, pp. 19–86.
- STANKOVIĆ, S., 2015, *Biography*. In: JOVIĆ, V., and KOSTIĆ, A. (Eds.), *Jovan Cvijić*. Serbian Academy of Sciences & Arts, Belgrade, pp. 11–77.
- STEPIŠNIK, U., 2015, *The Problem of Dissolution Doline Definition*. Dela, v. 43, pp. 29–40.
- STEVANOVIĆ, Z., 2013, *The History of Hydrogeology in Serbia*. In: HOWDEN, N., and MATHER, J. (Eds.), *History of Hydrogeology*. Taylor & Francis, Boca Raton, pp. 257–274.
- STEVANOVIĆ, Z., and MIJATOVIĆ, B. (Eds.), 2005, *Cvijić and Karst*. Serbian Academy of Sciences & Arts, Belgrade.
- STUR, D., 1858, *Das Isonzo-Thal*. Jahrbuch der Geologischen Reichsanstalt, v. 9, pp. 324–366.
- SUESS, E., 1883-1909, *Das Antlitz der Erde, 4 vol.* Tempsky, Freytag, Prague, 2778 p.
- SUPAN, A., 1894, *Das Karstphänomen. Les Abîmes [book review]*. Petermanns Mittheilungen, v. 40, pp. 136–137.
- ŠUŠTERŠIČ, F., 1994, *Classic dolines of classical site*. Acta Carsologica, v. 23, pp. 123–156.
- TIETZE, E., 1873, *Geologische Darstellung der Gegend zwischen Carlstadt in Croatien und dem nördlichen Theil des Canals der Morlacca*. Jahrbuch der Geologischen Reichsanstalt, v. 23, pp. 27–70.
- TIETZE, E., 1880, *Zur Geologie der Karsterscheinungen*. Jahrbuch der Geologischen Reichsanstalt, v. 30, pp. 729–756.
- TRAMPLER, R., 1894, *Das Karstphänomen [book review]*. Mittheilungen der Geographischen Gesellschaft in Wien, v. 37, pp. 324–329.
- TRUDGILL, S.T., 2008, *Limestone Landforms, 1890–1965*. In: BURT, T.P., CHORLEY, R.J., BRUNSDEN, D., et al. (Eds.), *The History of the Study of Landforms or the Development of Geomorphology, vol. 4: Quaternary and Recent Processes and Forms*. Geological Society, London, pp. 107–125.

- UMLAUFT, F., and HAARDT, V. v., 1887, *Hölzel's Geographische Characterbilder*. Hand-Ausgabe. Hölzel, Vienna, 70 p.
- VOGEL, S., 2019, *Der Karst-Erklärer Johann Georg Kohl*. Die Höhle, v. 70, pp. 102–111.
- WARDENGA, U., 1995, *Geographie als Chorologie. Zur Genese und Struktur von Alfred Hettners Konstrukt der Geographie*. Steiner, Wiesbaden, 255 p.
- WEIGAND, B., 1894, *Das Karstphänomen [book review]*. Göttingische Gelehrte Anzeigen, v. 156, pp. 800–805.
- WESSELY, J., 1876, *Das Karstgebiet Militär-Kroatiens und seine Rettung, dann die Karstfrage überhaupt*. Albrecht & Fiedler, Agram, 366 p.
- WESTERMANN, A., 2010, *Overcoming the Division of Labour in Global Tectonics: Eduard Suess' "The Face of the Earth"*. Workshop "Earth Science – Global Science", York Univ., Toronto.
- WOODS, J.E., 1862, *Geological Observations in South Australia*. Longman & Green, London, 404 p.



Johannes Mattes is a historian of science specializing in the natural sciences (e.g. earth sciences, geography, cartography, archaeology, zoology, nuclear medicine) from the eighteenth to the twentieth century. He is currently a Marie Curie Fellow at the University of Oslo (Norway) and a research project leader at the Austrian Academy of Sciences in Vienna. Mattes is Secretary General of the International Union of Speleology (UIS) and a board member of the International Commission on the History of the Geological Sciences (INHIGEO) and of the History of Earth Sciences Society (HESS). He was awarded the Bader Prize for the History of Natural Sciences in 2021 and the Young Scientist Award of the Geological Society of America Karst Division in 2017.