MARTEL IN THE SLOVENE KARST IN 1893

Translated From His Publications and Correspondence
by **Trevor Shaw**

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ZRC

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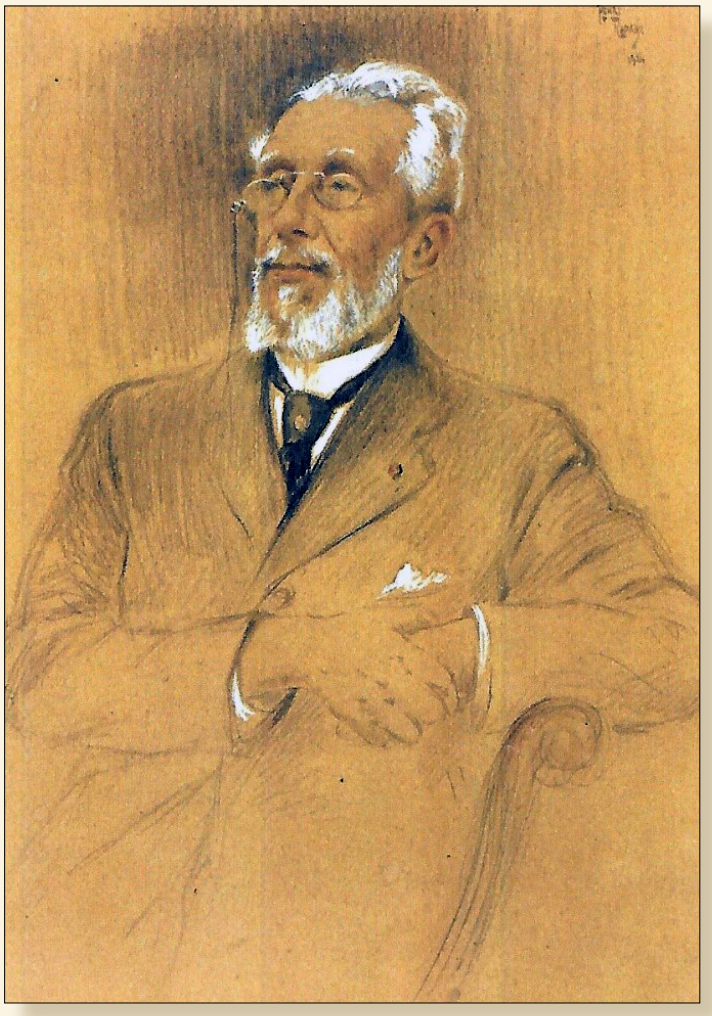
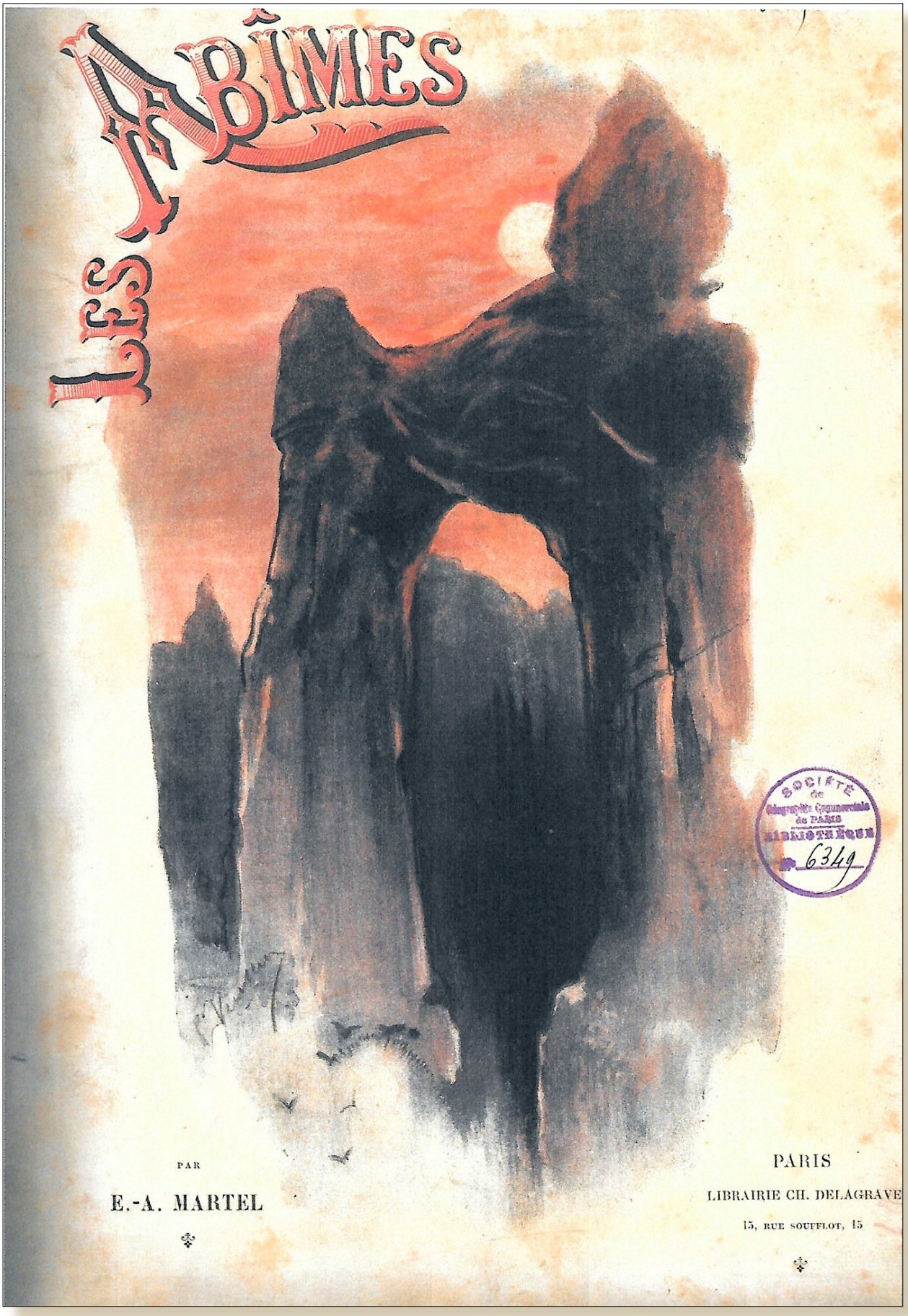


Martel in 1914

LES ABÎMES



PAR

E.-A. MARTEL

PARIS

LIBRAIRIE CH. DELAGRAVE

15, RUE SOUFFLOT, 15

E.-A. MARTEL

LES ABIMES

LES EAUX SOUTERRAINES, LES CAVERNES, LES SOURCES

LA SPÉLÆOLOGIE

Explorations souterraines effectuées de 1888 à 1893

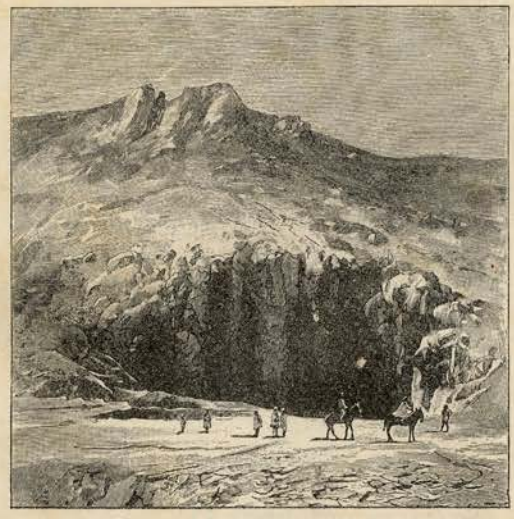
EN FRANCE, BELGIQUE, AUTRICHE ET GRÈCE

AVEC LE CONCOURS DE

MM. G. GAUPILLAT, N.-A. SIDÉRIDÈS, W. PUTICK, E. RUPIN, Ph. LALANDE, R. PONS, L. DE LAUNAY, F. MAZAURIC, P. ARNAL, J. BOURGUET, ETC.

4 Phototypies et 16 plans hors texte — 100 Gravures d'après des Photographies, et des Dessins de G. VUILLIER, L. de LAUNAY et E. RUPIN (9 hors texte)

Et 200 Cartes, Plans et Coupes.



PARIS

LIBRAIRIE CHARLES DELAGRAVE

15, RUE SOUFFLOT, 15

1894

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TRANSLATOR'S INTRODUCTION

The 588 – page book *Les Abîmes,* published in 1894, is commonly regarded as one of the most influential books in the history of speleology, perhaps the most influential. Its French author, E.A. Martel (1859–1938), is similarly often considered as having made the greatest advances in the study of caves and cave science.

The book given to Perko by the author, and signed by him, is in the library of the Karst Research Institute in Postojna.

The whole of chapter 27 of *Les Abîmes* has its 58 pages devoted to the Karst of Slovenia and some of its neighbouring countries. It describes Martel's own explorations there in 1893, together with those of Putick and members of the Postojna cave club, Anthron. It gives also a detailed account of earlier studies by Schmidl and others.

Naturally the book was written in French, Martel's native language. At that time, 130 years ago, French was the international language of the world, spoken in embassies for example, just as English is today.

The result of this is that the chapter on the Slovene Karst is not readily accessible to today's Slovenes. It is to remedy this situation that the present English translation has been made.

As will be seen, Martel's main text is accompanied by extensive footnotes. In the original, these are printed on or close to the pages that refer to them. In this translation it seems more helpful to separate all the notes from the relevant text and to refer to them as notes 1 – 109. The notes themselves are not essential to the understanding of the main text: they expand upon it and provide additional information.

Similarly the illustrations, which in the book are mostly located near the relevant pages, are here numbered as Figs. 1 to 34, for easy reference.

One of the problems in reading the original book is with the place-names of rivers and towns and of the caves themselves. Mostly these are the German-language names used in Austria at the time, when Slovenia was part of that country. Other names are the local Slovene or Croatian ones, which Martel did not always record accurately. Here, such names that are no longer current are printed, when they first appear, just as Martel wrote them, followed by the present-day names in square brackets: thus "Gottschee [Kočevje]". Subsequently, only the modern name is used. In a few cases the modern name may not have been identified and the reader may be wiser than the translator, who will welcome advice.

Apart from what the book states about its subject, the classical Karst of Slovenia and its vicinity, it also reveals much about Martel himself. Not only about the extent of his visits and explorations and their technical difficulties but his text also demonstrates aspects of this own life and personality.

Thus:

The immense amount of literature research he did enabling him not only to record previous activities in the region, but to emphasize where his interpretation of cave phenomena differed from previous beliefs:

The mutual respect that existed between this world-famous speleologist, with his vast amount of publications, and the equally brave and innovative Slovene explorers:

The seemingly impossible amount of work he did in a short time, not only his exploration and research, but the writing of this very large book in addition to his professional work as a lawyer in Paris. The book was written and published within a year of his visit to the Karst.

As an appendix to Martel's published account of the Karst in *Les Abîmes,* three of his manuscript writ-ings are also printed here, as facsimiles of the originals, together with their English translations. All three are in the library of the Karst Research Institute in Postojna, all with the same press mark IZRK II 35538. The first two have recently been printed, in the original French, in Daniel André's comprehensive 1997 publication (*La plume et les gouffres*). In that book the second item, the undated Report, is described as "after 9 November 1893" although the letter of that date refers to it as being enclosed. As will be seen, the final item in German is one of the relatively few things written in Martel's own handwriting. German script is notoriously difficult to read so a printed transcript by Fritz Reinboth is provided as well as an English translation via a French one by Bernard Chirol.

Also in the appendix is a bibliography of Martel's other published writings on the Slovene Karst. Those before 1893 are necessarily reports of other people's work there and so are most of the later ones. Any page numbers added in brackets after a reference denote those that refer to Slovenia and its vicinity. Many, but not all, the entries have been taken from Chabert and Courval's Martel bibliography of 1971.

p.432

The Karst

Phenomena of the Karst – Unclear boundaries – Early explorations – Schmidl, the founder of speleology – Flooding of valley basins [poljes] – Work of Kraus and Putick – Underground course of the Pivka: Postojnska jama, Pivka jama, Planinska jama, etc. – Recent discoveries – My task in the Karst – Action of surface and underground water: dolines and caves: formation, unroofing and collapse – Shafts or chimneys – Sumps – Intermittence and outlets of the Cerknica lake – Work on flood control – The deepest caves known – Wonders of the two Škocjans – Problems of the Reka and Timavo rivers – Seeking a source of drinking water – Kačna jama – Trebiciano – Flow of underground water – Foiba di Pisino [Pazinka jama] – The Poljes and springs of Dalmatia, Bosnia, Hercegovina – Legends of the Buna [spring] – Cold springs – Underground hydrology of Montenegro – The Rijeka, a penetrable Vaucluse – Unfinished explorations.

The *Karst* (*Kras* in Croatian, *Gabrek* in Slav, *Carso* in Italian) the name of which derives, it is said, from a Keltic word meaning *land of stones*, has for two centuries occupied the attention of geographers and geologists.

The word Karst seems locally to be limited to that part of the Austrian Empire that includes, between Trieste and Ljubljana, northern Istria and western Carniola between the Adriatic and the Sava. That is the *Karst proper*, so arid in places that it has been called the stony Arabia of Austria[1].

It consists of Cretaceous limestone plateaux which provide continuity between the Alps in the north and the backbone of the Balkan peninsular to the south (the Dinaric and Albanian Alps, etc.).

But the same geological formation and the same appearance continue further in a southerly direction – Istrian peninsular (*Istrian Karst*), the south-west part and the coast of Croatia (*Liburnian Karst*), Dalmatia, the west of Bosnia, Montenegro, Serbia (Kučaj), even Albania. In a word, the coastal regions of the eastern Adriatic, with sinking and reappearing rivers, caves and shafts[2] which together have been called the [p.433] *phenomena of Karst*. We have shown in previous chapters that those strange features of physical geography, which astonish travellers and scientists alike, are by no means limited to certain regions.

To say that they are exclusive to the Karst is not justified. Since we have been studying the underworld of the [French] Causses, the Karst is no more a “plateau *unique in Europe* for its chaos of stones, split rocks and the caves that are found all over it”. While it remains true to say “there are no countries in Europe more

notable for their underground hydrology", it can no longer be stated that "southern France and the Jura do not have in their caves as many lakes, shafts and flowing streams" (Reclus, **3**, pp. 218 and 225).

The *phenomena of the Karst* are generally the same as *limestone phenomena*. Whether the limestone is Devonian (Moravia, Hérault) Carboniferous (Kentucky), Jurassic (the Causses) or Cretaceous (Ardèche, Vaucluse, Austria), it has, wherever there are fissures, underground water circulating in the same way according to the same laws. All that can be claimed of the Karst is, on the one hand, that it is the first area where underground hydrology has been seriously and scientifically studied and, on the other hand, of possessing caves and underground rivers that are of the first rank in beauty and distinction among their peers.

This is not the place for a complete description of the underworld of the Karst. The time has not yet come to produce such a work. This underworld has, in the last ten years, shown so much that is new. It still remains, though, to await the results of new explorations (Kraus has told me of more than 30 sinking rivers in Carniola alone). Reports of recent work, too, will fill [p.434] a whole volume. It is necessary to delay the production of this special book, the production of which I do not despair of taking part in one day.

In this chapter I shall limit myself to making known progress in the subterranean geography of the Karst over the last 15 years, to describing briefly some researches that I myself have made there and to analysing the things seen to compare them with caves in France and Greece[3].

It is difficult to say where to start and finish an account of the underground hydrology of the south-west part of the Austrian Empire. Eighty kilometres north of Trieste one already meets the Alps at the southern flank of the famous mount Triglav (2864 m). There are several small lakes (8 according to W. Urbas) and several hollows with no surface water (up to 2000 m) but their water must gather and converge underground before emerging at the *Savitza-Fall* [Savica spring] (837 m). This spring, at the end of the *Wochein* [Bohinjsko] lake, considered as one of the two main sources of the Save [Sava] river, takes the form of a waterfall 66 m high[4] gushing out from a hole in a vertical cliff. It is not possible to enter behind it. This absorption of the waters above and their reappearance from fissures lower down is a true phenomenon of the Karst or rather of limestone, for no-one claims Triglav to be in the Karst. To the south, the boundary is even more difficult to determine, seeing that the katavothras of the Peleponese occur as sinks, shafts and caves, with springs more or less the same.

Going on now to the Karst proper, comprising a triangle with Laibach [Ljubljana] in the middle, Fiume [Rijeka] to the south and Trieste in the west. It is here that the fissured limestone [p.435] absorbs the rain-water that becomes the *Recca* [Reka], *Piuka* [Pivka] and *Unz* [Unica] and the *Zirkniz* [Cerknica] lake, its rising and then flowing on the surface over the impermeable beds of the Trias, flysch or Tertiary deposits, only to go underground again when they come to the limestone which is very permeable because of its fissures.

Schönleben in *Carniola antiqua et nova* (1681) and Valvasor in *Die ehre des Herzogthums Krain* (1689) seem to be the earliest two authors to speak of the cavities of the Karst, the former in a few words only and the latter with fantastic errors consistent with its date.

In 1748 the mathematician Nagel carried out various explorations at the order of Emperor Francis I, husband of Maria Theresa, and recorded the results in three very curious illustrated manuscripts now in the Nationalbibliothek in Wien.

Hacquet (1778), Gruber (1781), Rosenmüller and Tillesius (1805)[5], Hoppe & Hornschuch (1818), Agapito (1823), etc. all sought to draw attention to the caves of Carniola.

In 1818 the discovery of the main cave at Postojna opened the era of serious cave exploration in the Karst. After that, professor Arenstein and H. Freyer extended the scope of active research throughout Carniola.

In 1848 Anton Urbas, priest at Planina, went into Planinska jama, being for a long time the only visitor. To him is due the credit for recommending methodical exploration of the region's shafts and caves to understand the action of its underground rivers and to control floods[6].

Finally, in 1849, Adolf Schmidl made a preliminary investigation at *Adelsberg* [Postojnska jama], Planinska jama,etc., and then in the following year (August 1850), together with the surveyor J. Rüdolf and with grants from the Austrian ministers and the Geological Institute, he started the explorations which continued for four years, up to 1853[7]. The Academy of Sciences in Wien bore the cost of the book in which Schmidl published his results – *Die Grotten und Höhle von Adelsberg, Lueg, Planina und Laas*[8].

This work must be considered the first example of its kind, and it author as the true creator of speleology or the rational study of caves. Certainly there are some errors and wrong deductions in it but these are inevitable in the subject 40 years ago at a period of almost complete lack of experience. The example set by Schmidl in his studies and descriptions of caves is no less remarkable for its boldness, its novelty and its interest, than that provided by Saussure and the first English alpinists of 1855 climbing to conquer the great frozen peaks. But their efforts have been crowned with success and we know with what expansion *alpinism* has developed in the 50 years since, not only for the pleasure of tourists, but also for the benefit of science itself, since, from Agassiz's studies on glaciers (1843) to the creation of the two meteorological stations Vallot and Janssen on the very summit of Mont Blanc, Schmidl has not found as many imitators as Desor, Forbes, Dolfus-Ausset, Tyndall, Schlagintwelt, Bonney, Whymper, Freshfield, Coolidge, Duhamel, etc. although his work [p.436] is no less worthy of attention. I have no intention of making any parallel between the Alps and caves or between glaciers and underground waters. It just seems to me that the two subjects are both parts of the general study of nature and that the second has up to now been too much neglected. I wish to declare that I have simply aimed to follow and extend Schmidl's example by for six years carrying out my researches and publishing them. Thanks to advances in modern technology such studies are now easier and above all more extensive. But the honour remains with Schmidl and to him must be given the credit of really founding speleology[9], to which I wish to give a final boost.

If the "black unknown" has held back those simple tourists who do not fear avalanches from following Schmidl into the damp darkness of labyrinthine caves, it is nevertheless the curious researchers who appreciate, like him, the importance of the subject. We list here the names of such people: Stache, Lorenz, Fruwirth, Kraus, Putick, Kriz, Tietze, Hanke, Marinitsch Müller, Kouritska, Siegmeth, Fischer, Kolbenheyer, etc. in Austria and Hungary. The work of the celebrated geologist Hochstetter is mainly in palaeontology and prehistory, while that of Hauer is in geology.

But we must stop these introductory remarks and return, for the history and publications before 1853, to this same book of Schmidl. Kraus is producing another on his successors[10].

Among all the underground rivers of the Karst there are two that are specially famous and important, and we shall limit ourselves to them: the Laibach [Ljubljanica] in the north and the Reka in the south. They will show us the greatest *phenomena of the Karst.*

The town of Ljubljana, the capital of Carniola, is located between the right bank of the Sava [p.437] and a great marshy plain [Ljubljanska barje], at the extreme south-west edge of which, 18 to 20 km from the town, several springs (Bistra, Lebia [Ljubija], Ober-Laibach [Vrhnika] etc.), impenetrable to man, form the short and tortuous *Ljubljanica* river, a tributary of the Sava (at about 290m to 300 m above sea level[11]). The whims of these springs cause frequent flooding on Ljubljanksa barje[12], resulting from rain falling on the Karst. Immediately behind and above these irregular springs is a karst plateau, rising as a wall 800 m high to a most uneven tableland with *Nanos* at 1315 m, *Javornik* at 1270 m and Slivnica[13] at 1115 m. The surface river bed of the Reka, on the other hand, is at less than 300 m and the other so-called plateau, above Trieste and the Adriatic, is between 300 m and 400 m.

The Ljubljanica springs, like the Ouysse and the Tourvre in France, are simply the reappearance of water sinking above into caves or fissures. To explain this we must cross, in imagination, part of the Karst and stop 33.5 km south of the springs, at the edge of the *Pivka* river[14]. There, 2.5 km south-east of the railway station at Saint-Peter [Pivka] (the junction from Wien to either Rijeka or Trieste), a river is born amid the grass fields of a plateau 549 m above sea level. This is the start of the *Postojna* plain, a basin closed on all sides by heights which would force the water to collect as a lake without the cave we are about to describe. These sorts of closed valleys with no surface route for drainage are one of the characteristics of the Karst and are called Kessel-Thäler [Poljes].

The gradient of the Pivka is very slight, having 24 km of meanders (13.5 km as the crow flies) to reach (having been supplemented on the left by the Nanosca [Nanosčica] coming from Nanos[15]) the entrance of Postojnska jama at 511.5 m altitude[16]. The slope of the river bed is thus 1.58 m per kilometre (0.158%). For the 20 km which separate the cave entrance from the Ljubljanica springs (to which the Pivka contributes its flow, see below) the descent, in contrast, is about 210 m (10.5%) [p.438]. This is the part of the water's flow that is mainly underground.

In fact, one kilometre north-west of Postojna the Pivka meets a barrier of Cretaceous limestone which dips at 45º towards the north-west. Several of the strata have been carried away by the water due to the intersection of joints and small fissures and then, *exactly like the Lesse* at *Belvaux and the Bonheur at Camprieu, due to the enlarged fissures* it is swallowed up underground in that incomparable cave, the *famous Postojnska jama*, perhaps the most beautiful in the world [Fig. 1]. We follow the river, not directly downstream for the fissure narrows rapidly and cannot be passed by boat or man[17], but to the right and 18 m higher up[18] a double passage, conveniently enlarged to become the cave entrance, is one of the four or five former routes of the river. Its course had become lower and lower and further to the left. A curved passage, two natural archways and then we meet the course of the river again in a vast hall [Veliki dom] 33 m high. The water has followed an S-shaped tunnel[19], Veliki dom is a crossroads leading to three passages as well as the two where the water and the public enter.

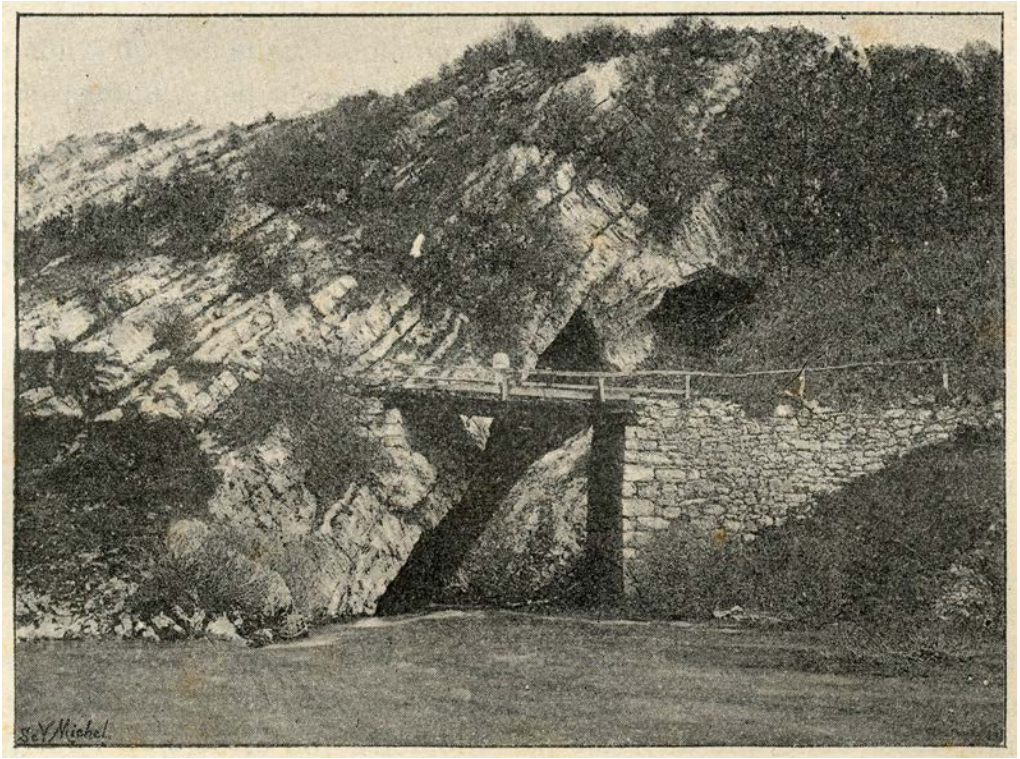


Fig. 1 The sink of the Pivka at Postojna

[p.439] The first of these, “the old cave” [Stara jama] was for a long time the only one known. Its walls are covered with inscriptions and dates of which the earliest is 1323[20].

The second passage, at the bottom, is the one where the Pivka now flows[21].

On the right side of Veliki dom, the opening into the third passage, named the Emperor Ferdinand Cave [Ferdinandova jama], was not discovered until 1818, by the worker Luka Čeč. Beyond it the way leads rapidly to Calvary [Kalvarija] and Tartarus. Archduke Johann’s Cave [Pisani rov], the most easterly, was found in 1832. In the following year (1833) the surveyor J. Fercher made the first plan of the known passages[22].

Putick in 1885 and Schmid in 1891 recognized that in the plan, reproduced and completed by Schmidl, Fercher had not taken account of the declination of the magnetic compass (about 11º 50).

In 1850 Schmidl discovered 570 m of the underground course of the Pivka. In 1856, based on that, a 15 m tunnel was driven to re-establish its former route before a roof collapse had occurred.

Some time later, near the cave entrance and to the left of Stara jama, a place was noted where some of the Pivka water was sinking into debris that probably blocked another passage which remains unknown. It would be interesting to clear access into this. At last, after a long period of inactivity, a lucky find was made in 1889. Peasants from the village of Veliki Otok discovered, 1145 m north-west of the Postojnska jama entrance, a new cave which they called *grotte d’Ottok* [Otoška jama] (altitude 531 m). It has very good and undamaged concretions and it leads, only 260 m from the entrance in a south-easterly direction, to its great hall (Belvedere) on a terrace formed on the summit of a former collapse mound. From here one hears the rumbling of a torrent reached by a 25 m descent over rocks (15 m of it sheer). The river runs in a passage oriented south-east to north-west. It is the Pivka which we are meeting again underground.

Now as early as 1852, Schmidl and Rudolf had already found this river at the bottom of a 65 m deep doline (Pivka jama [Fig.2] see later), 2450 m north of Postojnska jama entrance and 1500 m north-west of the (then still unknown) Otoška jama. The 1889 discovery naturally suggested investigating any link between Otoška jama and Postonjska jama on the one hand and with Pivka jama on the other. It was then that there was formed at Postojna the *Anthron Verein*, a club having [p.441] as its objective the continuation of Schmidl’s explorations. Its most active members are A. Kraigher [Kraji] A. Dietrich [Ditrih], Schäber [Šeber], Ruzicka [Ružička], Lovenčič, Petrič, etc.

In the autumn of 1890 the water of the Pivka was so low that, not only did they re-start Schmidl’s exploration there of 1850 but they also descended, with the greatest difficulty, a narrow passage with pools of water which led them from Tartarus to the Pivka (the Krajger link), as foreseen by Schmidl. This passage having been enlarged by explosives, the link with the Belvedere in Otoška jama became a simple journey of about 250 m[23]. The first part of the problem was resolved. Kraus certified this on 24 October 1890. The known extent of the [underground] Pivka rose to1140 m.

In 1891 the Anthron Verein discovered two other extensions to Postojnska jama. *The New Caves* [Lepe jame] contain, if not the biggest, at least the whitest stalagmite columns in the whole of this underground world, which is now 8 km long (including Otoška jama).

With the secret desire of extending the known length of the underground Pivka, I arrived myself at Postojna on 14 September 1893. The water was as low as possible, the weather good and all circumstances exceptionally favourable for an expedition beyond Otoška jama. [Fig.3].

It was nothing less, following the intentions of Kraus (who had kindly wished to join me at Postojna), than of coming out again at *Magdalena Schacht* [Magdalenska jama], 830 m north-west of the entrance to Otoška jama and 1830 m north of the Postojnska jama entrance. In the first place the peasants, and M. Šeber afterwards, had in the previous year descended that shaft and once more found the river Pivka, but they were unable to go upstream, not having a sufficiently light boat. [p.442] We counted on my Osgood [collapsible boat] and my telephones to make the connection and demonstrate the link [Fig. 3]. This hope must not be disappointed.

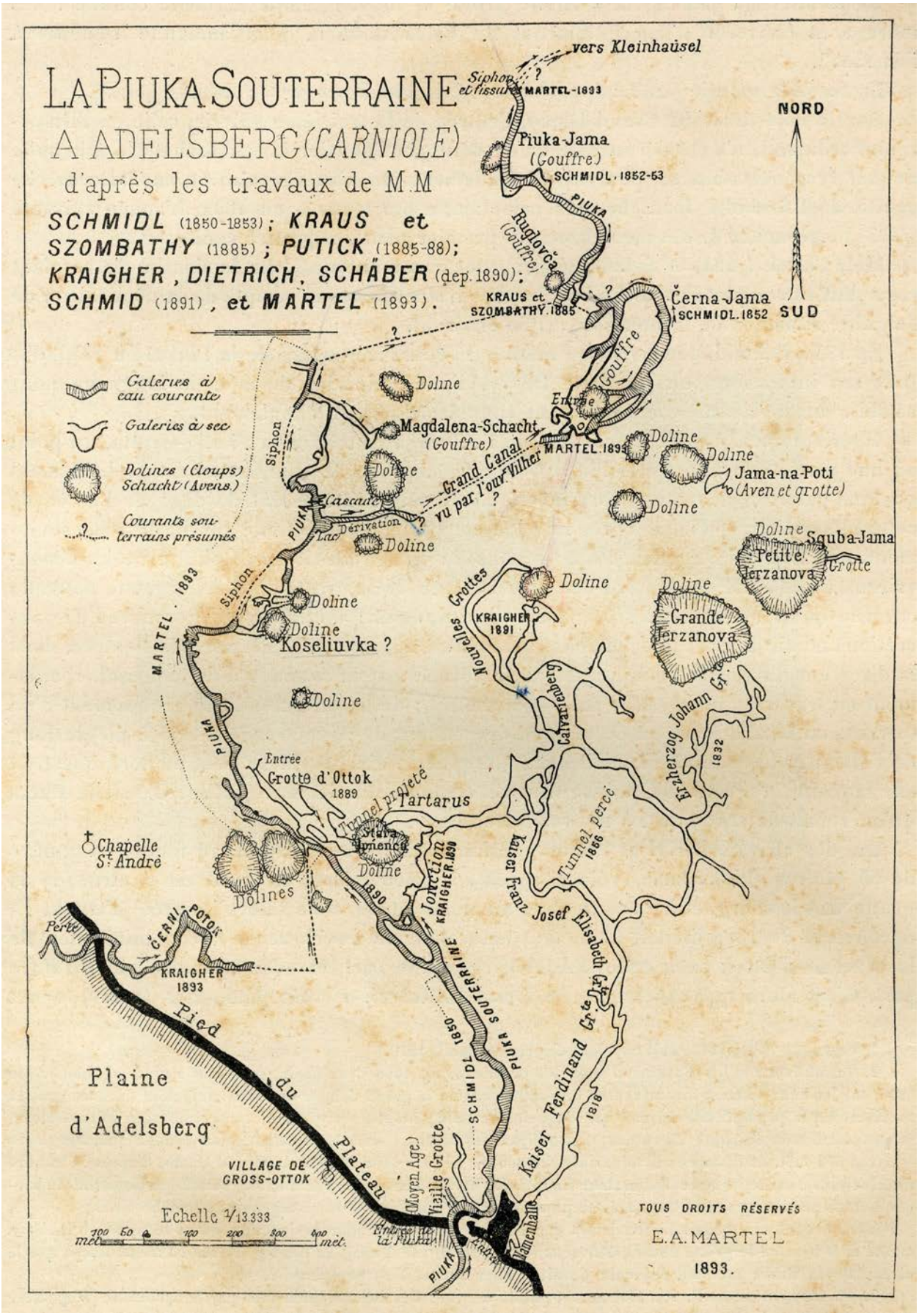


Fig. 2 The underground Pivka at Postojna

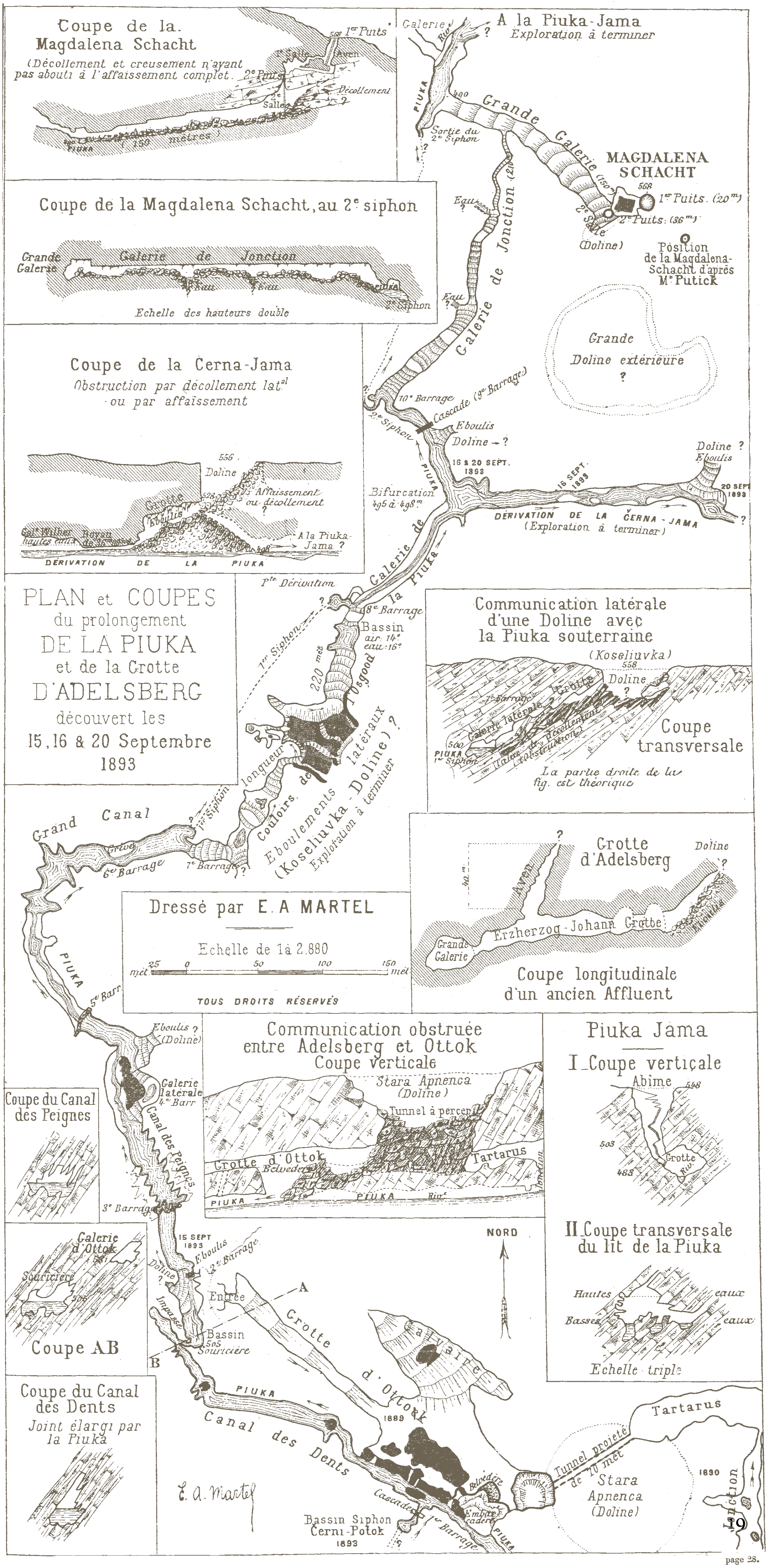

PLAN et COUPES
du prolongement
DE LA PIUKA
et de la Grotte
D'ADELSBERG
découvert les
15, 16 & 20 Septembre
1893
Dressé par E. A MARTEL
Echelle de 1 à 2.880
TOUS DROITS RÉSERVÉS
Coupe de la Magdalena Schacht
(Décollement et creusement n'ayant pas abouti à l'affaissement complet.)
Coupe de la Magdalena Schacht, au 2e siphon
Echelle des hauteurs double
Coupe de la Cerna-Jama
Obstruction par décollement latal ou par affaissement
A la Piuka-Jama
Exploration à terminer
Grande Galerie
MAGDALENA SCHACHT
Position de la Magdalena-Schacht d'après Mr Putick
Galerie de Jonction
Grande Doline extérieure
DÉRIVATION DE LA CERNA-JAMA
(Exploration à terminer)
Galerie de la Piuka
Communication latérale d'une Doline avec la Piuka souterraine
(Koseliuvka)
Coupe transversale
La partie droite de la fig. est théorique
Grotte d'Adelsberg
Coupe longitudinale d'un ancien Affluent
Erzherzog-Johann Grotte
Eboulements latéraux (Koseliuvka - Doline)? Exploration à terminer
Grand Canal
Communication obstruée entre Adelsberg et Ottok
Coupe verticale
Stara Apnenca (Doline)
Tunnel à percer
Grotte d'Ottok
Tartarus
Piuka Jama
I. Coupe verticale
II. Coupe transversale du lit de la Piuka
Echelle triple
Coupe du Canal des Peignes
Canal des Peignes
Coupe AB
Coupe du Canal des Dents
Joint élargi par la Piuka
Canal des Dents
Grotte d'Ottok
Tunnel projeté de 20 mèt
Stara Apnenca (Doline)
Bassin Siphon Cerni-Potok
1893
NORD
E. A. Martel

Fig. 3

page 28.

Fig. 4 The Underground Pivka – the sump, a drawing based on one by Giulizzi of the river in Trebiciano

This expedition lasted for three days (15, 16 and 20 September 1893). The main cause of its success has been the experienced help of Kraus, Putick, A. Krajger, A Šeber, Ružička and a number of workers from Ottok [Veliki Otok] and Postojna, notably Josef Wilher [Vilhar] and Anton Sibenik [Šibenik]. I wrote an account of it in the *Annuaire du Club Alpin Français* vol. **20** for 1893 [pp. 306–322]. The summary of this which follows is illustrated in Fig. 3.

On 15 September, having passed from Postojnska jama into Otoška jama by the connection made in 1890, we (Ditrih, I and three others) went for 350 m up the unknown underground river, as far as the *first barrier*. There we discovered an underground tributary which must be the Cerni-Potok [Črni potok] (black stream) which I have not mentioned before. It is a small surface stream coming for at least 1 km across the marshy fields from the Nanosčica river. It goes underground into a rock fissure between Gross-Ottok [Veliki Otok] and St. Andrew's chapel, 1100 m north-west of the Postojnska jama entrance. Krajger, Ružička and others were able, in 1893 before my arrival, to enter this new sink and follow the underground stream for 600 m until they were stopped by the narrowing passage. The plan in Fig. 2 was made by Ružička, a Postojna surveyor who kindly let me use it.

In the Canal des Dents [Podzemeljska Pivka] erosion has worn away the sloping strata between the projecting "teeth" especially in the narrow Souricière (Mouse Hole) passage. I know few places that better explain the formation of underground river channels. Schmidl attributed the destruction of a partition that separated pre-existing caves to the effect of hydrostatic pressure (pp. 133 and 198). It is more correct to say that the stratification and angle of the rock allows the water to attack and corrode the rock little by little, taking advantage of the natural fissures.

On 16 September, with Krajger (replacing Ditrih), five workers and two boats (one Osgood and one of wood), we made several more or less long advances on the river, interrupted by four obstructions (carrying the two boats) in a large passage where the strata again took the form of the teeth of a comb. At about 800 m from Otoška jama we were stopped by a large pool, a closed sump cluttered with wood and pieces of timber. Fortunately Vilhar and Šibenik found a passage to the right, climbing an immense heap of debris coming perhaps (by sideways slippage) from the doline called *Koselivka*[24] [Unška Koliševka]. With a thousand problems and difficulties, which reminded me of the Salles-la-Source delta, we were able to carry Osgood for 220 m through the almost impassable spaces through this chaos which evidently blocked the former course of the Pivka and forced it [p.445] to make its way as a sump to the left. At the end of this passage we came to a pool, the outlet from the sump (temperature: water 16º, air 14º). The debris had enabled us to bypass the sump. It made us just as happy as when we cleared a way through in Tindoul de la Vayssière! Krajger and I continued alone along a beautiful passage for 100 m as far as a lake where a branching to the left was an impassable waterfall, to the right an almost dry passage (used only by flood water) where I stopped after 60 m, for it was six o'clock in the evening. We had been underground for nine hours and shortage of food and light made us return the 1200 m to Otoška jama where we arrived relatively quickly at ten o'clock. We found Putick and Kraus, for they had expected us to make the whole journey through to Magdalenska jama.

It was from that shaft that we carried out our third attack on 20 September, Krajger and I with three men. Putick, with his usual kindness, remained on the surface, in the rain, at the telephone, to keep us informed of the state of the Pivka, enlarged by thunderstorms, which risked trapping us underground.

We see (in Chapter 29[=27]) the confusion produced between *avens* (Schacht, Jamas, Trichter) and *dolines* (depressions or cloups, see p.433) of the Karst, as used by Austrian geologists and to what extremes some of them go to generalise a theory of underground subsidence. I have already said (p. 306) that I consider it impossible to classify holes in the ground according to their external aspect alone. According to me, it is necessary to explore them to the bottom to be able to say whether they are the result of underground subsidence or of *surface actions*.

For the moment I state simply that Magdalenska jama is a *Jama*, an aven in French, which opens in the side, and not at the bottom of a great doline or, to be more precise, between two dolines. The section (Fig.5) shows clearly that superficial erosion has enlarged to a depth of only 20 m a fracture in the ground which has afterwards been hollowed out into a small cave. The walls bear clear evidence of chemical corrosion. Towards the bottom there is nothing similar[25]. But then a hole, at least one metre square, allows a rope ladder to descend for another 36 m. In another fracture is an enormous cave of which the floor is formed, without any possible doubt, by debris fallen from the roof. It is nothing other than a *separation* as at Reveillon, before the roof collapses altogether leaving a hole open to the sky. Now, the slope of the debris, the width and direction of the cave and the passage associated with it are such that I am very nearly convinced that the Pivka already flowed there, coming perhaps either from the diversion discovered on 16 September 1893 or even from the new caves [Lepe jame] discovered in 1891 north of Kalvarija in Postojnska jama! In all ways Magdalenska jama is a cave formed from the surface and joined to an incomplete collapse formed underground. These two happenings joined together without combining and without causing a complete collapse, rather similar to Combettes [in France] (see p. 329). Magdalenska jama shows [p.446] without any doubt that several causes must have operated at the same time in this particular case. It was a synthesis[26].

The plan and sections avoid any need for me to describe in detail the passages leading from Magdalenska jama.

At first there is a passage 150 m long and 10 to 15 m wide leading to the north-west which links with a lower passage, just as big, containing the Pivka river. On 20 September, 1893 this was greatly enlarged by the rains of the previous days and flowed so violently between the boulders in its bed that one could not

dream of launching the canvas boat. Above it on the right side I could progress for only 50 m, to a violent pool that could not be crossed on foot and where, after 25m, the water plunged for many metres. Šeber told me that he has been there at low water and found that the exit was an impassable sump. Exploration of this part of the Pivka is not finished.

Going back, one finds in the main gallery a side passage heading south, broken up and obstructed with debris, which after 210 m comes to the Pivka. Here too is a complete sump. This passage for the second time allows us to bypass the impenetrable part of the river. It must be admitted that the Pivka shows a certain helpfulness by making it possible to bypass these sumps. For upstream the river is clear and Osgood several times allows us to come to the foot of waterfalls. Our men carry the light canvas boat to the other side of the fall and we have the pleasure, Krajger and I, of exploring the lake which we had reached four days earlier, on 16 September.

The connection linked Magdalenska jama to Otoška jama.

In the branch passage which we had reached after only 60 m, we were stopped after 220 m: to the left by debris from some doline (perhaps the same one that had blocked the bottom chamber of Magdalenska jama); and to the right by a pool that we had not been able to explore because the roof is low and the water was rising, making it necessary for us to return if we wished to avoid being trapped by the flood. – I am almost certain that this diversion, where I had seen *one metre of water more* on 20 September than on the 16, reconnects with another nearby cave, Cerna jama [Črna jama] (see Fig. 2).

Our return was without incident. A terrible storm had struck Postojna, the rain never ceasing during the whole day. The level of the Pivka rose visibly and our collaborators outside concluded, at nine o'clock in the evening, that we had found shelter in the cave. It is certain that without the telephone they, knowing the behaviour of the underground river, would not have authorised this 3rd expedition which happily completed the work of the first two.

It was lengthened about 2 km (1500 m discovered by Krajger, Ditrih and me: 500 m already known in Magdalenska jama). The [p. 447] total length of Postonjska jama which now possesses *10 km of connected passages*, thus makes it the *longest cave known in Europe*[27], so beating its rival, the *Aggtelek* cave in Hungary which has 8700 m of passages.

We now ask how Postojnska jama was formed and how the course of the Pivka evolved. The strata here dips strongly to the north-west. This has had the effect of constantly *lowering* the river bed and moving it towards the left until it meets another rift and necessarily enters the next joint until it meets another, lower rift.

Thus it is that the former points where the river entered are all to the right and above the present entrance which is the *last on the left*. Ferdinandova jama and its extensions are similarly to the right and above the passage where the Pivka flows. The levels recorded during *Schmid*'s 1891 survey show this clearly.

Thus I agree with *Schmidl* that the Pivka formerly flowed through this part of the cave, which is now dry and arranged for tourists. Lepe jame, too, (from their direction) are a former bed, either unfinished or blocked by a collapse (which left its debris on the floor)[28].

The magnificent Archduke John branch [Pisani rov], 500 m long and discovered in 1832, which is the most easterly and least visited part of the cave, has a different character. It starts 4 m higher than the main passage and its level seems to rise steadily, only to drop a little towards the end (as in Saint Marcel in Ardèche). Not far from the [passage] entrance there is a circular vertical even in the roof, with traces of erosion. At a height of 40 m, which can be reached by ladders and crampons, it becomes conical and narrow – Krajger, Ditrih and others have been there without reaching the surface of the ground above. No doubt its former entrance there is blocked by soil. In the past, like one or two others nearby, it has absorbed surface water which enlarged a pre-existing fissure and continued [downwards] towards the great fissure below[29]. Further on to the left and right [p.448], are several side passages which end in great heaps of rubble, the result of roof collapse induced by water from the surface in the joints. The very end of this side passage is

blocked by a similar accumulation, all near the Velika *Jeršanova doline*[30] [see Fig.2]. I admit that this is the result of external erosion and internal subsidence that has affected the Pisani rov passage.

It could be similar to the *Mala Jeršanova* doline, close by, of which the eastern side has a small muddy cave, *Sguba jama*, recently examined by Krajgher and his companions. It all leads to the conclusion that Zguba jama, the two Jeršanova dolines, Pisani rov, its lateral collapses and vertical chimneys all form a simple tributary to the main cave (which is, according to Schmidl (pp. 100–102), 9.5 m lower than the bottom of Pisani rov and draining the abundant surface water of today).

Some of the other side passages in Postojnska jama have the same appearance of being tributaries that are now dry. The mass of immense boulders of the magnificent Calvarienberg [Kalvarija] (49 m high, 203 m long, 195m wide) is not the same [as the rubble heaps mentioned above], according to Schmidl. Bramabiau [in France] shows us all these phenomena – vertical avens, lateral collapses and the drainage of surface water. What we again see at Postojna confirms the universal law that fissures in the ground surface provide the water that filters down.

Otoška jama also was formerly the mouth of a tributary and is evidently part of the drainage system. It is interesting to note what disruption is caused where Otoška jama, Tartarus and the present course of the Pivka all meet. In seeking the way beyond that towards the north-west there are many more collapses (the Krajger Junction, the Belvedere in Otoška jama, etc. It seems even to have contributed to the making of a doline, the true subsidence of *Stara apnenca* which Schmidl's plan places between Tartarus and Otoška jama, and beneath which a 70 m long tunnel is planned.

Thanks to this detailed examination and comparative study, Postojnska jama alone is sufficient to establish what cannot be denied concerning the origin of cavities in the ground in a single theory.

I strongly believe that in the Karst the phenomena of collapse is, more frequently than in the Causses [of France], caused by the rivers here being more powerful.

Yet I do not hold the view that these pits are the result of a single action such as at Padirac and the caves of Peureuse and le Balset. I certainly do not find *dolines* to have the shape of a blocked cone, as broad at the bottom as at the top, to be such. Most dolines are funnel-shaped as at Bèdes, the two Besaces, Vitarelles, the Grande-Fosse and the Limousine pit. These are the best examples of dolines that I knew in France. Often, at the bottom of a funnel-shaped doline, there is a Jama or shaft, like the Igue de Baou at Planagrèzel (see pp. 303 and 335) [p. 449]. Kačna jama, near Trieste, is the best example of this (see later). It must be specially noted that the dip of the strata and the outcrop of their joints greatly facilitate the flow of rainwater through their joints and fissures. The mechanical and chemical action of erosion and corrosion breaks up and dissolves the limestone rock. By degrees it breaks apart sideways and even upwards to create an underground river passage, breaking up the rock until the river passage emerges into the open air.

I believe, then, that vertical development or collapse is less common, even in the Karst, than lateral development of passages. As for shafts or jamas, which are usually narrow, they are very numerous and result, as in the Causses, in surface excavation, either mechanical (erosion) or chemical (corrosion). In Carniola, in fact, it is their diameter that distinguishes between *dolines*, which are broad, and *jamas*, which are narrow. It is by misunderstanding this simple distinction that there has been so much confusion on the subject. What I have just said puts an end to this, I hope, since I recognize the correctness of all three theories of internal collapse, external erosion and also external corrosion. As for the application of each of these, it depends on the circumstances of each case. This will be further proved so by many examples.

1800 m north-west of the entrance of Postojnska jama and very near to the little Jeržanova is *Jama-na-Poti* [Fig. 5] (568 m altitude, taken from my own barometer readings), a one metre wide hole in the middle of a little forest road. It was discovered in 1889, at a place where it has been noted that the snow melts more than elsewhere. The hole leads to an oblique passage following the angle of the strata, enlarged by water entering it. This little cave has beautiful concretions. On the north-west side it is blocked by collapse

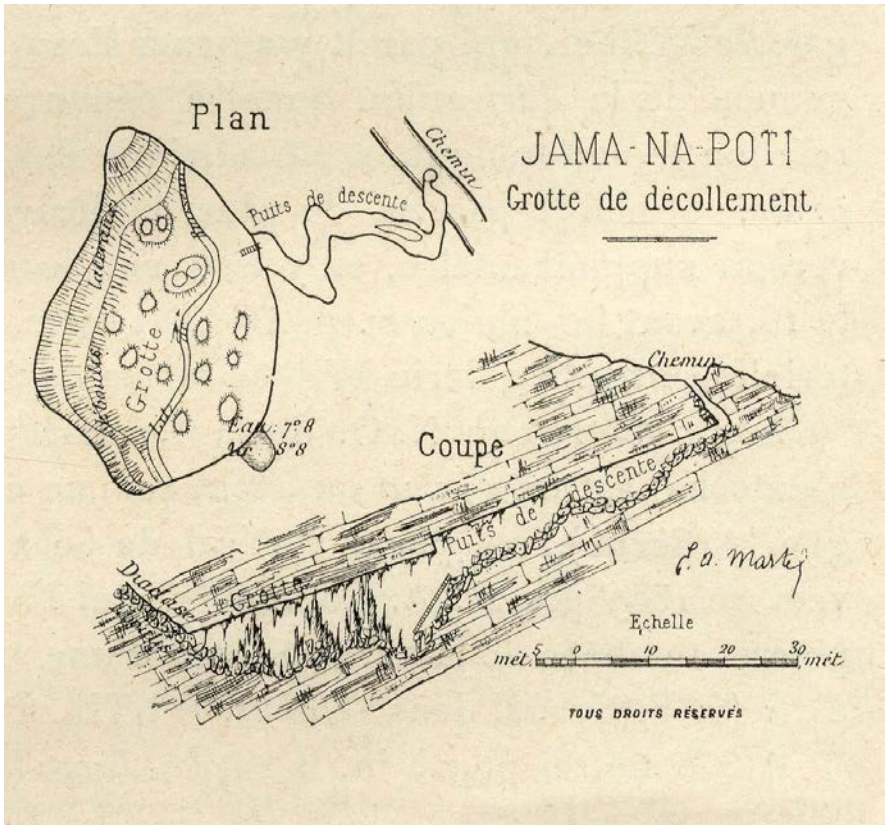


Fig. 5 Jama na Poti

debris, coming no doubt from the big doline nearby. Inside there are traces of a river bed, partly filled in. The concretions and collapses have destroyed any communication with other caves nearby. The main theoretical interest in Jama-na-Poti is in the form of its entrance, a simple joint, little by little enlarged into a cave. Here, too, external and internal corrosion are combined.

Črna jama (568 m) or the Black Cave (Magdalena Grotte of Schmidl), was, until 1816, the only cave visited in this region. It seemed at that time to be both a swallow hole and a collapse doline, (20 m deep). It is easy to descend. Schmidl stated that it was wrong to believe that the Pivka flowed there. He only ever saw that the water there was still. [p. 450] He was mistaken. For a long time the people of Postojna and also Kraus had seen flowing water there during floods and I was able to confirm its existence on 27 September 1893, after ten days of almost continuous rain.

Now Josef Vilhar has told me that he had found a new low passage in Črna jama, leading after 36 m of crawling, to a large and beautiful channel full of water. During my visit the passage was filled to the roof and impassable but, on the eastern side of the debris slope descending from the entrance above, a whole river was flowing vigorously between the stones in several places and ran rapidly through about three quarters of the Črna jama passages as shown in Fig. 2. Črna jama, in fact, forms a complete ring totalling about 500 m according to Schmidl. It appears that the collapse of the entrance has blocked the original course of the river.

In the past the Pivka, as I have already said, once flowed through Lepe jame. Nowadays Črna jama is no more than an overflow passage and the Vilhar gallery, which takes any excess water, is very probably a prolongation of the *diversion* which I discovered between Otoška jama and Magdalenska jama. The relation of topography and altitude between the two places (see figs. 2 and 3) indicates this *a priori*. And I have seen this diversion to effectively fulfil its role as a supplementary overflow on 20 September 1893. The water was 1 m higher than on the 16th, before the rains. It remains to discover, at low water, the junction between the Vilhar passage and my *diversion.*

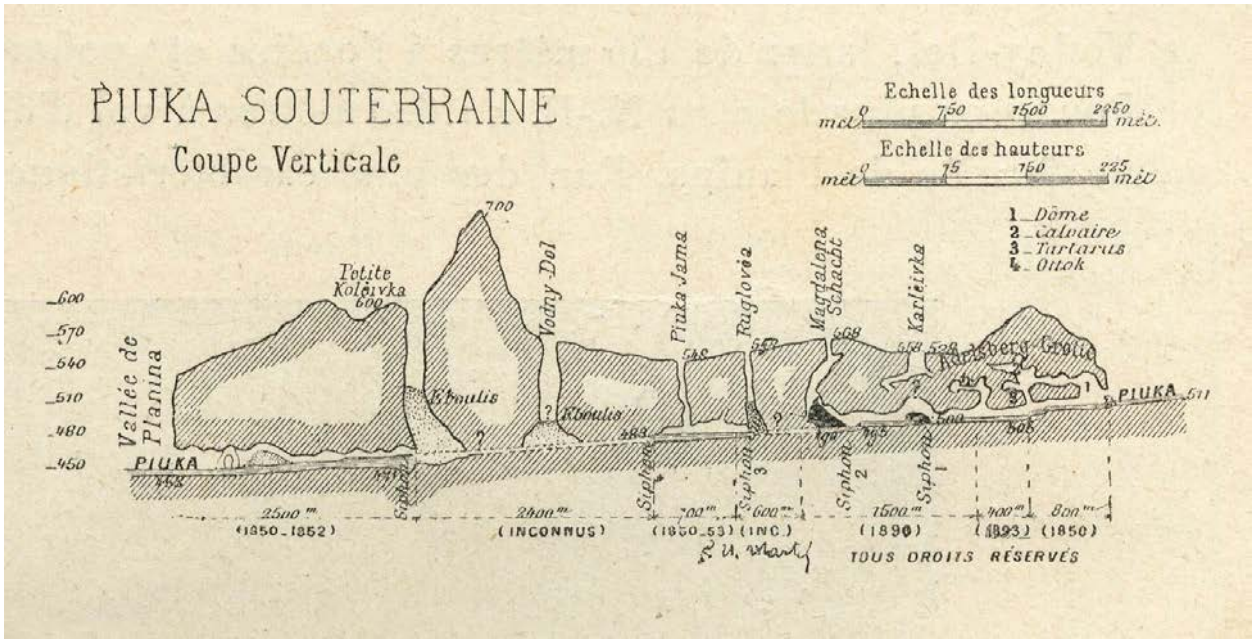


Fig. 6 Cross-section of the underground Pivka

250 m north-west of Črna jama is the *Ruglovča* [Fig. 6] (altitude 558 m) which, like Braunhie (in Lot) or Fontlongue (Ardèche), is a vertical shaft 50 m or 60 m deep. It was explored on 7 November 1889 by A. Lovrenčič and ended in a 20 m thick blockage of stones fallen from the surface. A current of air could be detected.

350 m further on, *Pivka jama* (altitude 548 m and 65 m deep), explored for the first time by Schmidl and Rudolf in 1852 and 1853, has been considered as a collapse doline up to now because of the size of its opening (50 m by 30 m). It is not: it is enough for me to invoke the extreme fissuring of the ground and the sectional view (Fig. 3) to prove that it is the product of superficial erosion at the side of an underground river. The roof of the latter has not subsided into it: it has lateral fissures. It goes without saying that the river is the Pivka (altitude 483 m). To the north one follows this flow (when the water is low) for 150 m (according to the exact measurements I made on 15 September 1893 with Kraus and Putick) and not "150 klafter" (284 m) as Schmidl had said. It continues as far as a large sump, preceded by several rocky fissures which only water can penetrate as it breaks up the strata. The passage is 12 m to 20 m high and 20 m to 30 m wide.

Upstream the accessible length is much greater (550 m) according to the plan made by Szombathy in 1885. Schmidl had said 500 klafter (948 m), giving 1232 m in all. I saw Pivka jama on 15 and 27 September 1893, first completely dry and then in full flood; calm with a quiet stream the first time and tremendous with a furious river the second. What must it have been like on that second date [p.457] where 8 days earlier I had been in Osgood between Otoška jama and the diversion? I understand why underground exploration proceeds so slowly on the Karst where the rivers present such frightening fury. I also understand why so many support depots are used and how, after a series of repeated floods, more than one roof may collapse. Schmidl, however, sees that Pivka jama is clearly not such a collapse. He thinks that the bottom of the original chasm was close to the level of the cave's interior and that the collapse of the separating partition has produced the debris which links them now. It is thus that one needs to understand that most such collapses (as at Rabanel) do not make complete perforation to the surface (as at Padirac). Schmidl has well described Pivka jama as "a Tindoul de la Vayssière of the second order", not being so deep at 65 m.

Quickly arriving at the bottom, I saw that there is, to the east, a closed basin 20 m to 30 m in diameter, perhaps the head of an impassable sump by which it may discharge flood water from Črna jama where, until now, no such place has been found. While on the west there is a debris mound, no doubt the bottom of the one that blocks the bottom of Ruglovča[31] (Fig. 2). A judicious excavation would establish or re-establish a communication that remains incomplete or else is non-existent[32]. Suitable wooden stairs were made in 1885 (and repaired in 1893) in this beautiful *Tindoul* of Pivka jama.[33]

[p.452] 1200 m east of Pivka jama is *Vodni dol*, a vast depression where one would like to see a roof collapse in that completely unknown part of the Pivka's course … Unfortunately, the fissures at the bottom do not allow us to go down to rejoin the river.

It is the same with *Mala Koliševka,* 1200 m north-east of Vodni dol, 150 m wide at the top and 60 m to 70 m deep.

Going further to the north-east, 1600 m as the crow flies from Mala Koliševka in the closed valley of Planina, [is] one of the most characteristic poljes … of the entire Karst. There, at an altitude of 453 m (58 m lower than where it sinks at Postojna), the Pivka returns to daylight [Fig. 7], large and majestic, at the foot of an escarpment 70 m to 80 m high, from a magnificent arch (19 m high and 29 m long according to

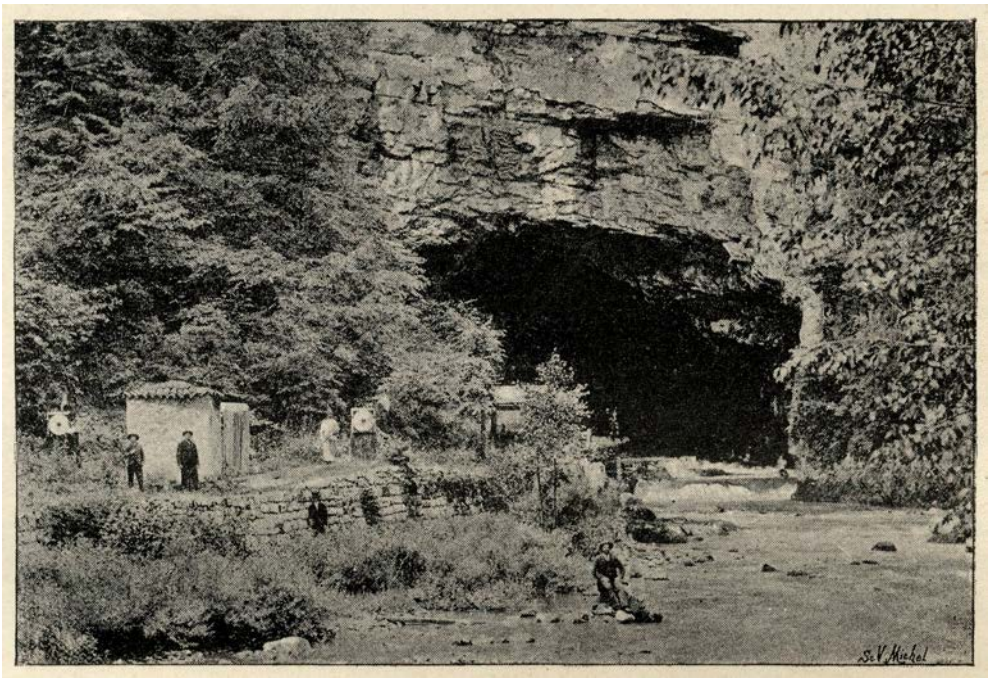


Fig. 7
The Pivka, emerging from Planinska jama (phot. Šeber)

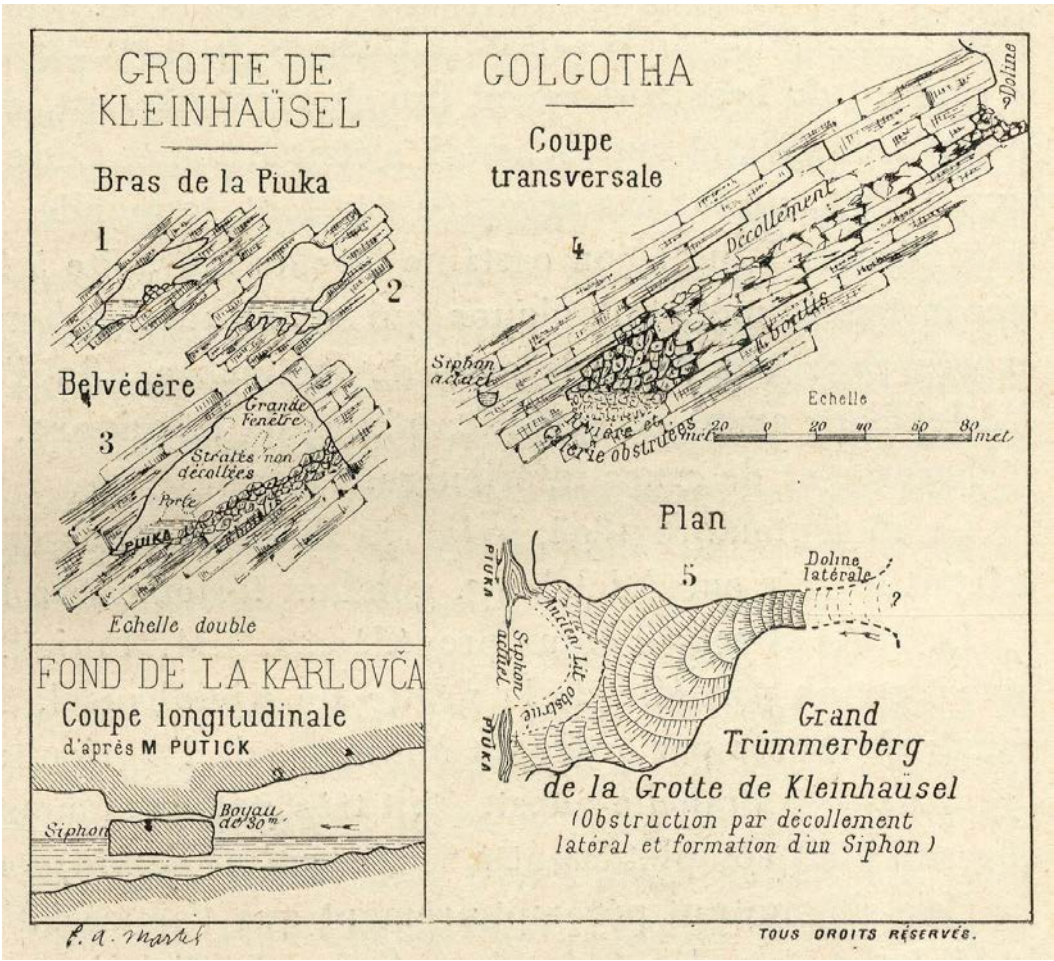
Schmidl), more beautiful perhaps than those of Lison in the Jura and Reveillon in Lot. This is the cave of **Kleinhaüsel**[34] [Planinska jama], one of the marvels of the Karst.

Schmidl has recorded his exploration, extraordinarily daring, of this cave which, [p. 453] 450 m from the entrance, divides into two branches, one to the west and one to the south [Fig. 8].

Following first the branch to the west, without noting its difficulties: after 2 km of meanders, boulder heaps and cascades, all formidable obstacles, (not to mention the danger of floods) the happy explorer arrives, at the end of the *Proteus chamber*, at a pool 140 m long, 45 m wide and 15 m deep beneath a roof 12 m to 15 m high.[35] The depth indicates there is no sump there. Rudolf's plan indicates a sump near Mala Koliševka; so that would mean a collapse blocking the Pivka of which about two and a half kilometres remain unknown[36] (Fig. 6). At Mala Koliševka, as at Vodni dol, it would need an immense amount of work to clear the bottom[37].

Underground, I hardly think that either the Reka at Škocjan or Padirac could equal in grandeur the junction of the two branches of Planinska jama. It is a lake 75 m long and 46 m wide, beneath a roof 20 m

Fig. 8
Planinska jama and the rising at Karlovica



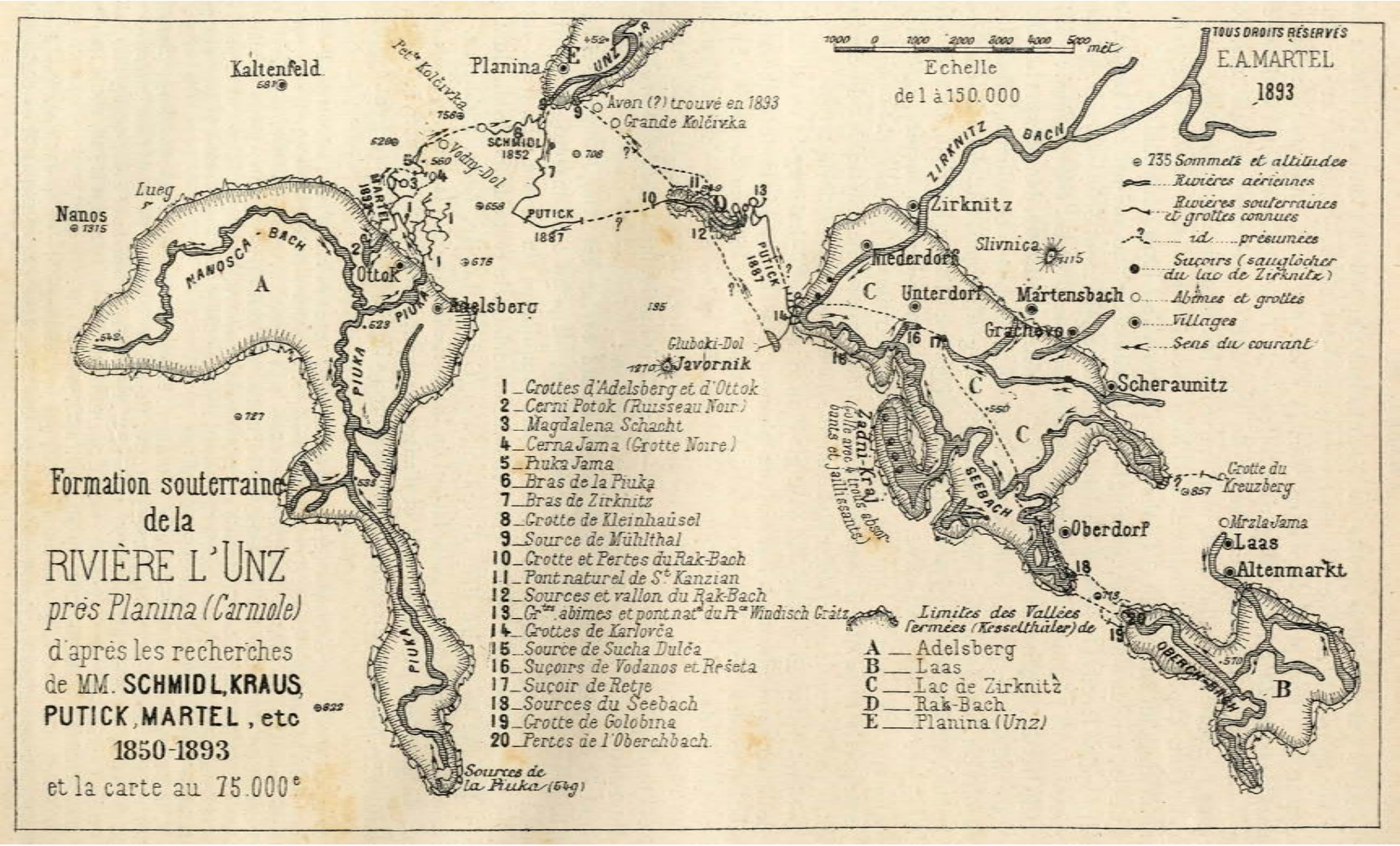
or 30 m above. There are no stalactites and the rock is dark, but the mass of water is impressive, for only the Pivka, deep and rumbling, fills this sombre space. The scene is overwhelming.

Furthermore, this underground confluence [Fig. 9] is one of the most curious hydrological phenomena known where two rivers, coming from afar, join together. Here it is the Pivka, which I have already described, and the discharge of the famous lake of Cerknica.

In 1852 Schmidl went a long way up the south branch of the cave which is even longer [p.454] than the western one, some 3 km[38], without being able to reach the end. In 1887 Putick went 1 km further but still without coming to the end. The origin of the two streams has been the subject of a long controversy. As early as 1848 the priest A. Urbas was led to believe that the southern branch came from the Cerknica lake and the western one from Postojna. Schmidl, on the other hand, had the Pivka from Postojna in the southern branch and made the western branch the collector of drainage from the plateau of Kaltenfeld [Studeno]. In 1877 Professor W. Urbas expressed the same opinion and put the origin of the western branch as the sinking of the Lokva at Predjama. But Putick in 1887 stated that the stream in the south branch really came from the east, from the Cerknica lake, not from the south, and that Schmidl was wrong. This interpretation by Putick and [A.] Urbas was not accepted by everyone. It is, however, the true one and I was able to confirm this during my visit to Planinska jama, thanks to meteorological circumstance which suited me admirably. I had deliberately chosen September for my study, to examine the caves around Postojna before and after the autumn rains, that is to say when they were dry and also when flooded.

On 16 September 1893 the Cerknica lake and its outlets were dry and that evening a storm broke over Postojna, greatly swelling the Pivka.

Fig. 9 The underground course of the Unica river near Planina



On 18 September Putick, Mller and I were in Planinska jama, using a sturdy wooden boat made expressly by order of the Austrian Minister of Agriculture. We can state that the water in the western branch was very high and still rising, while the southern branch was completely, dry *which I had never seen before*.

This demonstrates clearly that Putick's recognition that the Pivka and one of the outlets from the Cerknica lake do meet underground was justified and that Schmidl's opinion (reproduced by Reclus) was wrong[39].

[p.455] The river that comes out from Planinska jama is called the Pivka at Planina but, after flowing towards the north-east for 1800 m, it is joined on its right side by a stream 1 km long which rises 1 km east of Planinska jama at the impenetrable springs of *Mühlthal* [Malni] [Fig. 9] (like those of the Touvre). This is the other outlet from the Cerknica lake. The combined stream, after joing the Pivka, is called the *Unz* [Unica]. We shall follow its course later.

Before that we explain how the Pivka receives the Cerknica water from these two tributaries, one underground (Planinska jama) and one in the open air (the Malni springs).

For that we return about 20 km south-west from Planina to another closed valley, the Polje of *Laas* [Lož] [Fig. 10], north of mount *Schneeberg* [Snežnik] (1796 m). Several springs feed streams which unite as the *Oberch-Bach* [Obrh]. At the west of the basin this stream disappears (at 570 m) at low water like those of Issendolus and Bandiat [in France]. In German they are called *Sauglöcher* (suoirs) [swallow-holes]. In flood the water sinks in a curious cave called *Golobina* (Pigeon Hole), about 9 m higher (579 m). In 1882 Obereigner found a stream passage there 15 m below the sinks but could only follow it for 150 m before it became too tight. Some of the water reappears 2 km away at the impenetrable springs of the Seebach [the Obrhagain]. Another part presumably continues its course underground.

The *Obrh* starts in one corner of a polje, 10 km long and 5 km wide, which has the curious habit of being alternately dry and flooded. It is called the intermittent lake of *Cerknica* or just the *Jessero* [Jezero].[40] It has been specially famous since Valvasor's strange descriptions were published in 1689. But the recent studies of Vicentini, von Hauer, Obereigner, Putick, etc. seem to me to have definitely resolved the problem of this intermittence. Here is a resum of the matter.

When there has been no rain for a long time and the lake is completely empty, the Obrh, almost dry, winds sluggishly into its marshy bed (altitude 550 m), crossing toward the north-west over four fifths of its basin. The two places where the water sinks, the *Vodanos* [Vodonos] and *Rešeta* [Rešeto], absorb what remains of the Obrh, some of it having been lost in various sinks (Gebno, Leviše [Levišča], Kotu [Kotel], Bübnarca [Bobnarica], etc.), opening in a sort of side branch of the lake, *Zadnji-kraj*. Here and there on the rest of the lake's perimeter, below mount *Slivnica* (1115 m) to the north-east, are several other streams coming

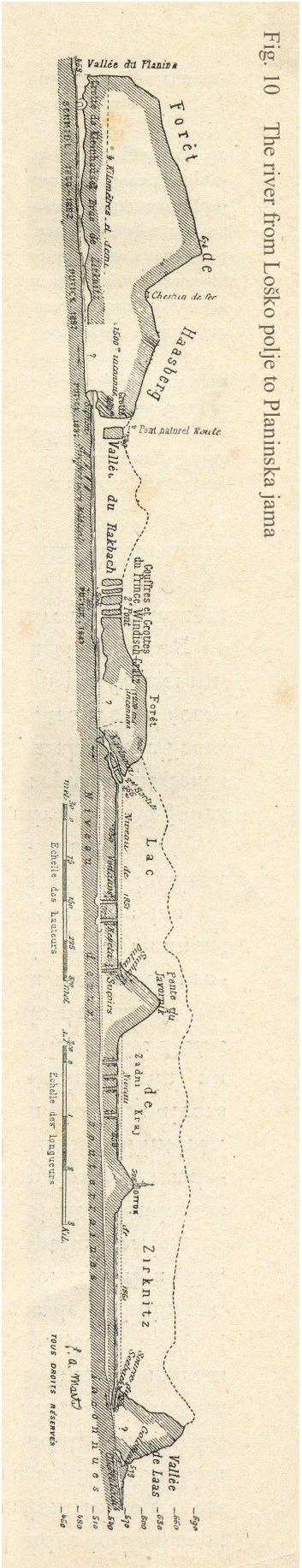


Fig. 10 The river from Loško polje to Planinska jama

from impenetrable springs[41] [p. 457] in the low ground, but are absorbed by the sinks before they can reach the Obrh. The *Retje* is the most important of these sinks. To the north the *Zirknitz-Bach* [Cerkniščica river], whose course is entirely on the surface and is much longer than the Obrh, follows the northern flank of the polje where it loses a little in various sinks along the way. It then passes in front of the Karlovica caves (see later) without, at low water, entering. It then makes an abrupt turn towards the south-east and finally what remains of its water sinks in the same places as the very end of the Obrh, the Vodonos and Rešeto (see Fig. 9).

When the sinks absorb the whole of the stream water, the bottom of the Cerknica lake is almost completely a fertile plain, richly cultivated. Thus it was completely dry on 3 August 1887 and during the summer of 1893, up to September.

But when the storms come and the autumn rains are heavy and prolonged, then the sinks[42] cannot absorb all the water from the swollen and overflowing rivers. I myself observed with great interest, on 21 September 1893, the transition from one to the other. Furthermore the various sinks in Zadnji Kraj become gushing springs. Finally one hole located a little above the edge of the lake at the foot of Javornik, *Sucha-Dulca* [Suha Dolica], becomes a strong spring if rain persists[43].

As the land submerges, the extent of the water increases, the level rises and the inhabitants of the villages around, many of which become islands, can only meet each other by boat. The lake of Cerknica has returned. It is seen that it depends entirely on the local rain regime ; its intermittence is not regular as some writers have said.

Its area varies between 2100 and 5600 hectares. It has been seen to fill in three days and to empty in two weeks. Until the usual outlets return to their normal functions, that is to say until they once again absorb water, it is necessary that the lake, surrounded on all sides by heights which seal it, seeks an outlet not by a mountain col but underground in the barrier to the north-west between the hill of Javornik and the town of Cerknica. This outlet is provided by the Karlovica[44] group of caves [Fig. 8] which become true swallow-holes[45].

Why do the sinks refuse to take more than a certain amount [p. 458] of water? Why do some of them become gushers? It has been supposed for a long time that this was because the Cerknica lake was an overflow for unknown underground reservoirs. And now we are definitely assured that this is so.

In exploring at low water the labyrinth of the Karlovica caves[46] (Velika Karlovica, Mala Karlovica, Vokenza [Velika Skadnenca], Schlesinger Grotte [part of Velika Karlovica] (etc.), one finds below the level of the bottom of the Cerknica lake a lower stream as in the Golobina [cave]. It is clear that there are two hydrological levels. In dry weather the lower level carries the water from the sinks in Loško polje and Cerkniško jezero but it is too narrow to take heavy rain. Above the higher part of Golobina [cave], the Cerknica lake itself and the upper parts of Karlovica are simple overflows like the Crousate [in France]. When the lower level is full, the surplus water coming from the surrounding hills rises, in accordance with the principle of inter-communicating vessels, and invades the higher level. The holes in Zadnji Kraj and Suha Dolica produce the water that has filtered down from Javornik (relatively high and extensive) which cannot enter the lower passages which are already full. And the lake itself, rising more and more, can only flow when it reaches the level of the Karlovica sinks[47].

Putick has penetrated 800 m into Velika Karlovica as far as a narrow tunnel (30 m long and 0.9m or more[48] in diameter), [p. 459] which will have to be enlarged to enable Osgood to get through. Beyond, one could follow a large passage containing a stream which extends to a point where we shall go when we return.

Passing over a ridge which overlooks the lake to the north-west for 100 m to 150 m or more, we come, after 2800 m as the crow flies, towards the north-west from Karlovica, to the little valley called *Rak-Bach* [Rakov Škocjan] [Figs. 11, 12]. It is only 2.5 km long but is perhaps the most curious of all the poljes.

Fig. 11 Mali most at Rakov Škocjan (phot. Šeber)

Fig. 12 Veliki most at Rakov Škocjan (phot. Šeber)

At its upper end a river emerges from the cave [Zelške jame] of *Prince Windisch-Grätz* who was owner of the magnificent forest surrounding it. On going upstream one sees what can be described as two letters S placed end to end. Going even further upstream the cave roof is pierced by three big holes and three little ones. I know of nothing so strange as this arrangement. If one walks on the surface above, vertically above the underground river, one comes to see beautiful openings, between 5 m and 50 m wide, at the bottom of which one sees, 60 m below, the green ribbon of the river coming out from one dark arch only to disappear under another. One of these pits[49] has a convenient path down it[50] and if one walks around the edge of the water one crosses 3 or 4 caves, passing from one to another through various openings of different heights. In the largest, the effect resembles that in Tindoul de la Vayssière; and even that one is separated from the next, not by a real cave but by a layer of rock that has not collapsed, held in place at a dizzy height by a gothic arch as graceful as it is strong, called the *Little Natural Bridge of Saint Kanzian* [Mali naravni most] [Fig. 11]. In the last cave upstream Putick followed the river for 1500 m, 1200 m of these in a boat, passing many natural barriers and obstructions. It is only 1200 m further on that he would have reached the Karlovica cave. It was not a sump that blocked progress at this point. It was lack of time that prevented him from achieving this interesting junction which I would willingly have attempted if the water level had allowed.

Putick noted in this cave several side passages (some open, some blocked) which seem to correspond to branches of Karlovica cave and the ground beneath the lake [p. 460] of Cerknica. One of these (Prince Ernst cave), which I visited, is blocked by stalagmite after 150 m but impenetrable side fissures extend beneath the lake floor. In fact there is no doubt that the Rakback [river Rak] is the overall collector that drains the whole *system* of the Cerknica basin, for it rises at an altitude of 500 m, 50 m lower than the bottom of

the lake. Such a difference, over a distance of scarcely 3 km, would make it very possible to control and regularize this drainage and outflow system.

About half way along the Rak valley and on its left side is a powerful impenetrable spring, either another one supplied from Cerknica or drainage from rain-water on the hill of Javornik to the north.

Finally, after flowing in the open air for 2 km, the river, when there is enough water in it, flows beneath a true rock arch [Fig. 12] where it has made its way through a barrier of resistant rock, 45 m high and 50 m thick. It is the *Great Natural Bridge of Saint Kamzian*[51] [Veliki naravni most], the archway being 19 m high and 46 m long.

After Veliki naravni most (over which there runs a motor road) the open-air course of the river continues for about 150 m to 200 m and goes into another cave [Tkalea jama] with no special name. Putick has followed it for 360 m as far as a closed sump at a circular pool, 20 m to 30 m in diameter, beneath an arch 8 m to 10 m high.

It is not seen again until, after 1500 m as the crow flies, it reappears in the southern branch of Planinska jama[52], which corresponds with the unnamed passage recognized [by Putick] as the main outflow from the Cerknica lake.

[p. 461] The other outflow [from Cerknica] is the water from the 31 springs at Malni, *of which 20 never dry up* (some of them gush out under pressure). On average these Malni springs are at a level 5 m higher than the Pivka branch in Planinska jama. Between the latter and Malni is the doline of Velka-Kolečivka [Unška Koliševka], 85 m deep and 280 m to 230 m wide with its bottom at an altitude of 480 m. Perhaps, like Vodnidol and Mala Koliševka, it is a collapse on the course of this unknown flow. There is no cave entrance at the bottom. All these dolines have a striking similarity to those at Bèdes and Vitarelles.

A little closer to the Malni springs a peasant claims to have discovered in September 1893 a shaft, almost blocked by rocks between which he threw stones which he said, *fell into water*. Putick intends to clear this and explore the shaft.

Rakov Škocjan, with its fragment of roof still in place, is an excellent argument for the theory that certain valleys have been formed by the collapse of caves – a theory of which I am a willing supporter but which is not widely accepted. Thus it is, I believe, an exaggeration to say that "the only differences between dolines and poljes is in their size and that the origin of depressions is collapse due to underground erosion" (Kraus, *Entwässerungs-Arbiten*). The action of surface erosion is important too.

We have successfully shown that the Unica river is the product of the joining of the Pivka with the two outlets of the Cerknica lake and that the junction occurs underground for the Planinska jama branch and in the open air for the Malni one. It is therefore not correct to call Planinska jama the Unica cave as is sometimes done.

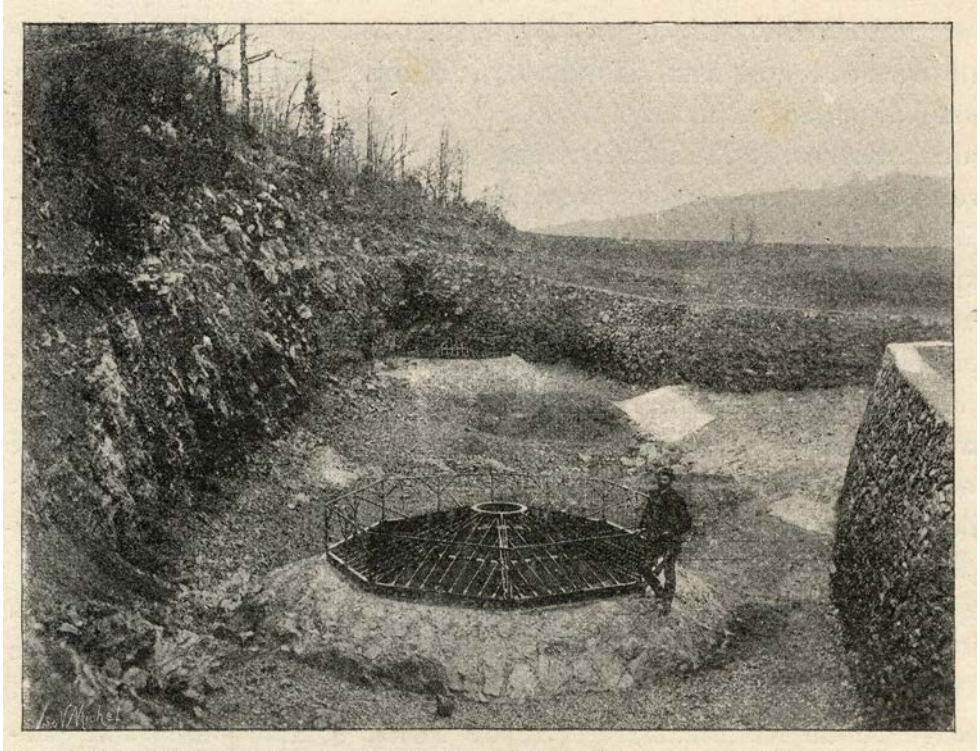
On the same side of the place where the river takes the name Unica and below the Haasberg castle (on the right side of the Unica) the Shratouka [Škratovka] cave was considered by the Reverend Urbas as being perhaps a branch of Planinska jama. It is now accepted as being a simple overflow for the Malni springs, producing a lot of water after heavy rain.

The periodic floods which affect Planinska polje (specially severe in 1802, 1820, 1844, 1851, 1872, 1875, 1878 and 1880) have for long attracted the attention of the public works department in Austria and it is in an attempt to overcome these floods that Kraus has been working for more than ten years[53].

They are caused by the swelling of the Unica (and also various smaller rivers around the edge of the polje) after melting snow or heavy rain and especially because of the limited outflow at its northern end.

The water there drains into a series of narrow *swallow-holes* [Fig. 13] at an altitude of 440 m, beneath the rocky plateau of Loitsch [Logatec] at between 500 m and 800m. From there it reappears at the Ljubljanica springs, 10 or 11 km to the north-east. The flood water, it is said, takes 11 hours to cover this distance.

Fig. 13
Putick's works at Pod Stenami (phot. Šeber)



[p.462] Knowledge of the water's underground route beneath the second barrier is much less than that of the other two (Postojna/Planina and Cerknica/Planina). The difficulties are much greater and the difference in altitude is 150 m.

Putick, charged with putting into effect the ideas advocated long before by Urbas, engineer Vicentini (in 1875) and Kraus, carried out the most remarkable explorations and works that I regret not being able to analyse in detail[54].

Thus he explored various shafts and caves on the Logatec plateau[55] to [p. 463] study the routes of the underground Unica as Urbas had tried in vain to do 40 years earlier. Despite his great efforts, he could still not discover the passage containing the flowing water. He found only caves of various lengths, former branches which now only act as overflow passages for flood water and which, if modified, could be very useful as reservoirs and holding places. The most important of these is *Falkenhayn-Höhle* [Logarček], 2 km long and closed at both ends by sumps where water emerges when the Unica floods (no doubt from the sinks at Laze) and disappears when the river level falls.

The biggest chamber (70 m long by 40 m wide, according to the measurements I took by measuring tape when I was there with Putick on 19 September 1893, and about 35 m high) also has two pools of water. The quantity of alluvial clay carried by such a flood is immense. One enters the cave, some 70 m deep, in two stages, using the fissures of the oblique stratification [56] similar to that in Pivka jama. The cave itself results from the spacing of the joints and the breaking up of the strata by water (hydrostatic pressure, erosion and corrosion). The sectional views [Fig. 14] make this clear[57].

After the rain I saw abundant trickling from the roof fissures. One particular vertical chimney even produced a real cascade, the flow from which is creating a basin of red and white crystals. Here, this kind of formation seems to be due to the movement of the water in the pool resulting from the falling drops – the intermittent nature of the dripping causing a changing water level – and due also to the irregularity of evaporation and crystallisation that results.

In the western part of the Logatec plateau many caves remain to be explored[58], [p. 464] and many streams sink into fissures in the ground to become (like Črni potok at Postojna) underground feeders of the

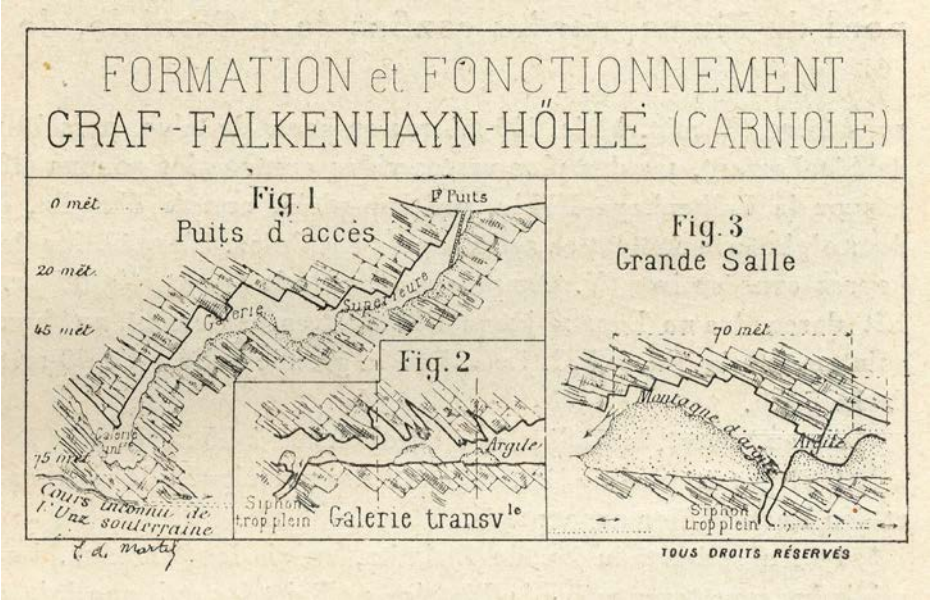


Fig. 14 Logarček jama

Unica. The main one is the *Reka* or *Logasica* [Logaščica], which disappears into a swallow-hole (the *Jačka*, which formerly, according to the local old people, connected with a deep cave that is now blocked with clay) close to the railway station at Dolenje Logatec.

Openings, caves, shafts and springs abound no less in the south-east part of Carniola which lies to the east of the Cerknica lake, between the rivers Gurk [Krka] and Kulpa [Kolpa][59].

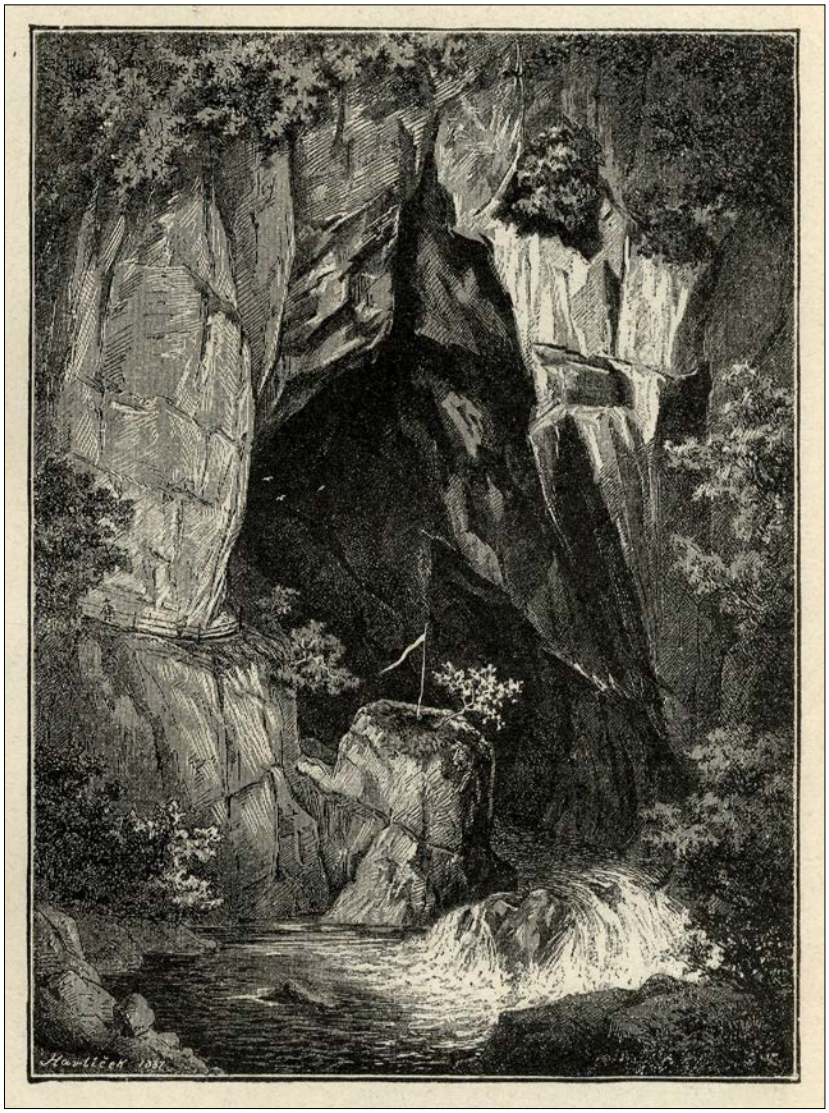
To say more about the places mentioned in note 59 would need an entire volume and collaboration with all those who have studied them in various degrees of detail[60].

Returning to the west and passing beneath Schneeberg [Šnežnik] we find, north of Fiume [Rijeka] and on the boundaries of Carniola, Croatia and Istria, the head of the most [p. 465] important river of the whole Karst, the Recca or Reka[61], which has created underground what are perhaps the most gigantic caves in existence. No attempt to make them popular for visitors has yet been made, for their exploration begun in 1840, is still not ended on 6 September 1893.

After about 60 km flowing in the open air the Reka leaves the Triassic grits at their border with Cretaceous limestone and loses some of its volume into impenetrable fissures in its bed at an altitude of 340 m. 8 km further on the whole river sinks at an altitude of 324 m beneath the rocky arch of a cave entrance [Fig. 15] at the foot of a cliff about 100 m high.

For 300 m it runs, with five foaming cascades through a cave (Mahorčičeva and Mariničeva jama). There are two large holes in its rock roof, one of which (*Okroglica*) reaches the surface 80 m above at the picturesque village of Saint Canzian am Karst [Škocjan][62]. Then the Reka, at a 6th cascade (at the top of which Marinitsch, carried there by flood water, spent 12 hours between life and death through the night of 4 May 1884) reaches daylight for the first time at the foot of a hollow 110 m to 130 m deep called the *Small Doline of Saint-Canzian* [Mala dolina]. Then there is a second rocky barrier pierced by the river without any collapse [Fig. 16]. Its route through it is so short that the four cascades which thunder beneath the arch are all lit by daylight. The last of these cascades falls into a small lake (at an altitude of 275 m according to Müller) at the bottom of a second hollow, much bigger than the other and called the *Great Doline of Saint-Canzian* [Velika dolina] [Fig. 17]. Its west wall is vertical and 160 m high. But the other sides are not so steep, and the Küstenland Section of the German and Austrian Alpine Club has been able to make a system of convenient footpaths which enable one to admire [p. 466], without danger or difficulty, one of the strangest features on the surface of the earth.

Fig. 15 First exit of the Reka (Marinitscheva jama)



The two dolines of Škocjan together measure more than 400 m in diameter. The narrow ridge which separates them, hardly two metres wide at the top, is 60 m broad at its base by the edge of the dolines which, seen from above, seem to be merged into one and crossed by the ribbon, green or yellow (depending on the height of the water) of the Reka winding at the bottom. From the look-out points around the periphery of the dolines (Stephnie-Warte [Štefanino razgledišči], Mizi-Warte [Mičin razglednik], Martinitsch-Warte [Mariničev razglednik], etc. The sight is extraordinary, Müller's descriptions[63] are not exaggerated.

The great number of side [or subsidiary] caves, Czörnig [Čoernigova], Brichta [Brihta], Tominz [Tominčeva] (600 m long), Brucker [Bruckova], etc., which appear at various heights in the main caves or in the walls of the two dolines, show clearly the work of underground water seeking to penetrate further, which is the principal cause of these enormous craters[64] in the ground here where the infiltration of surface water serves to enlarge the joints, separating great masses of stone and allowing them to slip like a badly cemented arch. The two sorts of erosion and corrosion, internal and external, are here combined as at Rabanel, for example, but on a much larger scale, with a more powerful flow of water attacking [p. 467] weaker ground. The Natural Bridge is only an arch where the keystone has not fallen.

The Reka and all the minor caves of the dolines come together to lead finally to a third sink (8 m wide and 15 m high), the overall collector where the true underground river course begins [Fig. 18]. To the right of this and 35 m above it is the *Schmidl-Grotte* [Schmidlova dvorana] so named in honour of the brave explorer of Planinska jama) and the *Brunnen-Grotte* [dvorana Ponvic] (discovered 15 April 1888) which

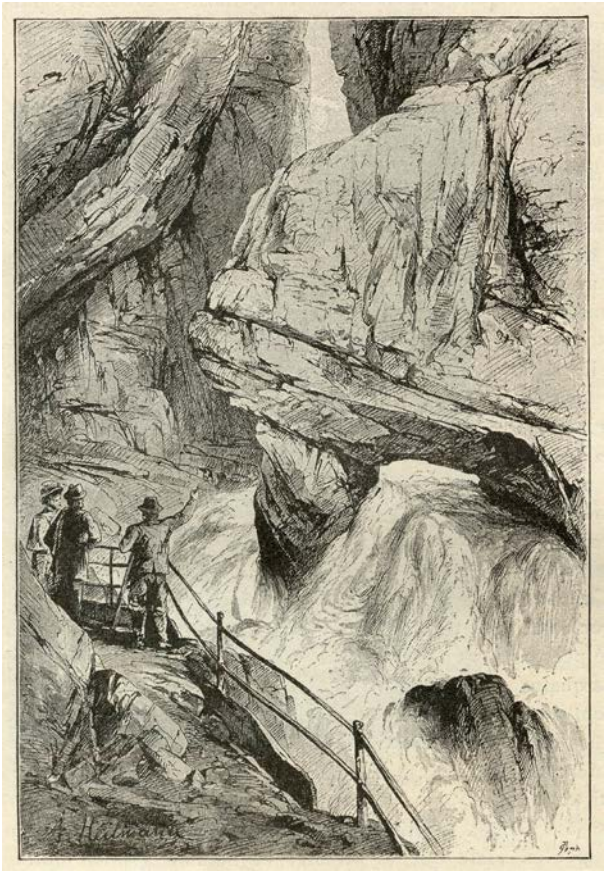


Fig. 16 Waterfall beneath the Natural Bridge between the two dolines (the second sink)

Fig. 17 Velika dolina at Škocjanske jame

contains the *Brunnen* [Ponvice] or gours in a cascade, like those in Saint-Marcel [Grotte de Saint Marcel d'Ardèche in France] only smaller.

The engravings in F. Müller's books [Figs. 19, 20, 21, 22, 23], graciously lent by the German and Austrian Alpine Club, while very correct, give only a feeble idea of the grandeur of this unique site.

The history of exploration of the underground Reka, which has taken 53 years to cover 2100 m, is truly remarkable.

Indeed the Reka is not a small river like Bramabiau, Tindoul or Padirac: it is a really large one where the wildly furious torrent can rise several metres in a few hours, flooding the whole width of the cave. It is not like Padirac but twice the size, a succession of enormous passages, a unique place three or four times larger where it expands into great chambers sometimes 60 m or more in width, alternating with narrower channels where the walls are only 4 m or 5 m apart. The height of the (invisible) roofs certainly reaches 80 m[65].

[p. 468] Throughout its length, the river occupies the bottom (and sometimes the whole width) and it falls at 25 cascades (not counting the 11 in the first two caves). It is only in a future *Monograph on the Underground Karst* that one could record *in extenso* the strait forward and rousing account of these latest explorations, written by Müller and carried out by him with his colleagues[66].

[p. 469] On 6 September 1863 Marinitsch found his way blocked by a final sump (lac de la Mort [Mrtvo jezero] 13 m deep) like those he had already met in Pivka jama, Planinska jama and Rakov Škocjan [Zelške jame].

It seems pointless to refer here once again to what we keep remarking upon: rock fissures, erosion, cascades, sumps etc. Even more powerful, the action of the Reka is nothing new nor unexpected.

Marinitsch has calculated that the total passage length at Škocjan is 5740 m of which 2100 m is occupied by the Reka from its third sink to the sump[67].

Where does the Reka go? It has always been thought that it reappears (36 km north-west of Škocjan) as the famous Timavo, that group of many springs, powerful enough to reach ships in the Adriatic, 1 or 2 km away. Virgil said it had nine outlets, others gave it seven. It is difficult to know exactly how many more springs there are (also impenetrable by man) in the marshy ground. [p. 470] The way these waters appear resembles those of the Touvre and their fan-like spreading makes one think of an underground delta. But for the more than 50 years that people have been trying to resolve this problem [of the destination of the Reka water], despite many historical and geographical studies[68], there has been no proof positive of this communication.

Here is a very brief attempt to summarise the main attempts made to locate the Reka at the bottom of shafts and caves in the Karst between Škocjan and the Adriatic [Fig. 23].

First, near the village of Dane and 1100 m south-west of the third sinking of the Reka at Škocjan, Marinitsch and Müller on 1 March 1891 descended the *Jama na Prevali* [Fig. 24], a 90 m deep cave (of which 50 m is a vertical descent) with a total length of 240 m. The main chamber contains several little pools of water and its shape suggests a collapse cavity, like the Bar cave in the département of Lot. But there is no Reka, not even the Dane stream which sinks 375 m to the south-east. Perhaps [p. 471] excavations there might discover extensions, following perhaps the course of any water from the cave.

In 1892 Marinitsch, Müller and Novak visited, also without result but without any difficulty either, the *Med-Jama* [Mejame] near Dane on 25 September (90 m long, 52 m deep), *Jama-na-Sokol-Jakam* [Jama nad Sokolakom] on 3 April (38m deep) and *Triglavca* near Divača, also on 3 April.

To the west-north-west, very many dolines seem to have broken up the Karst. Some consider that they are subsidiaries caused by and spread by flowing water. There seems to be no confirmation of this yet nevertheless at the *Grižca-Dolina* in winter a flow of warm air at 12ºC rises from

Fig. 18 The third and last sink of the Reka

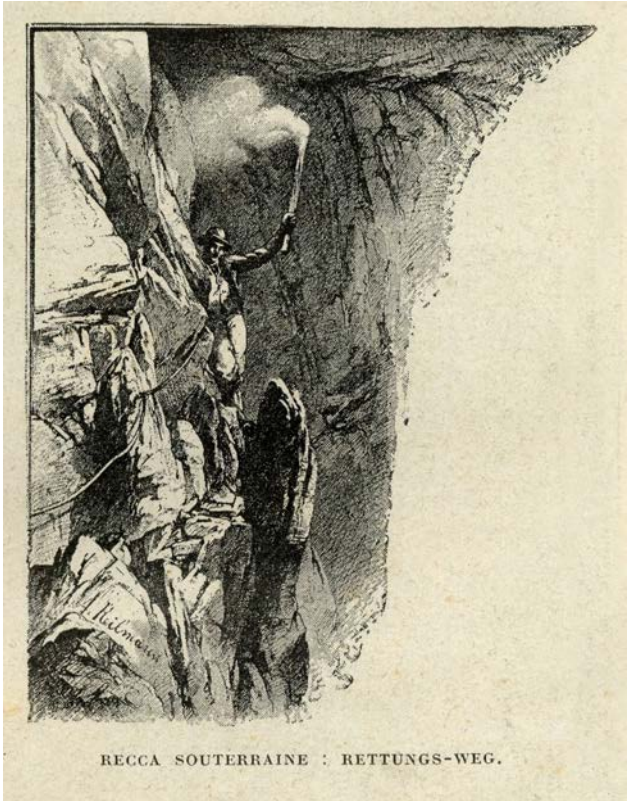


Fig. 19 The underground Reka : Pazzejeva resilna pot

Fig. 20 The underground Reka : the first passing of the 6th cascade

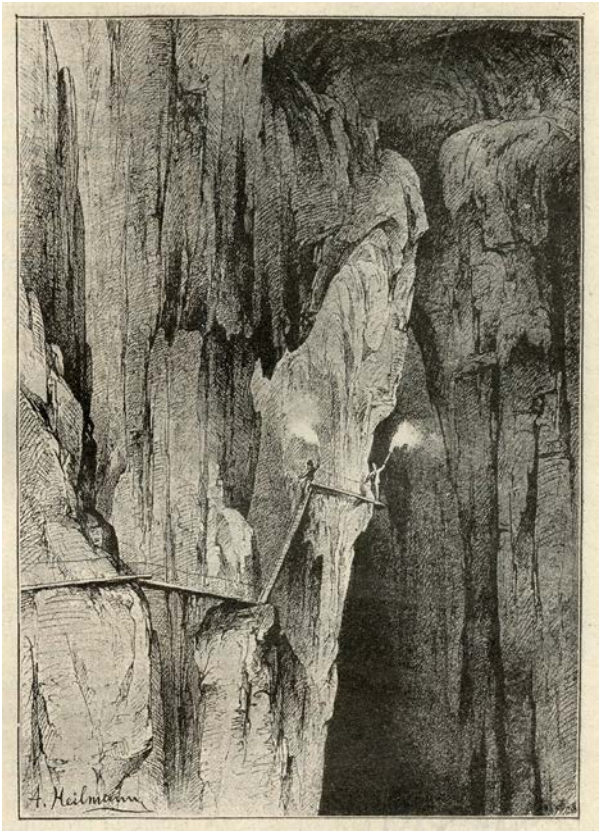


Fig. 21 The underground Reka: footway in Rudolfova dvorana

the fissures when the outside air falls to zero (F. Müller).

One of the largest dolines is that of *Risnik*, 2500 m from Škocjan. It edges are at an altitude of about 445 m[69], it is 90 m deep ([to altitude] 355 m) and its diameter is 260 m by 205 m. The Reka, where it first sinks at Mahorčičeva jama, is at an altitude of 324 m, falling by between 125 m and 150 m[70] to Mrtvo jezero at either 175 m or 200 m above the sea. This sump is (without taking account of any bends underground) 800 m in a straight line from Risnik doline, towards which the Reka is indeed running. But, even supposing [p.472] that it does not slope as far as the level of the Risnik doline and that it is Hanke's measurements that are correct, the bottom of the doline is still either 180 m or 155 m above the river [see Fig. 23]. The thickness of the debris cone resulting from the subsidence represents therefore twice the depth of the doline. Now at Padirac the cone (45 m thick) occupies only half the distance (103 m) which separates its river from the surface of the ground above. Thus at Risnik the river would have to be between 270 m and 245 m below the surface. That seems to me to be completely unrealistic. And if there is some indirect link, which I readily admit is possible, it would be oblique rather than vertical, by some lateral loosening no doubt, like the Golgotha [Golgota] in Planinska jama (see p. 453 [Fig. 8]) and the Grotte Jubilé [Orlovo Gnezdo] in Škocjanske jame (see p. 489) [Fig. 22].

Still in a north-westerly direction, 800 m from the Risnik doline, *Kačna jama* (the serpent cave) is, to my knowledge, the third deepest (260 m or 253 m) of all the natural shafts descended by man.

Its mouth is at an altitude of 445 m above the sea, at the bottom of a collapse doline 45 m long and 35 m wide. In 1892 a way was found, like the one in the Igue de Baou in Lot, which allowed access for 40 m down to the mouth of two narrow holes, separated by a ridge as at Rabanel. But this ridge is only between 0.75 m and 1.20 m thick by 5 m or 6 m long.

The dip of the Cretaceous strata is only between 10º and 15º. It seems likely that Kačna jama

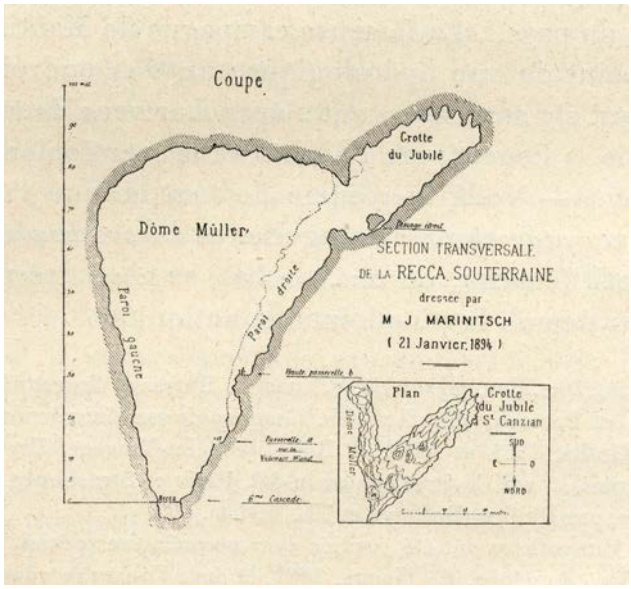
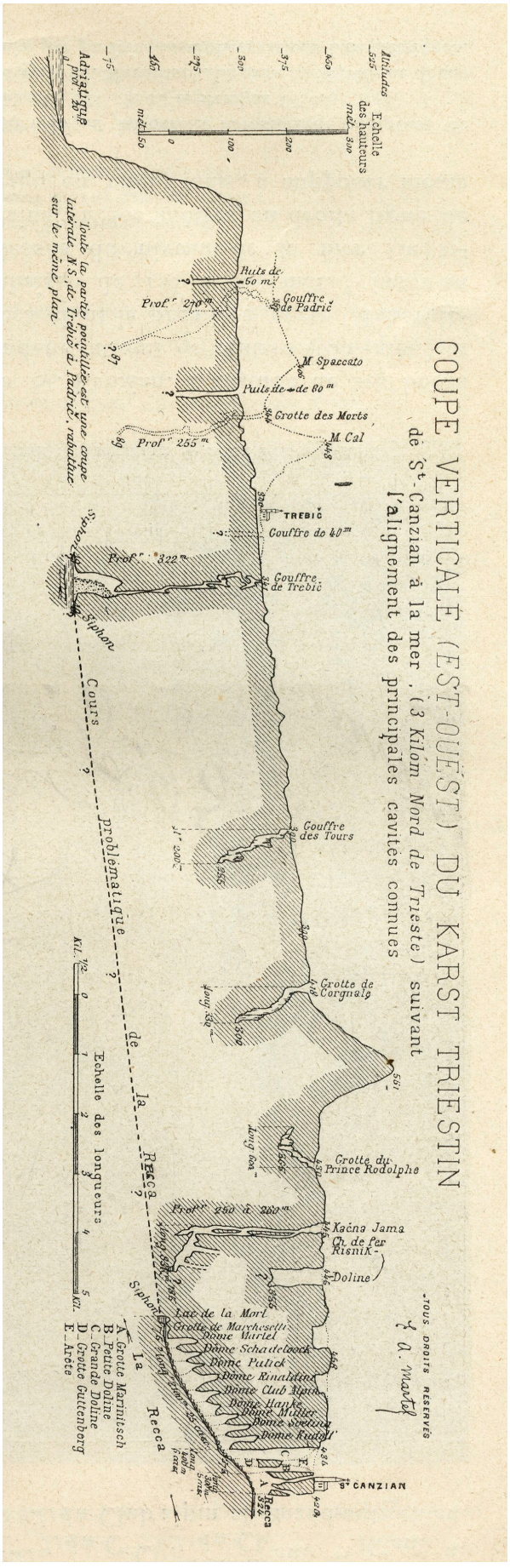


Fig. 22 Cross-section of the Reka [In Škocjanske jame]

Fig. 23 East-west section of the Trieste karst from Škocjan to the sea →



[p. 473] is a shaft made by surface erosion, from which a great vertical rift results in its extreme depth.

After many attempts (especially in 1889) and a whole week of preparation, Hanke succeeded in descending on 28 June 1891[71] and followed a long passage at a level about the same as that of the Reka. Also Hanke thought that a large sheet of water which stopped him is, if not the river itself, an overflow for floods. The degree of approximation in the heights and depths, both of the Reka in Škocjanske jame and of Kačna jama, means that such suppositions must be treated with great caution[72]. We must await the results of a new exploration.

One kilometre west of Kačna jama and west of the Risnik doline another doline (or rather cave) is the entrance (430 m above sea level) of the beautiful *Cave of Prince Rudolphe* [Divaška jama] [Fig. 25]. This is 600 m long, [p. 474] of which the lowest point is at an altitude of only 365 m. If it has ever had any relationship with the Reka, which flows 150 m to 200 m lower and an unknown distance away, it can only have been as a tributary fissure enlarged by water leading to the main river.[73]

Three kilometres west of Divaška jama and 4 km from Kačna jama is the cave of *Corgnale* [Vilenica],

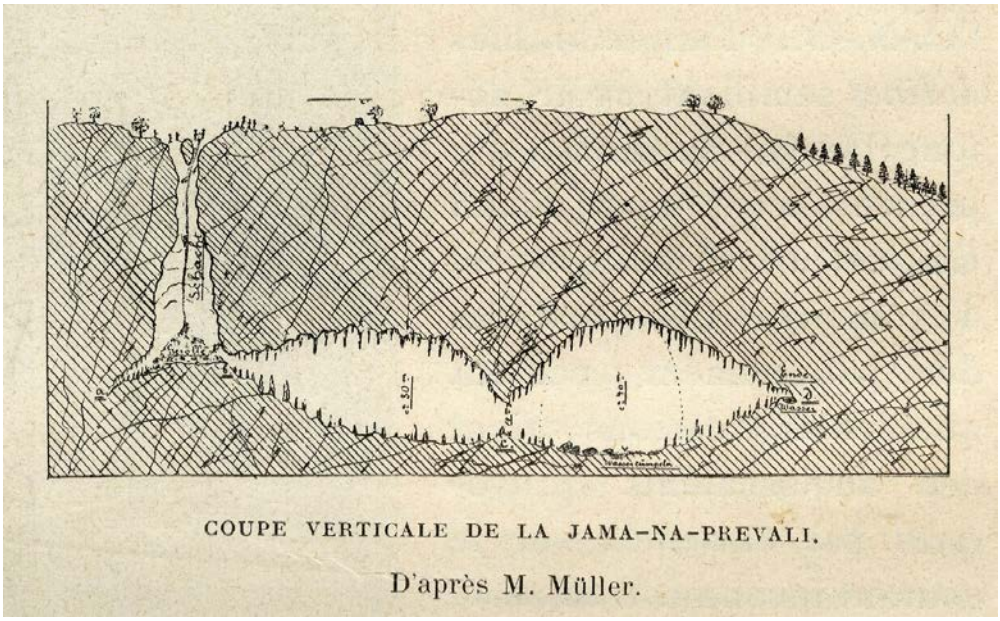


Fig. 24
Section of Jama na Prevali [2]

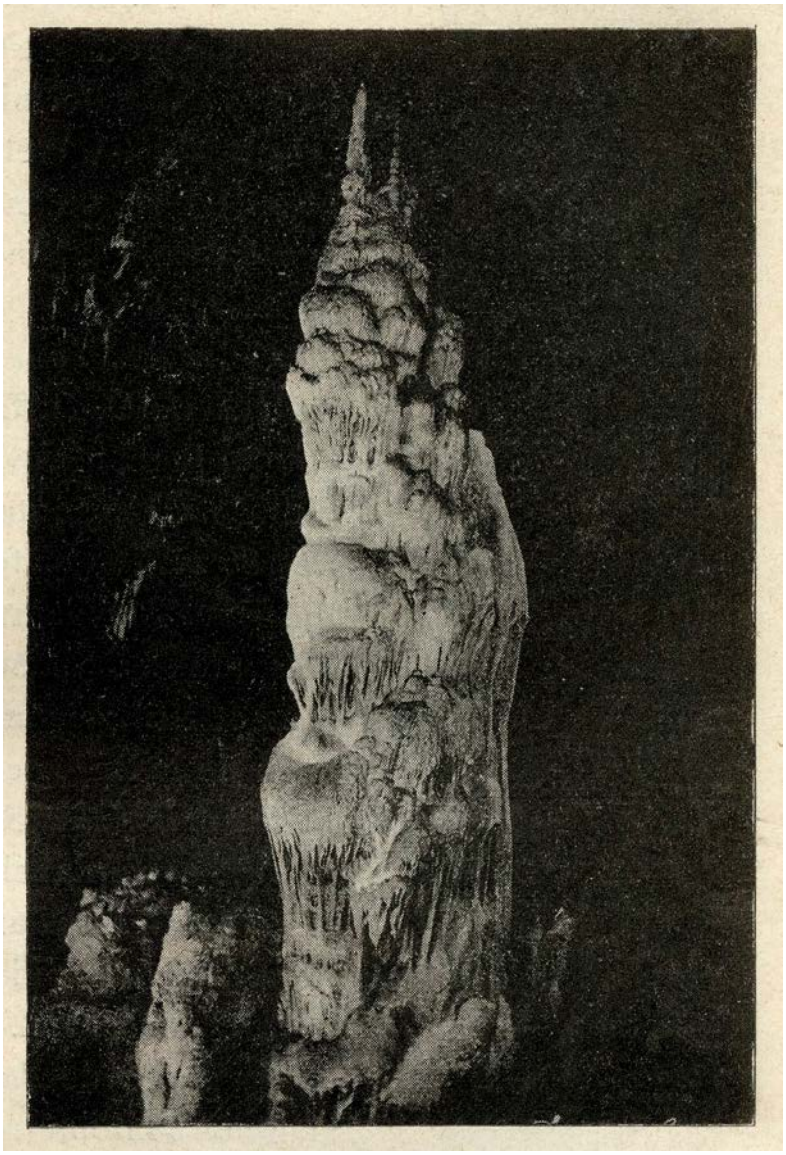


Fig. 25 Stalagmite in Divaška jama

explored and described by Nagel in 1748. It ends in a system of large shafts 330 m long and 115 m deep (Schmidl pp. 39 and 203). It is the former bed of an underground river, of which the far end is similar to that of Marzal in the Ardèche.

The cave of *Tours* (grotte delle Torri) or of *Bezovščina* [Lipiška jama], 2.5 km west-north-west of Vilenica, resembles in section the Aven du Marzal. It is an eroded shaft, the source of an underground river, now dry. *Bending towards the south-west*, it is about 160 m long, descending for 130 m to collapse debris that blocks it. The cave entrance (4m in diameter) is at an altitude of 390 m and its deepest point it is at 260 m. Both caves are far from the level of the Reka.

It seems that in two dolines close by Lipiška jama there are holes from which a strong flow of air blows when the Reka at Škocjan is swollen.

The cave of *Padriciano*, 12 km east[=west] of Škocjan and 10 km east-south-east [=west-south-west] of Kačna jama, should, because of

its depth (270 m) which puts it second of all the deepest caves known, and because of its altitude (only 357 m or 370 m[74]), give a good result. But it is blocked 87 m or 100 m above sea level and its location is too far south for it to be a tributary. Its cross-section shows that it is a swallow-hole of the Altayrak type. Its entrance is an erosion shaft followed by a passage [p.475] which follows the stratification. The cave extends to the south for 500 m, sloping at 30% but dropping at 54% overall, due to several vertical drops, one of which is 45 m deep.

The *Grotta dei Morti* [Fig. 26], which contests with Kačna jama as the third deepest in the world, ends in an impassable fissure at a depth of 255 m. Three kilometres east of Trieste, it opens at an altitude of 344 m on the side of Monte Spaccato. From 1861 to 1866, 20 000 francs were spent in unsuccessful and disastrous works[75] in search of a water supply [for Trieste] but it was never found[76].

Finally, Trebiciano, 12.5 km east-north-east [=west-north-west] of Škocjan[77] and 4 km north of Padriciano, is the deepest natural cave known at 322 m [Figs. 4, 27]. This is not precisely accurate since Lindner in 1840 and 1841 spent 11 months enlarging and linking the 12 overlapping vertical fissures (1 m to 7 m wide and 7 m to 58 m high) which on 6 April 1841, finally led to a depth of 259 m underground. There he found himself at the top of a heap of sand which filled part of an immense cave, 230 m long, 10 m to 80 m wide and 75 m to 80 m high, containing, 63 m below at the foot of the mass of sand, a stream that seemed to be hardly moving. It was 13 m wide at low flow and between 1.8 m and 4 m deep [p. 476], only 19 m above sea level. The water is at too low an altitude to be used, as had been hoped, as a drinking water supply through a tunnel for the city of Trieste, 6 km away to the south-west. But we may suppose (note the similarity of the sand and the discovery of a mill wheel blade by Lindner at the 10th pitch at a depth of 220 m) that the river thus discovered at the cost of all this work and perseverance in the *Lindner-Höhle* [Trebiciano, Labodnica] (the name is given deservedly) is under the Reka, at least 150 m lower than the final sump at Škocjan.

I remember that the river-lake of Trebiciano is firmly sealed by sumps or impenetrable passages at

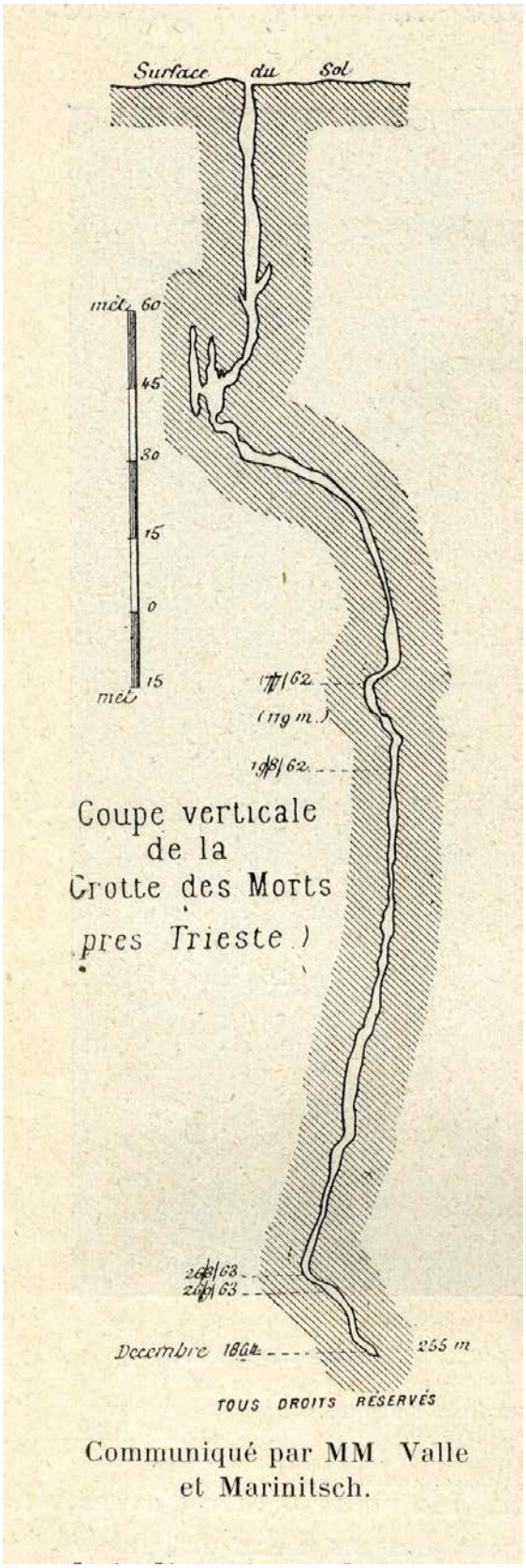


Fig. 26 Vertical section of Grotta dei Morti near Trieste

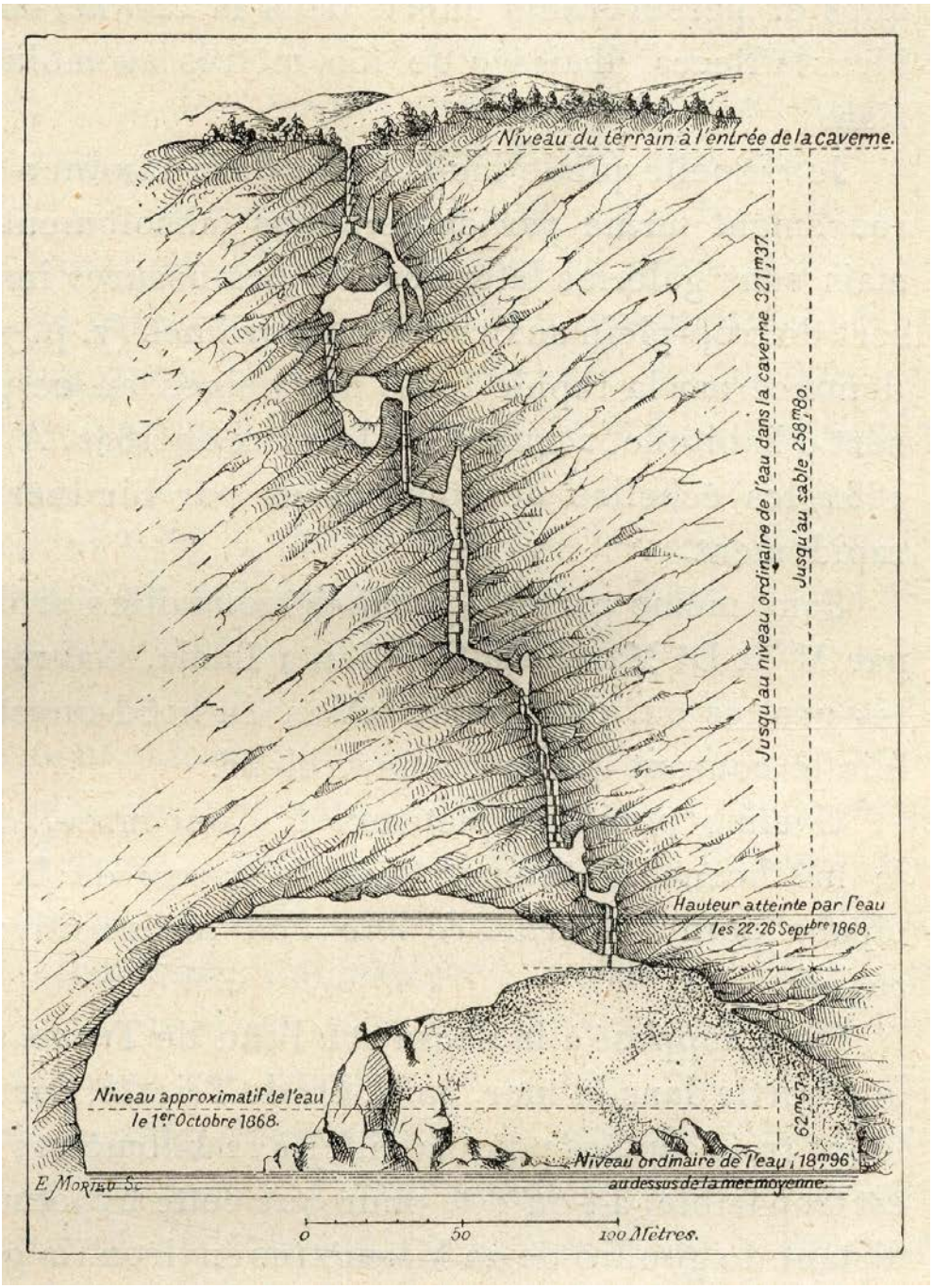


Fig. 27
Vertical section of Grotta di Trebiciano [based on a larger and clearer drawing – Fig. 3 in Società Alpina delle Giulie *Atti e Memorie* for 1886 & 1887, Trieste, 1887]

both ends (exactly like the case of the Pivka but without any side passages) and also acts as an overflow reservoir for underground floods. The mouth of the cave (at 341 m) is made evident by the rapid melting of snow there. The draught of air that normally comes out of it inspired the work there in 1840. On many occasions (1851, 1866, 1884) the wooden ladders left by Lindner have been repaired, for the humidity makes them decay rapidly.

Without even mentioning the important prehistoric and protohistoric work done by Dr Marchesetti at Santa Lucia, Gabrovizza, etc.[78], I also ignore the caves towards the north-west where we tried to find the underground river once again[79].

As with the plateaux of Concourès, Gramat and the Braconne, I limit myself to the sectional view in Fig. 23 which zigzags between the main places described, showing all we know positively about the underground water of the region.

It is supposed that the Reka and the water at Trebiciano have another outlet besides the Timavo, that is to say one beneath the sea north-west of Trieste by the eight under-sea springs of Aurisina, 12 km north-west of Trebiciano (of which three have been captured for the city's water supply). But their output is too low, it has been said, for this hypothesis to be true. As for the Timavo itself, about 22 km from the [Trebiciano] cave, the geology of the region and comparison of the outlets[80] show nothing incompatible about the supposition. Hanke, in 1885, even descended, to the east and very close to the mouths of the Timavo, into two little shafts, [p. 477] 24 m and 48 m deep. In these he found flowing water but without being able to follow it beneath roofs that were too low or in fissures that were too narrow[81].

However, despite the local legends, there is no formal proof of such correlation and I myself do have some doubt since my underground visits in the Karst. I cannot prevent myself from questioning how it can be that over a distance of 22 km (in a straight line) there is an altitude difference of no more than 18 m or 19 m between low water level in Trebiciano and the Timavo river. That would mean a gradient of only 0.818 m in every kilometre (0.082%), whereas for the 13 km between the first sinking of the Reka in Mahorčičeva jama at Škocjan there is a drop of 305 m or 23.6 m per kilometre (2.36%)[82]. I do not wish, arguing from incomplete and indefinite data, to complicate a matter already so difficult, nor to discuss the determination of these figures. I am content to point out how strange it is, in the generally agreed hypothesis, to accept the sudden change of speed, the calming of the flow of the Reka water between Trebiciano and the Timavo[83].

Kraus even doubts whether the water in Trebiciano is the Reka! In short, the problem is far from being resolved and it was by no means clarified by the fluoroscein tests of 1891[84].

It seems from all that has been said in this chapter, that the Karst is penetrated by several great channels deep underground (Pivka, Unica, Cerknica, Rak, Sica-Gurk [Krka], Reinniz-Rinnsee [?Reifnitz], Teménitz [Temenica], Reka, etc.) which have enlarged certain pre-existing fissures into caves whose forms depend principally on the inclination and direction of these fissures. Other fractures and joints in the rock on the ground surface, absorbing and draining rain-water and low ground, are enlarged mechanically and chemically and create caves and shafts that act as tributaries to the main underground rivers. The whole system is similar as in all fissures in limestone terrain, to the circulation of blood in animals and of sap in plants. Underground, narrow places, dips and roof collapses here and there create sumps. These slow up the flow, making reservoirs that supply permanent springs, or cause, by their excess or failures, either floods or disastrous droughts.

[p. 478] These things are no different below the [French] Causses. From Trieste to Sparte [Sparta, in Greece], as in France, a thorough knowledge of the course of underground rivers is important for controlling the output of springs and hence the benefit of regions that suffer from either too little or too much water.

The only notable difference in the Karst is that, the Cretaceous being softer than Jurassic limestone and the rivers there being more powerful, roof subsidences are necessarily a lot more frequent than elsewhere and have blocked a lot of natural cavities.

The Istrian peninsular, which slopes gently towards the south-west from the Tchitschen-Boden [Ćićarija] hills (500 m to 1200 m), parallel to the Reka and Monte Maggiore [Učka] (1396 m) near Rijeka, to the Adriatic (Gulf of Venice), is no less provided with sinking rivers, caves and shafts than the Karst proper. Their study, however, is a lot less advanced. The two main hydrological problems in this region, which is almost an island, are the lake Čepić and Pazinska jama.

The *Čepić* lake (on the eastern side of Istria) has no visible outlet and it is necessary to unblock and enlarge a *Foibe* (cave or Katavothra) on its south bank. According to tradition, it is by this Foibe, today blocked and filled with sediment, that the lake discharged and led to a coastal or under-sea spring in the Kvarner Gulf (Bersec-Šapova, according to Putick). In fact when rain fills the lake (mean altitude 26 m) it then floods the surrounding fields, crossing the marshy ground (at 25 m to 29 m), and then reaches the neighbouring valley of *Arsa* where it wreaks havoc.

Unfortunately the foibe, so fatally blocked, is 0.7 m below the normal level of the lake. One can only work there when an extraordinarily long period of drought allows evaporation to lower the level. Several years ago the government tasked Putick with the work of drainage and protection. He has still not succeeded.

The *Pazinska jama* is a river which should properly be called Foibe which geographers, if not the local inhabitants, use for all the depressions and caves of Istria which seem as if they were specially designed to absorb streams, *goules* [swallow-holes] in fact.

The Foiba, formed by the junction of the Boruttesci [Borutske potok], the Bakovik [Rakov potok], etc., after running for about 22 km (since the source of the Borutesski), goes into a kind of narrow transverse valley which surrounds it on three sides, getting deeper and deeper into the rocky promontory with the picturesque town of Pisino [Pazin] or Mitterburg, the ancient capital and market town of Istria. The walls of this valley get so close that they join together to form a cirque, at the foot of which the Foiba is swallowed up in a cave. The walls here are vertical, those on the right (west) being 130 m high and those on the left (east) are only 80 m. This is the confirmed depth of this impressive gulf[85]. On the semi-circular crest of these walls rise in tiers the bell tower, the old chateau and the houses of the town. Two pathways allow access down to the cave.

Pazinska jama [Fig. 28], which dries up sometimes, is often only a small streamlet but [p.479] heavy local rain or storms can swell it so that within 24 hours the water rises 40 m in the cirque and it then takes 2 or 3 days to subside.

On 25 September 1893, thanks to my Osgood, and the co-operation of Putick and of the two workers Vilhar and Sebenik [Šibenik] of Postojna, I was able to discover the cause of this slow draining away of the water[86]. [Fig. 28] explains how the stream has made in one rift a descending passage like that of the Reka but a lot smaller, only 100 m long and flowing into a lake. This lake, oval in shape, relatively large and closed on all sides, is 80 m long by 10 m to 30 m wide. Its depth in dry conditions is 13.5 m at the far end. The roof rises to some 12 m above the water level. It is exactly the same lay-out as that of Mrtvo jezero on the Reka. It is the head of a sump of which the other end is unknown.

It is this sump that delays the draining of the flood water. The Foiba is claimed to "lead to the Gulf of Venice by the Leme channel" near Rovigno [Rovinj] (Vivien de Saint-Martin, *Dict. de Geograph.*). It is certain that many coastal and submarine springs that gush out along the western coast of Istria, between Paenzo [Porec] and Pola [Pula] are the reappearance of the water that sinks in the many foibes of the peninsular. But nothing allows us to identify just where the Pazin water emerges. The underground lake in Pazinska jama, that I refer to is about 180 m above sea level, 27 km east of the Adriatic and 25 km west of the Kvarner Gulf. The east-south-east direction of the passage cannot give any indication because it is too short.

Short of wishing to study the end of the lake in a diving suit [p.480] there is no way of further investigating Pazinska jama. Out visit was easy but on the very next day rain made access to the cave impossible.

In the vicinity of Sanct Pietro in Selva [Sv. Petar u Šumi] (341 m altitude, 8.5 km south-west of Pazin) there are two deep unexplored holes (according to Chevalier von Schwarz, administrator of the Pazin district) which perhaps connect with an unknown extension of the underground Foiba. To sum up, this reproduces exactly, on a smaller scale, the phenomenon of the Reka and presents the same puzzle.

The study of the underground hydrology of the Liburnien Karst (Croatia and Dalmatia) on both sides of the long mountain chains of Grosse Kapella [Velika Kapela] (1532 m) and Vellebič [Velebit] (1758 m), etc. between the Kulpa [Kupa] and the Kerka [Krka] in the south[87] has only been started by Tietze, Foetterle, Wolf, Stur, Pilar, Riedel and some survey officers of the Austrian Institute of Military Geography. In making their map, these officers can only make limited notes about the surface detail[88].

There are also both sides of the Dinaric Alps to consider in Bosnia and Dalmatia, between the Krka and the Narenta [Naretva][89].

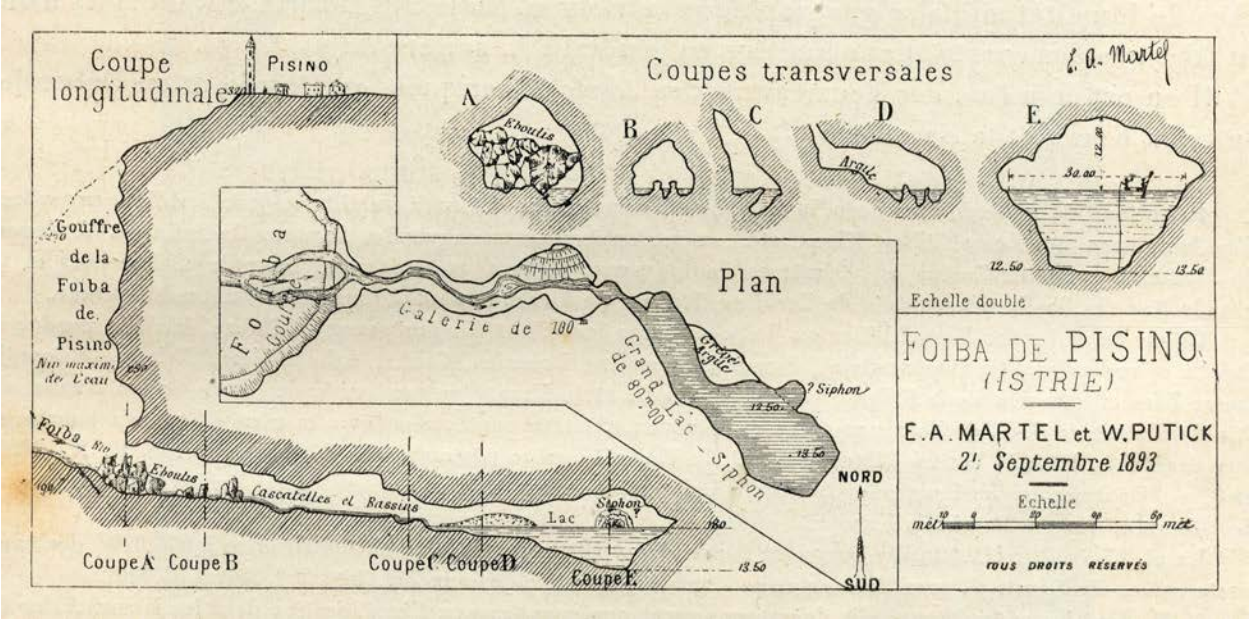


Fig. 28 Pazinska jama in Istria

[p. 481] It will take years fully to understand all this underground region.

In October 1893 the amount of water hindered my attempts to enter these risings. Besides, most of these spring out direct from the ground as does the Loiret in France and, where some do come out from open caves when the flow is low, to explore them it would be necessary to have equipment that was not available. For the local people, who are not used to such things, would not go far underground and it would be necessary to bring in, at great cost, experienced cave explorers from France or Postojna or Škocjan.

[p. 482] I can, however, state that the springs here are, like those of the limestone in France, Greece and the true Karst, the reappearance of rain-water absorbed in fissures on the mountains above and of rivers that sink into caves on the plateau above. The general law that fissures in the ground are utilised by the water that circulates underground is again found on all sides.

Here are the particular observations that I have been able to make :

Thirteen kilometres west-south-west of Sarajevo, the capital of Bosnia (537 m above the sea), are the springs of the *Bosna* river (at 495 m to 500 m), innumerable trickles of water (60, it is said) welling up between the stones to form pools, from which comes the river. There is no individual spring direct from underground or out of a cave. At one and the same time it is draining the forests and the wooded mountains of Igman-Planina (1505 m) where the 1:150 000 map of Bosnia[90] shows several very high *poljes*. As at Vaucluse the temperature of the Bosna spring water (8.1º, air 21º, 5 October 1893) is lower by about 1º than the mean annual temperature of the place, which is 9º at Sarajevo (13.2º in October)[91]. This proves that the water has come from higher up. After heavy rain I have seen that water very clear, while other rivers of the Sarajevo plain (Miljacka, Zelesnica, etc) were thoroughly yellow.

The same is true of all the springs (a lot more beautiful than those of the Tarn gorge) on the two banks of the Naretva river between Jablonitz [Jablovica] and Mostar, thus:

On the right bank of the *Comadina* river beneath the bridge of the same name, between strata dipping to the south-east, is a splendid cascade gushing from the ground. Another spring about 15 m higher, with tufa deposits. – A third spring and cascade on the left bank. – A spring/sump on the right bank with a side overflow perhaps penetrable at low water, 1 km above the Gabrovica. The overflow flowing on 4 October 1893, but not flowing on the 6th after two days of good weather. – Before Dreznica on the left bank, a

cascade as attractive as the one of Comadina, comes from a cave which resembles the two upper openings of Boundaulaou. Next, and before Baskagora, six springs on the right bank produce beautiful flakes of silvery foam between the stones and fissures. It should be enlarged. Several of these springs have 2, 3 or 4 outlets. – There are similar ones on the right bank. – Lastly, between Baskagora and Vojna, I counted, in addition to one on a left bank promontory which forces the Naretva to make a loop to the left, six other springs very close (several of them multiple). They are formed as a group, perhaps coming from some delta. They come from inclined joints. In some places there are close groups of fissures, each one producing a riverlet.

All these are only the outlets of limestone mountains between 2000 m and 2200 m high which, surrounding the Naretva, are in all directions filled with joints and fissures and where the powerful action of water is shown by the curious shape of individual rocks, deposits of tufa and layers of conglomerate. Nature shows itself to be active there with underground water creating fissures in the ground to rejoin the great rivers on the surface. The large number of these springs and their extreme purity after the heavy rains of spring and autumn, which made the Naretva almost a river of [p. 483] mud and the extreme fissuring of the ground seem to indicate here an underground circulation in fissures as narrow as they are numerous, a percolation so to speak, and perhaps a total absence of large caves.

To verify this we should try, after a long dry period, to penetrate any of the springs where that is possible.

13 km north-east of Mostar is the source of the *Buna* [Fig. 29], one of the most imposing I know, more magnificent than that of Vaucluse. On 7 October 1893 it did not have the same clarity as the ones just mentioned. Its water, slighty milky, comes out from a single small cave passage, 5 m wide, which it seems to occupy fully for several metres. The strength of the current was such that I could not launch my Osgood in the large deep basin immediately outside,15 m to 20 m in diameter, for it would have been dashed under the mill wheel there so I could not determine whether the cave could be entered for some way or if a sump would make this impassable. I was unable to get any information at Mostar about its interior[92]. I suppose it produces the water of the *Zalomska* sinking 20 km to the east at 812 m above sea level in a ponor in Nevesinsko polje (near Ljubovići) which N. von Franz was unable to descend because of the narrowness of the vertical fissure.

Fig. 29 Cliffs and source of the Buna

Viscount Caix de Saint-Amour records a local legend of a shepherd's crook having passed from the Zalomska to the Buna. A shepherd profited from this by every day sending one sheep stolen from his herd to his father the miller [at Buna]. His master discovered this and sent the guilty shepherd's headless body by the same route[93].

The marvellous cliff at Buna is well fissured! Who knows whether one of the holes (inaccessible without ladders) in this wall may lead, like the window at Salles-la-Source, to the passage containing the underground river beneath this 20 km barrier where the Zalomska (if it is that) drops nearly 800 m (4 m drop in every 100 m, exactly the same slope as in the Grotte de Saint-Marcel d'Ardèche, which is a now dry river bed). Such is the hypothesis that remains to be proved: it is not unreasonable.

In the south of Hercegovina, the *Trebinjiča* is the main river. Coming out from a cave near Belek, it passes Trebinje and, in Popovo polje, it sinks in three successive groups of sinks and ponors, 100 km from its source[94].

The biggest sink-hole (at an altitude 224 m) is half an hour south of Hutow[95]. A wide cave mouth of the same type as Reveillon in Lot, see p. 291.

[p. 484] Various outlets have been attributed to the water from these Trebinjiča sinks. One is at Gabela polje, or the Drupa marsh near Metkovič on the left bank of the Naretva. Von Groller thinks, (with reason, we believe) that the Trebinjiča, because of the much-fissured ground, is divided into different channels which feed the springs in the rocks of the Naretva delta. Finally it has been suggested as, at the very least, a branch of the famous *Ombla* [Fig. 30] at Ragusa [Dubrovnik], that magnificent spring/fjord that is at the same time both a river and a branch of the sea (see Reclus vol. 3 p. 229). It is 5 km long and between 1 m and 100 m wide, like the Touvre but a lot more powerful. The great cliff there, a 400 m high vertical face, is streaked with fissures but does not seem to have any penetrable cave. Its strata dip from south to north and at the northern corner of the broad basin one can distinctly see water boiling up, from a sump no doubt as at Vaucluse. This has also been claimed to be bottomless[96] (Humitia believes, on the contrary, that the Ombla has a completely independent source).

When one has gazed, always for too short a time, at the exquisite view of ancient times that is Dubrovnik, its style of costume a mixture between Brittany and the East, its palace of the Italian Renaissance, its rocks and Monaco aloes, its green islands between the sea and the Greek sky and its old walls worthy of Rhodes or Carcassonne, it is necessary to follow the coast a little way [north] to reach the Val Breno.

A spring at the Gulf of *Breno* comes from a cliff 80 m high, the water emerging from many holes and trickling among the moss on the rocks and the roots of the overhanging fig trees. Then the *Smocowienatz* (?) (75 m above the sea), rather similar in appearance. These two were at a temperature of only 14° on 13 October 1893. Their origin is not known. A third, [p.485] at the edge of the sea itself, must be the reappearance of the *Ljuta*, which sinks 13 km to the south-east at 40 m altitude (a slope of 3 per 100) in the blind valley of *Canale*, celebrated for the magnificent [traditional] dresses of the inhabitants, between Dubrovnik and Kotor. This small valley, like Planinsko

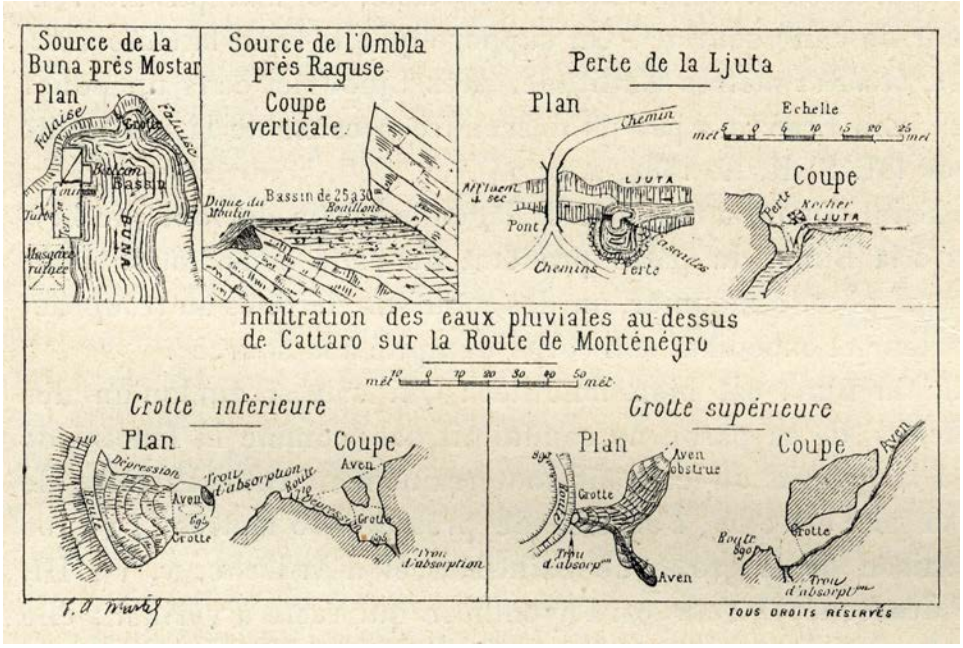


Fig.30 [Caves in Montenegro]

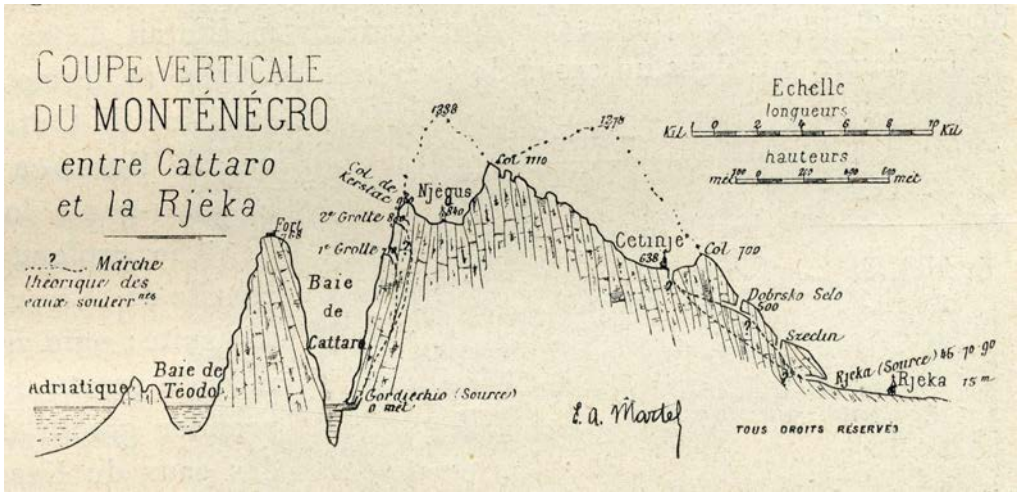


Fig. 31
Vertical section of Montenegro between Kotor and the Rijeka

polje, becomes a lake after heavy rain because the sink-holes in its floor are too narrow to absorb all the water. The lowest of these is north-east of Gruda in the middle of the valley at the foot of Mount Snéjznica (1234 m). On 13 October 1893 I saw the entire stream disappear there in three cascades into a wide hole 5 m deep, forming a basin filled with the water. No exit is visible. It was the top of a sump the narrowness of which admitted only a limited flow of water. It was not possible to descend but this fall showed decisively that natural shafts are perfectly well able to be formed by surface erosion by the mass of water being absorbed. We enter, like birds, the warm blue gulf of Kotor, carved out as if with a pastry cutter between limestone cliffs 1000 m high. Around the edge of the gulf are an immense number of springs which give back[97], through fissures [p. 486] in these cliffs, the rainwater that sinks into the cracked surface of the plateaux above.

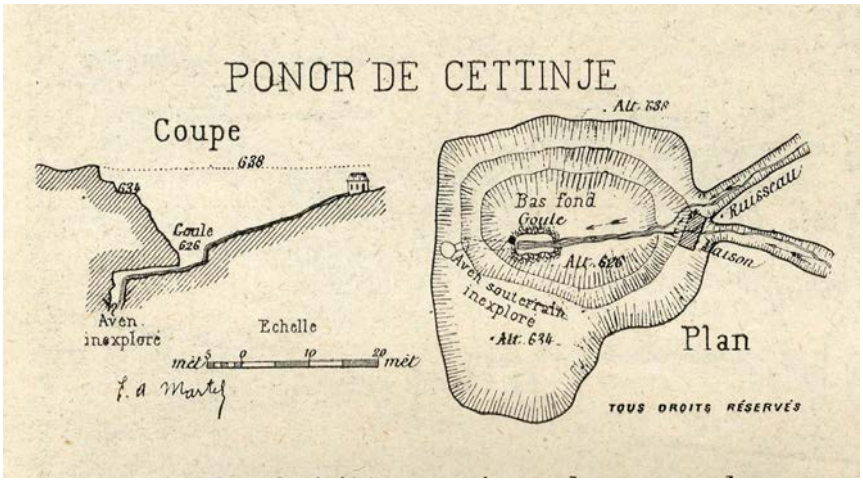
In climbing the sharp bends of the great highway that rises from Kotor into Montenegro – the splendour of which no-one has succeeded in describing – and where going down it at a gallop is like being in a balloon, one comes (at 710 m and 890 m above the sea) to two little caves of no great depth – true sink holes which explain at the same time the disappearance of the rain-water and the origin of the region's springs. The section (Fig. 31) allows me not to repeat descriptions of the many funnel-shaped sinks (Roudinas, Krisev-Do), from a few metres to several kilometres wide, which make the south-west of Montenegro like a lunar landscape.

Being well informed, thanks to the helpfulness of Count Sercej, attaché at the French embassy, of the Russian chargé d'affaires and of Prof. Rovinsky, I am able to state that here also the absorption of meteoric waters occurs through fissures in the ground, and that a whole series of cavities should be thoroughly explored.

The ponor [Fig. 32], in a hollow 40 m in diameter, is the only outlet from the plain of Cetinje. Its water emerges, like that at the Aven de Hures in Lozère, from a hole 4 m long, 1.5 m wide and 2 m deep. A horizontal passage, 10 m to 12 m long follows, leading to a black hole of unknown depth. This is the first stage in the drainage from Cetinje polje which (according to Cvijić) becomes flooded every 10 or 20 years [Fig. 33].

The second stage, 4 or 5 km east of Cetinje, on the way to the Scutari Lake [Skadarsko jezero], is the cave of *Dobrsko-Selo* where Rovinsky descended a 20 m deep vertical rift 15 m long and 3 m wide. He followed the cave upstream for 3 hours without coming to the end. Having no ladder, he was halted by a not very deep vertical hole. Up to that point the passage was steadily rising, he told me, and carried water after floods. The unexplored downstream passage to the south-east may link, beyond a mass of collapse debris, with the Dobrsko-Selo plain, which, being at a lower level, sometimes becomes a lake after heavy rain.

Fig. 32 The Cetinje dolina



Further down, the third stage is the cave of *Szeclin* which, like some of the sinks at Cerknica, ejects and absorbs water alternately. It does not seem to have been completely explored.

Finally the fourth and last stage is the cave spring of the *Rjeka* [Rijeka] [Figs. 31, 33, 34], no less imposing than the Buna. While the *Guide Joanne* (Danube et Balkans, 1891, vol. 1 p. 197) states that "one can follow the cave for half an hour to the edge of an underground lake, the overflow from which feeds the river", everyone at Cetinje agreed in telling me that the "lake" is simply an underground river coming from impenetrable holes in the rock where I could not pass.

In fact, one sees on the plan and section [Fig. 33] which give the altitudes above [p. 487] sea level and the temperatures (air inside 12.5º; water inside 11.6º; water outside 11.7º) that at about 250 m from the cave entrance, at the end of a slope of rubble one comes to the river. It is the Rijeka, which filters through the rubble in summer (at about 180 m from the entrance on 11 October 1893) and rises above it during floods.

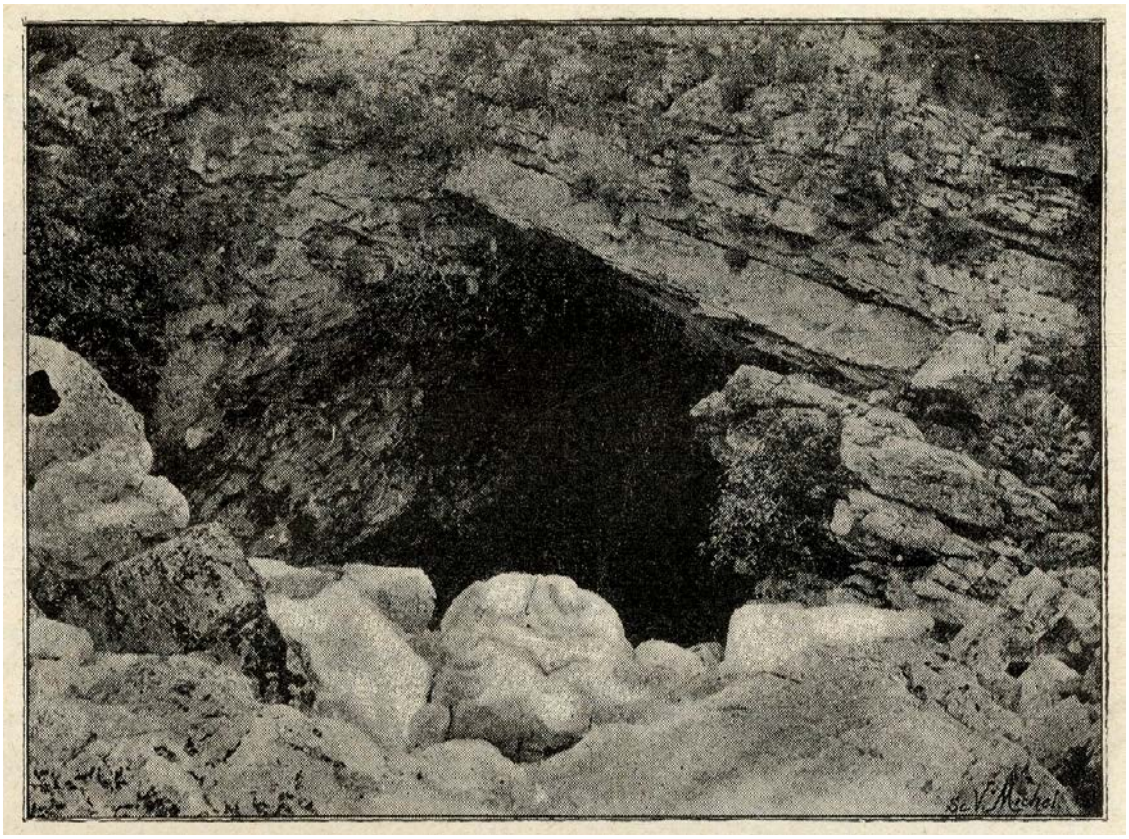


Fig. 33 Entrance of Rijeka cave

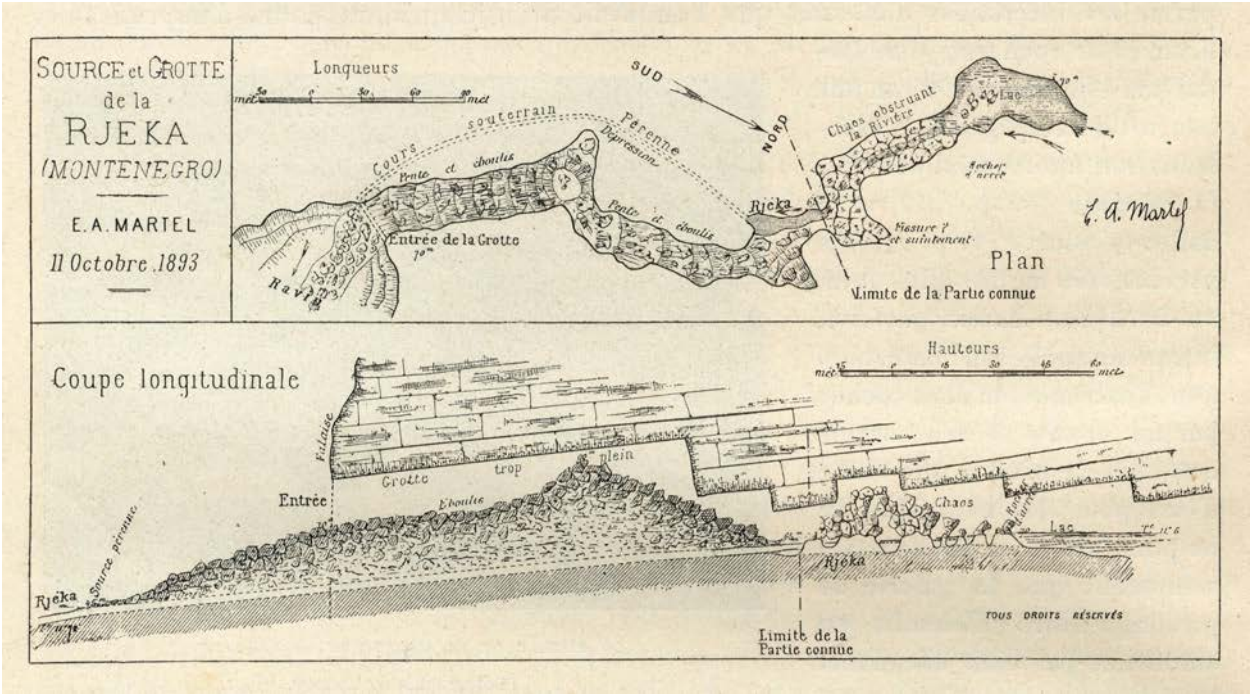


Fig. 34 Rijeka cave

Things happen in the same way at Vaucluse, with this difference: that the Montenegro cave is *a penetrable Vaucluse because of the direction of the strata – parallel rather than perpendicular to the current.*

Coming to the water, my interpreter, the *guide* that I had brought from the village of Rijeka, and the two men from Cetinje who carried my Osgood in sacks, all declared that this was the end of the cave. They let me cross the river to seek a way on through gaps in the heap of debris which until then I had thought to be impenetrable fissures in the rocks. I soon found a way and after an hour of scrambling and climbing no less painful than at la Poujade and at Salles-la-Source, I came 150 m further on, to the edge of a deep pool, impassable without a boat, the far end of which was hidden from me by a bend. I seemed to hear the sound of a waterfall a little further on, but I cannot confirm this. I can only state that the passage continues free of debris and I have thus discovered the course of the river that rises at Rijeka after having drained the rainfall of Cetinje. Returning by the same way and before reaching the part of the cave known previously I came across my four companions. Worried because they had neither seen nor heard anything of me, they decided to attempt the debris heap, guided by the candles that I had left in places to guide me on my way back. But I could not persuade them to go back and collect Osgood[98].

So I had to content myself with this general view of the underground hydrology of Montenegro and to give up, as in Hercegovina, a complete exploration. This could only be done at the cost of much time and money. I had exhausted both of these at Postojna so there was none left for Cetinje. [p. 488] That is why I could not organise a proper expedition like that of Rovinsky at Dobrsko-Selo. That would have taken a lot of preparation and needed a lot of assistants. How I regretted at Rijeka that there was no subsidy to offset the expence of bringing Armand to Cetinje, or at least Vilhar or Šibenik from Postojna[99]. The Rijeka might perhaps resolve an important secret, a connection with Szeclin or Dobrsko-Selo! At least no sump had occurred in the several tens of metres up to the point where I was stopped. That is the point that awaits clarification.

In the north of Montenegro the sinks and caves of the Zeta near Niksič [Nikšić] also await exploration[100].

What will happen? And when? Between Montenegro and Greece, the lake with no outlet, Janina [loánnina] (in Épire [Epirus in Greece]) continues the almost uninterrupted chain of those mysterious swallows

that border the eastern coast of the Adriatic[101]. It is less than 20 years since in this region Carapanos rediscovered the ruins of Dodone[102] [in Greece]! Will it be before the 20th century that we shall study this region more deeply to find there new Pivkas?

[p. 489] To summarise: the hydrological phenomena of the Karst[103] and the whole western part of the Balkan peninsula are the same as those of France, Belgium, Greece and all geologically similar places.

I have shown at Pazin, Postojna and Rijeka that, although the Austrians spent more than half a century scientifically studying the underground of the Karst, there is still much more of such investigation to be carried out. To aid this are two pieces of equipment, used for the first time in France: collapsible boats and the telephone. There, as well as everywhere else, they will open a new era, full of promise, for underground geography, for *spelaeology*.

[Chapter 34 and an introduction to it]

[In his chapter 27 on the Karst, Martel refers to passages in the subsequent Chapter 34, on the meteorology of caves. Thus, in note 97:]

> To avoid repetitions, all too frequent in this book, we refer to our chapter on meteorology and the discussion about the temperatures recorded in the caves of the Karst by Schidl, Morpurgo, Müller, etc.

[Here, then, is what he wrote in that Chapter 34 on pages 564 to 565 and its accompanying footnotes:]

[p.564] Water influences the temperature in caves, raising it or lowering it.

It is known that *evaporation* causes cooling: also it is always cooler in caves near trickles of water[104]. Readings from hygrometers and wet and dry bulb thermometers can easily be taken.

In caves that receive water that has already flowed in the open air there are several irregularities in the behaviour of the temperature. It is especially the influence of the seasons and even of the hours (of night and day) that affects them in a remarkable way. The Bramabiau, the Reka and the Pivka clearly show this[105]. [p. 565] Their water, warmed in summer and during the day, raises the temperature of the cave they enter; cooler in winter and during the night they lower the temperature. One notices those cases where, by complete exchange of heat, rivers that have been long enough underground enter warmer and leave colder (or vice-versa) than the cave air where they have been.

It is not necessary, however, that the air movement should always be rapid. I have explained (*les Cévennes*. p. 141) how I failed to detect it with smoke in Nabrigas. Schmidl, too, stated that it was not possible to make a fire in caves (Adelsberg, p. 42) and Hovey tells the story of 500 people who (in 1881) came together for a celebration in Cacahuamilpa (see p. 548) narrowly escaped asphyxiation from the smoke of their torches (*Celebrated American Caverns*, p. 213).

Without raising the question of thermal waters, I must remark that their presence is the cause of warming in certain caves[106], Monsumano, Monteils, etc).

When one understands better the laws of behaviour of air in caves, it can have industrial applications as in cheese caves like those of Roquefort, and even artificial ice storage chambers could possibly be made in many caves.

As for research on air pressure[107], time of falling bodies, gravity[108], [static] electricity in waterfalls[109], etc., caves are natural laboratories for many curious studies.

NOTES

1. Mainly between Trieste and Postojna; for between Postojna and Ljubljana the magnificent centuries-old fir forests (Haasberg Forest, etc.) extend over vast areas.
2. Because of the very various languages in this polyglot corner of Europe, there is such confusion in geographical literature on the precise meaning of local terms used to denote these features of the earth between Carniola and Montenegro that I think it helpful to unite them in the following table. This is approximate and not complete:

definition	**Germany**	**Carniola**	**Montenegro etc.**	**Moravia**
large depressions open to the sky (Cloups in Lot)	Trichter	Dolina Bedjenj	Krisev-D Vrtača (Srbija)	Zavrtek
shafts narrow, deep, dark	Schacht, Schlund Abgrund	Jama Brezdno	Roudinas	Propast
impenetrable sinks (bétoires in France)	Saugloch (suçoir)	Ponique	Ponor	Propadeni
penetrable sinks (goules, Katavothres in Greece)	Schwinde	Foíba (in Istria)	Ponor	?
marais	Sumpf	Jessero (lake)	Blatto	?
dry valley	Kesselthal	?	Polje	?

   In all this there is too often confusion between the words Dolines and Foibes (see Reclus, vol. 3 p. 219). Schmidl, however, well distinguishes between Jama and Dolines. The latter are sometimes so large that, as at Quercy, at the bottom there are cultivated fields called Ogradas or Dolac. When they are uncultivated, they are often called *Kolesivka*. As for the basic distinction between sinks and their penetration, Professor Penck proposed (*Die formen der Erdoberfläche*, Verhandlungen des IX deutschen Geographentages, p.29) to call valleys without water flow *Wannen* (cistern or bath) in place of *Kessel* (cauldron or kettle); this would create one more synonym without useful purpose. Cvijić (*Karst-Phämomen*, Wien, Hölzel 1893), calls all natural pits Dolines and distinguishes between *Schüssel* (ten times wider than deep), *Trichter* (funnels, two or three times wider than deep), and shafts, (*Brünnem*, much deeper than wide). These arbitrary classifications can be multiplied at will.
3. In 1893 the Minister of Education decided, for this comparative study, to entrust me with a scientific mission to Austria, Bosnia and Montenegro. His Excellency Count Falkenhein, Minister of Agriculture in Wien, not content with providing me with special letters of introduction to the civil and military authorities throughout the whole region, charged engineer Wilhelm Putick, the joint inspector of forests at Villach in Carinthia, to take me to the most interesting caves that he had discovered and explored between 1886 and 1888 in the course of his studies and work in the Austrian government drainage project in Carniola. Counsellor von Salzer had taken the trouble to come to Postojna, to formally introduce me to Putick. Finally two independent societies concerned with studying the caves of the Karst, the Anthron Verein (in Postojna) and the section Küstenland of the German and Austrian Alpine Club (of Trieste), made it possible for me to visit many caves that were not open to the public.
   If I emphasize the great assistance that enabled me to achieve my object, it is particularly attractive in a German-speaking country. This is not the first time that I have had occasion to remark upon the helpful way that Austrians treat French travellers.
   It is important to mention that it is due to the friendliness and precious support of the Austrian minister in this matter, that F. Kraus (of Wien, who for 20 years has devoted himself to the study of caves and development of speleology in Austria) had already in 1891 attracted the attention of His Excellency count Falkenhein to my own researches in France. It is thus that I was able, as you will see, to become intimately acquainted with the underworld of the Karst.
   The reader must excuse me here for expressing my gratitude to the two ministers and to everyone who assisted me in my task.
   Mr. Putick deserves special thanks for his friendship, his unselfishness and the devotion with which he made his publications available, repeated difficult explorations and provided all the equipment necessary for making the curiosities of the Karst known in France.
   Finally to Kraus, J. Marinitsch, F. Müller, Pazze, Marchesetti, Valle and Novak who gave me important assistance and obtained for me the most valuable series of documents, printed and manuscript, that I had searched for in vain

in libraries. It will be seen, from the bibliographical references in this chapter, how important this was. I regret that I have not been able to give detailed credit for all the original information I was so willingly given.

4. Prof. W. Urbas, *Oro-hydrographie von Krain, Zeitschrift* (Annuaire) *Club-alpin allemande-autrichien,* 1874, p. 307. *Schaubach* (*Die deutschen Alpen 2d édit. 1867*, vol. 5, p. 309) gives the fall as 240 feet (77 m).
5. See the detailed bibliography in the works of A. Schmidl, F. Müller, W. Putick, etc, cited later.
6. In *Illyrisches Blatt,* 1849, no. 28, 29, 30, Prof. Voigt proposed using the caves of the Karst to allow an underground railway line from Ljubljana to Trieste!
7. See *Sitzungsbericht der Akademiè der Wissenschaften*, Wien, Dec. 1850. He later made other researches in the Karst and Moravia, Hungary, etc.
8. One octavo volume of 316 pages, with a folio atlas of 15 plates, Wien, Braumüller 1854. See also, by the same author, *Wegweiser in die Adelsberger Grotte*, etc. 16° with 3 lithographs, 1853, Wien.
9. He began to bring to life the following prophecy by a distinguished French academician: "There is still room for a new Christopher Columbus. It remains for him to make a voyage of discovery in which he will discover lakes, totally unknown rivers, islands of which the best geographers have no notion, animals that no naturalist has ever described, effects of temperature that have never been published by any academy, wonderful regions that can only be inhabited by fairies". (X. Marmier *Voyage en Allemagne* [1959, 1860], part South, p. 247).
10. It would be wrong not to recall, at least briefly, the efforts made by Kraus to carry out underground research in the Karst and to ensure that Schmidl's work was continued. – Struck in 1878 by the interest and the urgency of reducing the periodic floods that ravaged certain closed valleys (*Kessel-thäler* [poljes], where the water from the heavy rainfall could not find sufficient holes or big enough caves to drain away, he undertook the task of putting into practice the ideas put forward some 30 year earlier by the priest Urbas (see p. 435). – In 1879 there was founded in Wien the *Verein für Höhlenkunde* (Speleological Club) which in 1881 became the *Section für Höhlenkunde des oesterreichischen Touristen Clubs* (of the Club for Austrian Tourists) and in 1888 became the *Section für Naturkunde* of the same club. This association published its *Mittheilungen* periodically from which we shall quote frequently. It had at its heart a *Karst Committee* which, from 1881 to 1887 and always at the instigation of Kraus, was interested in projects to drain poljes (by studying caves). This committee included the Sudbahn railway company, the Home Secretary and the Minister of Agriculture. This resulted in the *official* activities of Putick who, funded by the government, explored between 1886 and 1889 more than 100 cavities large and small (caves, shafts and springs). He also carried out beneficial works [e.g. enlargements and grids] and arranged similar work by many others. A second engineer, Mr Hrasky, made equally important researches. The impetus spread around the Empire and, by the end of 1892, Kraus had knowledge, in Austria-Hungary alone, of 659 natural caves, with more or less detailed descriptions (150 in Carniola and Istria, 160 in Austria, 103 in Transylvania, 72 in Styria, 66 in Hungary, 35 in Moravia, etc.).
    We add that clubs in Hungary, Transylvania and the Carpathians often published reports on caves in Hungary and at Trieste. There were two bodies for the exploration of the underground Karst. One, in 1883, was the Section Küstenland of the German and Austrian Alpine Club. The other, in 1884, was a Commission within the Societá Alpina delle Giulie. We have more than once made use of their publications.
11. The highest of these springs is 296 m above sea level according to the 1:75 000 Austrian ordnance survey map.
12. See *Die Ursachen der Morast-Ueber schwemmungen,* Laibach, 1889. Attempts at drainage began in 1554. Since 1762 they have started again and have been diligently continued (W. Urbas. *Die Gewässer von Krain, Zeitschrift* of the German and Austrian Club, 1877, p. 153). A recent project by engineer Podhayski (costing 5 million francs) is under consideration now.
13. Here, according to W. Urbas and Reclus (vol. 3, p. 216) is the Slovene pronunciation of the following letters: c=ts; č= tch; č= tj; j=I, š= sh; u=ou; v=u; ž=j; lj=ll; nj, gn. I do not guarantee the spelling of any of the geographical names used in this chapter. It is generally rather variable.
14. The Slovene name *Pivka* is called *Poik* in German.
15. At the foot of Nanos, between Postojna and Divača are the caves of *Lueg* [Predjama] see Reclus, *la Terre,* vol. 1, p. 358), Nussdorf [Orehek] (Schmidl, p. 298), Präwald [Razdrto], Senosetsch [Senožeče], etc., which I took the trouble to note. Schmidl (pp. 30 and 114 of his book) gives a detailed description of the curious three-level cave of Predjama (1080 m of passage) and the sink [there] of the Lokwa [Lokva] which re-appears, it is believed, 13 km west at the Wippach [Vipava] springs having run beneath the Nanos plateau.
16. According to Schmidl's triangulated plan of 1891 (see later); 501 m on the 1:75 000 ordnance survey map; my barometric readings gave a mean of 511 m.
17. Hacquet, however, claims to have gone through this passage in 1774 when the water level was very low. Schmidl repeats that account but only with some reserve. At Postojna now one cannot believe that it was ever possible.
18. 529.8 m at floor level in the small entrance, according to Schmidl; 531 m, 768 m on the plaque fixed to the wall of the main entrance. The bridge is at a height of 523.9 m, 12.4 m above the river.

19. This very complex arrangement is clearly shown in Schmidl's book and its atlas which shows Postojnska jama in the minutest and most exact detail. In this book we simply continue to indicate his book by a letter S, followed by the page number.
20. Another date, 1213, should be read as 1413 according to Schmidl.
21. Schmidl and his son Ferdinand were the first who, all alone, risked (in 1850) going in a boat on the often tempestuous waters of this dark channel. The great danger in all exploration in the caves of the Karst is the extreme rapidity with which the water can rise after storms outside, closing the return route by reaching and blocking any low roofs. Schmidl went only 300 toises from Velika dvorana. (about 570 m. The Austrian toise or *Klafter* is 1.896 m), the distance being measured later by his colleague Rüdolf. He had to stop before a low roof under which his heavy boat (less practical than our Osgoods) could not pass, "even if we laid on the bottom" he said.
Nevertheless Schmidl was convinced that one day the junction would be made between the point when he was stopped and an arm of the cave called *Tartarus* (see later) for he had seen that the water arrived at the same temperature as the upper Pivka. Recognizing this shows his perspicacity.
22. In 1839, count F. von Hohenwarth published drawings of the cave made by Schaffenrath some time after 1830 (*Wegweiser für die Wanderer in die Adelsberger-Grotte,* Laibach, 19 copper engravings).
23. During these discoveries, tensions arose between the communes of Postojna and Veliki Otok on the rights of cave ownership in relation to those on the surface, as in France (article 552 of the Civil Code). Progress along the Pivka was halted, for the peasants of Veliki Otok did not have either the resources or the equipment to continue and Anthron Verein was forbidden entry. One could not dream of coming from Velika dvorana in Postojnska jama because of the sudden and dangerous variations in river level and because of the difficulty of dragging heavy wooden boats. The natural starting point and refuge was the Belvedere in Otoška jama, which was effectively blocked.
In 1891 the Austrian Minister of Agriculture had charged engineer surveyor J. Schmid (of Pzibram in Bohemia) with the task of making a mathematical plan of Postojnska jama and Otoška jama. Adolf *Schmidl* described Postojnska jama, Ferdinand *Schmidt* studied the fauna and Joseph *Schmid* made the geodetic plan. This high precision work, done to the nearest millimetre, made with the aim of establishing the relationship between the caves and the surface, would take not less than four months. Calculating the angles, plotting the lines and the layout of the excellent maps at 1:1000 and 1:2880 scales, which will be the end result, could not be completed until 1893. With the greatest kindness, these remarkable documents have been placed at my disposition during my stay at Postojna in 1893 and I have taken notes to study fully.
As mentioned previously, Putick and Schmidl recognized that earlier maps had drawn all the passages of the Postojna cave too far eastward because the magnetic declination (11°50) had not been properly taken into account. This means that the end of Tartarus is 70 m from the Belvedere in Otoška jama and it would be easy and not too expensive to drill a tunnel between these two points. It would allow tourists to enter at the main Postojna entrance and to exit from Otoška jama, having seen the subterranean Pivka.
However, this drift of the whole of Postojnska jama towards the west complicates even further the difficulties arising from the division of ground property. It would be most beneficial for this conflict to be resolved, in order to make the planned tunnel. This would reduce the duration of the visit and allow seeing the whole of Otoška jama which is one of the most beautiful parts of the system.
Agreement is certainly not impossible for, during the whole of my research, Anthron Verein and the inhabitants of Veliki Otok have rivalled each other in their zeal and helpfulness towards me. It is true, in my opinion, that the personal intervention of His Excellency count Falkenhayn has reduced these difficulties.
24. Pronounced Karleshiuka (?). This doline, not very deep, has in its northern corner a fissure or shaft by which one can descend into a rarely visited cave. It is possible that this cave, draining from the surface, provides the doline with its main stream, linking (after some collapse) with the great collapse mounds of debris at the Pivka sump (the Osgood passages). It is this idea that I formulated on my 1:2800 plan [Fig.3]. I do not confirm that it is correct. Kraus made a detailed investigation in the southern corner of this Koliševka. It is perhaps more likely than the northern one.
25. It must be the same shaft, *Surjova jama,* that Kraigher noted to the east of Postojna on the slopes of the high ground called Pečna Reber (766 m). A vertical pitch of 50 m leads to a second one of 90 m ending in a 10 m high mound of stones closing it completely, 150 m below the surface.
26. Besides, one cannot lose sight of the effects of earth movements (see p.69). Schmidl attributes a lot of collapses to these (p. 199) and describes (p. 184) the violent tremor that occurred at Postojna and Planina on 2 February 1834.
He recalls also the temporary stoppage (lasting for an hour) of the Vipava springs on 31 August 1838 (p. 188). See also Stur *Das Erdbeben von Klana* (near Rijeka) in 1870, *Jahrbuch der geolog. Reichsanstalt*, Wien 1871, p.

238; von Hauer, Geologie, Wien, 1874, p. 79; prof. W. Urbas, *Gewasser von Krain*; Lorenz, *Geologische Recognoscirung im liburnische kaste Jahrb, Geolog. Reichsanstalt*, 1859. p. 345.

27. This addition of 2 km (which required 3 days of work, for it is true that "2 hours does not mean 2 leagues [=8 km]" Schmidl, p. 13), is assuredly only a round figure liable to modification. For I made this plan of the new part of the underground Pivka by a somewhat rough method. *Length measurement was only to the nearest decametre*: lengths were estimated by Kraigher and me in passages where we could walk upright, and *by the number of paddle strokes per metre* when we were afloat. Despite the magnitude of such approximation, this overall result of my underground survey gave a location for the shaft of Magdalenska jama only 40 m from its true position determined by Putick's trigonometrical survey on the ground surface above in 1885. This curious result, in which the reciprocal compensation of many errors must, it is true, play a great part, is one of the greatest successes of our rough method.
    I use this note to cite a book which I did not know about before writing my first chapter. It is the *Traité de Topographie* by Peletan, Paris, Baudry, 1893. Importantly, it contains a complete study of the compass and its variations, daily, general, local and accidental. It shows, from experiments made in the Clausthal mines, 525 m underground, that daily variations in declination are the same underground as on the surface.
28. Since my stay at Postojna a narrow hole has been found on the surface of the ground south of Črna jama which, once it is enlarged, may lead to extensions into new caves (Kraus, *Peterm-Mittheil*, January 1894, p. 14).
29. Near the artificial tunnel of 1856 and the *Cloche*, there is in the main passage, beneath a vertical chimney, a rock, with deep eroded scoring like that seen in the Tindoul.
    Also Schmidl (p. 49) states that in autumn 1852 he saw a fissure near the "Saint-Étienne tower", from which a stream flowed. He notes also (p. 97) at the beginning of Tartarus a chimney more than 20 m high which must lead to the surface, as Freyer found little bones there in 1836. Some fissures in Postojnska jama always serve to drain rainfall.
30. Kraus also recognized it in 1885 (Von Hauer, *Oesterr. Touristen-Zeitung* no. 7 of 1886).
31. It is possible that the extreme (downstream) end of Črna jama is not as close to the upstream end of Pivka jama as is shown in Fig. 2. Rudolf's plan of Črna jama in Schmidl's atlas does not have a scale so the true dimensions of that cave are uncertain. I have accepted the 1:2880 plan given to me by Putick, but its extent given there exceeds the 500 m stated by Schmidl and is even more than 1 km. This should be checked carefully.
32. This gives, with Otoška jama and Magdalenska jama, four sightings of the Pivka, but it is possible that some could be side branches, and not *directly surveyed* as conceived by the Abbé Paramelle (op.cit, 1856, p. 184 et al). Between the two places upstream of Pivka jama, Kraus, in July and August 1885, tried to discover the continuity of the Pivka. For this purpose, he removed several barriers that lay across the stream. This long and expensive work, which took 6 weeks, allowed him to lower the water level by 1.5 m, leaving just 15 cm of space above the water. The formerly sealed roof was then enlarged by explosives (see *Mitth. S. Höhlen-Kunde*, 1885, numbers 3 and 4, p. 34, *Oester. Touristen-Zeitung*, no. 7 of 1886 and *Entwasserungs-Arbeiten*). But behind the former sump he found (11 Aug. 1885) a second one 6 m deep in a little chamber several metres in diameter which was thus closed on all sides.
33. The plan shows where future work is needed to extend the underground river at Postojna. It is necessary to continue downstream from Magdalenska jama where the flood of 20 September caused me to stop 600 m (as the crow flies) from Ruglovča (see Fig. 2). For this purpose the Anthron Verein of Postojna is going to get an Osgood boat. If they succeed in reaching the foot of the debris from Ruglovča, they will only have to remove the stones to get round (as I did in two places further up river) the sump which stopped Kraus. The problem is exactly the same as the clearing done in Tindoul de la Vayssière.
    When this has completed the underground communication now evident between Magdalenska jama, Črna jama and Pivka jama, Postojnska jama will be at least 13 km in total length (at present it is 11.2 km, with Pivka jama and Črna jama, of which 5 or 6 km are filled by the Pivka river during floods). As the difference in level between the sink at Postojna (511 m) and the bottom of Pivka jama (483 m) is 28 m, it would be possible to carry out a whole series of modifications to enlarge the narrow places, to turn large pools into reservoirs, to replace inadequate natural barriers by dams with sluice-gates – in a word, to control the Pivka to diminish the effect of floods and to augment its flow when low. What we seek at Vaucluse is now found at Postojna where the Pivka awaits its sluice-gates.
    We see that before long this will be useful. Its good functioning is assured by the fact that in November 1851 the water rose naturally by 9.5 m in Velika dvorana at Postojna.
34. In the autumn of 1848 Urbas, the priest at Planina, went beyond the junction I have spoken of along the right-hand branch for a distance which must have been about 600 to 800 m, according to his description (die Grotten und Abgründe von Planina, in *Illyrisches Blatt,* 1849, nos. 28, 29, 30, reprinted in *M.S.H.K.*1886, no. 2, p. 24). This exploration ended after seven and a half hours, due to shortage of lights.

35. According to Putick, Schmidl gives (p. 140) a breadth of 56 m and a depth of 13.6 m at a level of 18 m above the cave entrance (at its altitude of 471 m).
36. Valvasor, who made up the story of featherless ducks at Cerknica (see p. 154) considered any communication between Postojnska jama and Planinska jama to be a fable. Not being able to carry heavy wooden boats over the debris barrier, he had to make them in place using materials carried in separately.
37. Schmidl called the branch passage the *Tropfstein paradies* from the beauty of its stalactites ([Schmidl] p. 141) but did not name it on his plan. It did not allow him to by-pass the sump and rejoin the river upstream. But he did see narrow side fissures rising up which it seemed to him, reasonably, to provide "drainage channels for rain-water which collects in the doline ["above"]. This explains the presence of the clay which fills the fissures" (p. 141).
Putick, who repeated this exploration (16 hours walk) in 1887, could not see this inlet any more. I did not seek to refind this unimportant place. The water level would have prevented it anyway. I can only say that, going to Haidinger Grotte [Galerija] 1 km from the entrance *Trümmerberg* by way of the debris slope of Golgotha [Golgota], the water, as always, comes from enlarged fissures in the ground. (Schmidl says (p. 151) that above Golgota he has seen a 6 m deep doline on the surface, indicating a sink. Fig. 8 shows sufficiently how the dip of the beds makes one believe it is a sideways loosening). Only, as the rock is sufficiently soft, the boulders are rounded in this enormous tunnel which reaches 10 m to 30 m in width and is 15 m high.
38. One sees in his book what was the aim of this expedition. He called the last part *Unheimliche Grotte* (Sinister Cave) and he was stopped at a roof so low that his boat could not, to his great regret, pass beneath it. Thirty-five years later Putick succeeded in forcing the passage and pushed on 1 km further, being stopped, not by a closed sump as in the other branch, but similarly at a low roof. It would have been unwise to continue, for blockage by flood water was always to be feared and this expedition lasted for no less than 28 hours (going and returning).
Schmidl, in different parts of his book, gives different figures for the lengths of each of the two branches (for the western one 1530 toises [2980 m] or more than 1713 toises [3318 m]; for the southern one 1710 toises [3315 m] or 1580 toises [3080 m]) and for their total length either 2980 toises [5800 m] or 5650 m[sic]. Using an opisometer, Rudolf's plan gives 6460 m (including branches). With Putick's kilometre [presumably another type of surveyor's measuring instrument] the total exceeds 7 km.
39. The absence of water in the southern (or Cerknica) branch shows us also the nature of the bed of underground rivers. Almost always it is littered with fallen blocks from the roofs and in some places they are like reefs when the water is high. Rather similar to broken up glacial moraines, this disorganized chaos has not only a series of hollows at the bottom of which one can sometimes descend to the floor of the cave, carpeted with sand and little round pebbles. If the river bed were preserved in its original state we would no doubt be able to follow Putick's 1887 route and even pass his final point. (Further on the journey, if there was water there, would resemble exactly that of Padirac. According to Schmidl's description (p. 144) and Putick's account, low tunnels alternate with high stalagmitic passages with weirs; 7 m to 30 m wide and 1 m to 15 m high). But the uninterrupted succession of climbs and acrobatic descents that require sheer strength and the removal of blockages only allowed us to move forward 500 m in two hours. 200 m further than Schmidl achieved in the Rudolfshafen [Rudolfovo Pristanisče] where he had to make a boat, and where Urbas was stopped in 1848. For 4 km, we had taken 32 hours (going and returning) of these gymnastics.
The thing would be impracticable, and for exploring the river passages impossible without a boat. Moreover Schmidl, wo had only seen 150 m of boulders without water, described it as "the most arduous part of the whole exploration" (p. 162). The appearance of this curiously dry passage, with some puddles of water are exactly like the final part of the Tindoul but double the size and with the boulders a lot larger and more difficult.
40. See Schmidl's description of this stream (p. 292 et seq.). See also: von Steinberg, *Gründliche Nachricht von dem Zirknitzer See*, Laibach, 1758; W. Putick, *die Fischerei am Zirknitzr See,* Mittheil. des oesterr. Fischerei Vereines, no. 27 (1888?); W. Putick, *Himmel und Erde, October 1889,* Berlin, Paetel; Gansauge, *Annales de Poggendorf,* 1840, t. 51; Pfeil, *Gaea*, 1872, p. 586; W. Urbas, *Das Phänomen des Zirknitzer Sees,* Zeitsc. Club apl. all.-autr., 1879, p. 17–33: etc.
41. It comes no doubt from the nearby caves such as the Kreuzberghöhle [Križna jama] (to the north of Lož). One of them, Stebesica [Steberk], is perhaps even the reappearance of the waters lost to the east in the polje of Gross-Oblak [Bloško Polje] or of Plosica (altitude 728 m). See W. Urbas (*Gew. von Krain*), Schmidl (p. 279) and Ferd. de Hochstetter: *Sitzungsberichte* of the Vienna Academy of Sciences, vol. 80, Dec. 1879, pp. 526–556 with a plan of Križna jama (1650 m long) drawn by Szombathy and *Denkschriften* vol. 43, pt. 1, p. 293.
42. Schaubach (*Die Deutsch en Alpen*) vol. 5, p. 323, 2nd edn., 1867, Jena) claims to have counted 400. Gruber mentions 28 and Cvijić only 18. Reclus wrongly calls them the Dolines (*La Terre* **1**, p. 363). They give the lake its ancient name of *Lugeus Lacus*, Lake with holes.
43 This intermittent spring is the place where Valvasor's story has blind and featherless ducks being washed out at certain times (p. 154). This fantasy has been repeated by Arago (*Notice sur les puits artésiens,* p. 211 and *Notices*

scientifiques, vol. 3, reproduced by Agapito and by Stan. Meunier, *Les Sources*, p. 94, Hachette, 1886). It seems true on the other hand that the fish of Cerkniško jezero do retreat during the dry season into unknown subterranean passages, to reappear in the water of the next flood. Putick believes that this is so. Otherwise it would be difficult to explain the spontaneous repopulation of the lake when it returns. (On this subject see Schaubach, op. cit. vol. 5, p. 323). As for the aquatic birds, they arrive in flocks as the lake refills, attracted by the water which is often scarce in this region.

44. This word does not signify the cave of Karl, as is sometimes thought, but "throat that swallows".
45. Which communicate more less directly with various sinks in the plateau above (Gluboki Dol [Globoki dol, Obranja jama [Obravčja jama], etc.
46. In 1878, referring no doubt to Vicentini's project, which he did not complete, Reclus said (vol. 3, p. 275): "The winding passages in the rock, through which the overflowing flood waters are being replaced by a single branch where steam pumps dispose of the excess water; agriculture accepts it gladly. I never saw the flood of 21 September 1893 but I say that, on the contrary, the entire area has no channels so they cannot have been destroyed by the floods. It is true that there is a steam pump that takes water from the Cerknica river to supply a railway viaduct to Rakek station. Putick wrote to me on 27 November 1893 telling me that Cerkniško jezero was full and masses of water were flowing on to Karlovica. The drainage problem is still not solved.
47. The passages at the lower level could not have large chambers like those I have previously called overflows. Besides, descending after long droughts into large cavities and openings like chimneys, one finds at depths of 25 m or 30 m a labyrinth of passages, more or less high and heading towards the north west, some of them even with flowing water (Putick, *Fischerei am Zirchnitzer See*). The section of this land, between this water and the bottom of the lake, shows alluvium above very fissured limestones, all of it thoroughly permeable – see the important memoir of von Hauer in *Oesterr. Touristen Zeitung* 1883, no. 3 & 4.
48. During this exploration of 1887, a storm suddenly converted a low roof, beneath which he had to crawl, into a closed sump. Imprisoned thus, Putick and his companions were very fortunate, for after 5 or 6 hours of anxious searching they discovered a side passage which led them back to the cave entrance. But this passage was particularly difficult. On 21 September 1893 a lucky chance allowed me to find a second entrance, a lot easier, which avoided the dangerous sump and was very useful for carrying out the works proposed here by Vicentini (1875) and Putick. This was a matter of making enlargements and establishing in certain suitable places dykes with adjustable openings which would make it possible to diminish some of the extremes of Cerkniško jezero's behaviour. It is to be hoped that these useful regulatory works can be carried out with little delay.
49. At the bottom of which one could formerly see the Selzach sawmill destroyed by the floods of 1852 and 1853.
50. One cannot penetrate the rising itself (in the first cave), even in a boat (see Schmidl, p. 307 et seq.).
51. The tourists, friends of nature who go to visit Postojnska jama, make a big mistake in not devoting another half day to the phenomena of Rakbach Thal [Rakov Škocjan] which is one of the greatest wonders of Europe (see F. Kraus in *Laibacher Zeitung* of 25 August 1887). Sanct Kanzian in Wald (in the forest) is a small ruined chapel very close to it and not to be confused with Sanct Kanzian am Karst [Škocjan] by the Reka near Trieste. Schmidl had proposed to distinguish them and to name the curiosities we are considering now as the natural bridges of Maunitz.
52. We were not able, on 17 September 1893, to profit from the dryness. Putick and I went to see if the sump happened to be passable. Because of a narrowing 150m before the sump which it had taken Putick 48 hours to enlarge, the passage was freshly blocked with stones and tree trunks to clear which would have taken a long time. It was there nevertheless that we (accompanied by Kraus, Pazze, Marinitsch and F. Müller of Trieste) were able to make the important statement, reported above, that the Rak river was entirely absorbed at the sinks above Veliki most, beneath which we could pass quite dry. There was not a drop of water in the cave and on the next day, 18 September, the southern branch of Planinska jama was equally dry: proof positive of its connection with the part of the Rak that at high water is lost in the last cave (Rakbach-Schwinde [Rak sink, now Tkalca jama].).
53. Von Hauer, *OEsterr. Touristen-Zeitung,* nos. 3 & 4 1883, Wien, F. Kraus, *Die Entwässerungsa beiten in den Kesselthälern von Krain*, conference of 14 Jan. 1888, pub. in *Wochenschrift des æster Ingenieur und Architekten Vereines*, no. 13, 1888, Wien, 7 p. 2 pl.; W. Putick, *Die hydrologische Geheimnisse des Karstes, dans Himmel und Erde,* October & November 1889, Berlin, Paetel.
54. First, in 1886 and 1887, he enlarged several of the sink holes, finding some of them to be drainage passages (the caves Dreschboden, Winkler, Lippert [Najdema jama] and Lorenz-Liburnau or Skofu-Lom [Jama v Škofevem Talu]. He made two shaft-sinks (protect by grills to prevent blockage) which are named the katovothra *Pod-Stenami* (beneath the cliffs) and they have already greatly diminished the disastrous effects of flooding. Several other sink holes ought to be modified and enlarged, but the work has been suspended because of the inhabitants of Ljubljanska barja claim that their floods are getting more frequent despite the modifications already made. Whether this complaint is justified or not, it will still be necessary to control the drainage of the marshy Ljublja-

na plains. See W. Putick, *Die Katavotrons in Kesselthäl von Planina, Wochenschrift des æsterr. Ingenieur und Architeckten Vereines,* nos. 46 & 47 1889, Wien and *Mittheil. geogr. Gesellsch.,* Wien, 1887, p. 277, 1889, p. 57 et see Kraus, *Morastüberschwemmung in October 1888,* in *Laibacher Zeitung,* 1889.

55. Very close to Pod-Stenami a shaft, only 20 m deep, leads to Jama v Škofovem Talu. An artificial tunnel, 12 m long, would link it with a cleared swallow hole and so make it very much more efficient. 400 m from Pod-Stenami is Vranja jama (Crow Hole), an immense and very picturesque pit where the stratification, the collapses and the chimneys in what remains of the roof prove that it is at the same time both subsidence and collapse. It is clearly impossible to clear away all that would undoubtedly allow it to link with Najdana jama. But Putick has again found the link (already recongized by Urbus and Rudolf) with a former swallow hole (Marzla jama, Cold Cave), now almost completely blocked by the Unica. As I have already said several times, the narrowings and the differences in level cause a marked chill in this kind of tunnel sump now empty of water. I noted: outside air 14°, south entrance 7.8°, north entrance at the bottom of the doline 6°, pools of water 6°, all on 19 September 1893. The bottom of Vranja jama is 17 m below the surface of Planinsko polje.
    Four km south-east of the Pod Stenami sink holes, etc., two other long caves (Rinadlini [Jama v Dolenje Loka]) and Salzer take the water from various unblocked sinks.
    Finally, between these two groups of caves, a third has too few discharges to justify calling Planinsko polje an underground delta. This third group is linked with Logarček (see Putick in Mitth. der Sect. Nat. Ku. OE.T.C., 1889, n° 7).
56. In 1886 Putick (see *Mittheil. Soc. Géogr. Wien*, 1887, no. 11, p. 561) spent 14 days exploring this cave and making a plan of it. He undertook the immense task of removing the clay and destroying the stalagmites. The wooden ladder that had been installed at the first vertical pitch (of 25 m) had been repaired by order of Count Falkenhajn in September 1893 to facilitate access.
57. It was specially desired that the cave should be made suitable for visits. The lower passage is, according to Putick, between 10 m and 20 m below the surface of Planinsko polje and was nearly 130 m long. Temperatures: water 8°; air 8.2° to 8.8°.
58. 2.5 km north-west of Pod-Stenami, near the houses of Kalisch [Kališ], Urbas visited a cave that ended in a shaft that he could not descend. He had also seen, not far from there, the mouth (60 m wide he said) of a big shaft, Kalisheva Jama [Kališnica jama]. A peasant told him that a shepherd had fallen into it with two bullocks. The remains of his clothes were found at Vrhnika! Urbas placed the cave nearly an hour from Gartschreuz,and the peasant had told him also that the devil lived there. It seems without doubt to be the shaft (40 m wide at the top, 3 km north of Pod-Stenami) of *Gradišnica* or Teufelsloch (Devil's Hole). It remains, I believe, the 5th deepest natural shaft that man has ever descended (Putick in 1886), at 225 m deep the 85 m shaft, 100 m of a talus slope and then another 40 m vertical). It is no more than an immense collapse chamber, one of the biggest known (180 m long by 100 m wide). It is, like Logarček, an overflow space, filled with clay, that flooding of the underground Unica still avoids. Two sumps form when in flood. Putick's expedition in Gradišnica lasted 32 consecutive hours (see *Mitt. geogr. Ges. Wien*, 1890, pp. 488 et seq.). Schmidl had lowered one man at the end of a rope for 50 m only. In a small pool, condensation water was only 6.5°C. The floor of the great chamber is only 60 m above the level of the Ljubljanica springs. To the south-west, the Kalisniča is blocked after 75 m.
59. It seems that there are three main river systems whose courses are broken by their sinking underground, like the Pivka, the Unica and the Ljubljanica, and their poljes.
    1st. To the south-east of Cerkniško jezero is Gottschee [Kočevje]. The Sajovec sinks at Zlebič near Slatenek and must join the underground Bistrica which sinks at Weikersdorf not far from there, near Ribnica. A second underground junction can be assumed between the two previous streams and that of Ribnica at Niederdorf. The Rakinitz [Raknica] stream, on the surface for at least 2 km, then makes a third invariable branch, joined with other still unknown, is probably the source of the Rinnsee [Rinža] stream. This river itself crosses the long Kočevje polve, to be lost in the Ponique [Ponikve] at its south-eastern extremity. Finally, the last rising is, according to Putick, the powerful spring of Teufels-Rachen [Kotnice?] (the devil's mouth) on the left bank of the Kolpa, 15 km south-east of Kočevje. Other small poljes, like those of Rieg and Wetzenbach, south-west of Kočevje, must also be brained by this first system.
    2nd. To the north-east of Cerknisko jezero is that of the *Krka*. The Rašica and various little streams, lost in the village of Ponikve nearby, is the probable origin of the Sica. This, in turn, soon sinks also near the Dabrava which comes from the north. The outlet of this second system is at Obergurk [Gradiček], the source of the Krka which flows in the open air to join the Sava.
    3rd. Between the Krka and the Sava is the *Temeniz* [Temenica] which sinks for the first time at Ponikve (260 m) (a common local name. It reappears *without changing its name* at Witschendorf [Vinja vas] (at 230 m), sinks once more at Goritschendorf (226 m) and finally emerges at Luegg (175 m) at the sources of the Prečna, a short and winding left tributary of the Krka, above Rudolfsworth.

Do not confuse this Luegg with the one near Postojna and remember that *lugeus* means *with holes*. Not far from there to the south-west one finds the great natural glacier of Toplitz [Toplice] with Hornwalde. According to Schaubach (*Die Deutschen Alpen*, vol.5, p. 356) it sinks vertically to a great depth, where there is a magnificent ice palace (360 feet [sic] high by 600 long?!).

60. Hrasky, a regional engineer, succeeded in a little cave (Vršnica) in 1886 and 1887 in finding the underground stream between the Krka source and the sinks of Sica and Dohrova in the Raschna [Račna] valley. Making a little tunnel 5 m long and enlarging a narrow place has prevented the former terrible periodic flooding. He thus found 1160 m of unknown passages. A sump at the end prevented him going any further. Exploration of the cave sources of the Krka and the intermediate chimneys is by no means ended. Hrasky found the *Stremec* (83 m deep) and 30 other shafts that were completely blocked (*Mitth. Sect. für Natur. Ku.*, 1889, p.77).
Putick has also undertaken to develops his methods and has prepared many projects for minimizing and controlling water in the Kočevja region. See E. Graf, *Die Grottenwelt von Gottschee in Mittheil. der Section für Höhlenkunde des Œsterr. Touristen-Club*, 1882, no. 1; idem, 1887, no. 1, p. 6, et no. 4 p. 47; V. also F. Kraus, *Entwässerungs-Arbeiten et id.*, Laibacher Zeitun, 26 Aug. 1887.
61. One of its sources is named [Illirska] Bistrica, a word often used in the Karst to denote a rapid, flowing river (according to Prof. W. Urbas).
62. Which must be distinguished from Sanct Canzian im Weld [Rakov Škocjan] (see p. 460). This name is common in the Karst, like that of the Recca [Reka], which in Slovene signifies a river or flowing water and we shall hear it many times, from the Reka of Logatec to the Recca of the Gulf of Muggia near Trieste, the Recina [Reka] of Rijeka and the Rjeka of Montenegro. There are also two Rekas to the east of Ljubjana; one is a tributary of the Ljubljanica while the other flows direct into the right bank of the Sava.
63. *Führer von St. Canzian*, Trieste 1887, 111 pp, *Die Grottenwelt von St. Canzian*, Zeitschrift du Club Alpin All.-Autrich., Wien, 1890, 59 pp. and *Explorations de 1890*, in Mitth. Club All.-Autrich, (8), (9) & (10) of 1891.
64. At two places in Velika dolina the water rose to 70 m in 1851 and to 80 m in 1826. One can imagine the power downstream of such a column of water at a pressure of 7 to 8 atmospheres.
65. I am not exaggerating these estimates of recent explorers. Not far from the entrance there is a projection (Novak-Cap) on the right-hand wall, the height of which above the water was *measured* as 63 m: and there is a good 20 m above that to the roof.
On 23 September 1893, with Putick, Pazze, Marinitsch and Müller, I wished to measure the height of Rinaldini-Dom [Rinaldinijeva dvorana] 1100 m from the entrance, by means of a paper Montgolfier balloon. The humidity of the air prevented it going above 45 m. It did not reach the roof, which is not the highest in the cave.
66. I give here only the main dates in the long conquest of the cave, which claimed more than one victim.
On 21 July 1839 and 14 June 1840 Svetina, hydrological engineer of the city of Trieste, was the first to risk himself in a boat on the underground Reka. He claimed to have gone above 2800 m (1460 Viennese toises, see *Augsbergher Allgemeine Zeitung*), 28 April 1841, suppl., 118, p. 946). But later explorations have shown the inaccuracy of this figure. Besides, the men who went with him later showed Schmidl the place where they stopped, 130 m from the entrance, at the 3rd cascade.
In 1851 (20 Feb to 6 March) Schmidl and Rudolf penetrated as far as the 6th cascade (400 m). Despite their experience, 14 days of preparation and having appropriate equipment, they were unable to overcome this obstacle. (Acad. Wissenshaft, Wien, May 1851, class of Mathemetics and Natural Science; and Haardt von Hartenthurm, *Die Recca – Höhlern von Sanct Canzian* Mitt. Sect. Hoehl. Kunde O.T.C. 1883, no. 1, p. 1).
Thirty-two years later, in 1883, three members of the section Küstenland of the Deutsche und Österreichische Alpenverein, A. Hanke, J. Marinitsch and F. Müller, joined forces and resources to start work. Assisted by the brave workers Antončič, Gombač, Cerkvenik, etc., it took them 10 years to complete the task and to discover more than 2 km of new passage. Hanke even died [but not in this cave]. One has to see the Reka in flood to realise the dangers run and the difficulties overcome in the investigation of this river which throws the most solid wooden boats about like wisps of straw on the reefs and cascades.
Also, after the discovery of each new section it is necessary, before going further, to establish on one of the walls an escape route (*Rettungs-Weg*) consisting of several notches in the rock for the feet and a handrail of thin iron fixed to the wall with crampons. More than one attempted advance was taken by surprise by such a Reka flood that explorers hardly had time to reach the latest part of the Rettungs-Weg, sacrificing their boats, equipment and ropes to the fury of the water. On 21 October 1889 the water-level in Müller-Dom [Müllerjeva dvorana] rose by 20 m. In 1892 a beam was found on a ledge 50 m up in the dôme Martel [Martelovo dvorama], etc.
On 20 January 1884 the first attempt did not even get to the place reached by Svetina. On 9 November Schmidl's 7 m high 6th cascade was overcome again. By 18 August 1889 they had reached only the 17th cascade, 850 m from the entrance. In the year 1890, they made 1400 m of progress and on 5 October Hanke, Müller and Marinitsch were stopped at the edge of Mrtvo jezero. They had already been able to pass a very low passage, 1.5 m high at low water which became a flood when flooded. It took 3 years to confirm that this last lake which is triangular with

30 m sides, is entirely closed. Tree trunks, planks and wood from the banks of the surface river float still in the motionless water, just like in the Pivka's first sump, together with old boats and climbing aids used by previous explorers.

Exploration seemed to be ended, apart from trying to extend the side tunnels, etc. However, a little before the sump, on the left side a side passage, too narrow to penetrate and which should be enlarged by explosives, brings underground tributary water to the Reka. It is not known if this is water that disappeared further upstream in the cave or even from the surface stream at Dane that sinks 1500 m south of Škocjan.

On 21 January 1894, Marinitsch, Müller and Novak, climbing the right (north) wall of Müllerjeva dvorana, found at a height of 66 m above the 6th cascade the *Grotte du Jubilé* [Jama nad Sokolakon]. The section (Fig. 22) shows that it is a tributary passage draining water from the surface which is about 50 m above the roof of this new cave which itself is 90 m above the underground Reka.

Because of the high water level on 23 September 1893, I was unable to follow the progress of Pazze, Marinitsch, Müller and Novak who had reached the 20th cascade at 1150m. There was then only 700 m of the footpath complete with guardrails. By following 450 m of the Rettungs-Weg, which was the work of *ten years*, I was able to recognize that Hanke, Marinitsch and Müller had accomplished the most dangerous cave exploration that has ever been done.

67. The Section Küstenland plans to complete the footpath as far as the 24th cascade (2 km) at the end of the last great chamber which they discovered on 17 August 1890 and which they graciously intend to name after me.

One may ask if this path going all that way may not seem long and monotonous, for there are no ornamental concetions (except in the Brunnen-Grotte [dvorana Ponvic] near the start). The passage is black and almost impossible to illuminate. The smoke of [wooden] torches which alone can pierce the darkness is very awkward. The deafening noise of the rushing water makes one giddy. A lot of visitors are content to go only as far as the Hankejev Kanal, beyond the immense Müllerjeva dvorana, only a third of the whole cave, but even that reduced visit, coupled with the two dolines and the two upstream caves, which are really only introductions to the main cave, still make one of the most extraordinary excursions offered to the curious traveller.

68. Antenor poluit ….
… Fontem superarc Timavi,
Unde per ora novem vasto cum murmur montis
It mare proruptum, et pelago permit arva sonanti
(*Énéide*, liv. I, v. 242-246.)

W. Helliez, *Géographie de Virgile*, Paris,1771, in-12;, Kircher *Mundus subterraneus* (Amsterdam, 1678), lib. V. chap, IV; Kandler, *Discorso sul Timavo*, Trieste,1864; E. Reclus, *Géographie*, t. I, p. 226; plan springs of Timavo in *Pysikalisher Atlas de Berghaus*, pl. 17, 1890. From Austrian map 1 : 75,000; H. Noé in Müller, *Sanct-Canzian-Führer*, p. 66, etc. 69. The letters B.M. indicate readings from a hand-held barometer, related to the altitude of Divača railway station (433 m) on 28 September 1893.

70. 150 m, according to the sections made by Hanke, 125 m according to Marinitsch. The 1:75000 map gives only one altitude, that for the village of Škocjan, 426 m. I did not take any barometric readings.

71. 80 m below the arête (120 m depth in all) he reached, half way down the rope and wood ladder, a second arête where the two shafts, having been joined together for about 15 m, were once again separated into two vertical fissures. With the aid of a winch installed on the platform of this arête (dangerously exposed to falling stones), Hanke and his workers reached, at the end of a 100 m long rope, the bottom of the shaft at 220 m. The two teams were now reunited once again, 180 m below the surface of the earth (the same phenomenon as at Rabanel). A zig-zag passage full of sand, pebbles and clay has several side branches (8 or 10 of them blocked, a roof pierced with avens and a floor with depressions, some of them with pools of water. This continues for 836 m, descending gently to about 260 m below the ground surface, that is to an altitude of 185 m. (Temperature below the shafts 15°, in the passage 11.3°.) The figures of 220 m and 260 m are not at all consistent with those in Hanke's section which give depths of 213 m and 253 m. But that sectional drawing gives on 20 m instead of 40 m for the funnel-shaped entrance depression. See F. Müller, *Die Kačna jama*, Mitt. dt. u oesterr. Alpen Vereins, 1893, no. 8, May 1st.

72. One can only *suppose* that the Kačna jama passage is an overflow or a tributary of the Reka and accept that it does not pass beneath the cave and does not produce any depression. It must flow to the east; for the furthest part reached by Hanke is, as the crow flies, 400 m to NE of the Divača. 400 m from there, a little to the north is the unexplored *Kosova jama*. A peasant, his daughter and a pair of bullocks fell in there. The apron of the shepherdess and the team were recovered much later from the Timavo?? In the vicinity Müller cites also Pred-Jama, Bukwik [Bukove] *doline* (210 m long, 130 m wide and 100 m deep) and *Rudvany* [Radvan] *doline* (700 m long, 350 m wide, 80 m deep).

Unfortunately Hanke, weakened by all he did and suffered in the Reka, overstrained his heart and further exceeded his strength in a 14 hour expedition in Kačna jama. He came out suffering from Pleurisy and then endocarditis. He died on 3 December 1891 at the age of 51.

After his death, Marinitsch and Müller resumed their descent there at great cost. I myself withdrew from the great expense, in time and money, of all the preparations. But I strongly encouraged the two collaborators of the late Hanke (replaced by Captain Novak in the trio of explorers) to complete it. It is by that, I believe, that we increase the chances of finding the Reka again.

73. When it was discovered on 11 May 1884 Rudolfs-Grotte [Divaška jama] had wonderful concretions (see Putick, *Mitth. geogr. Ges.*, Wien 1889 (2) & (3). The commune of Divača, which owns it, had the unfortunate idea of covering the paths that they had made in the cave with cinders from railway engines and coal dust instead of sand. The humidity and the dripping attacked the carbon and all the stalagmites and stalactites were covered with a black film and the cave lost a lot of its beauty. Besides one had to breathe the resulting heavy air polluted by carbonic acid (temperature 10° on 28 September 1893). The depth is only 65 m, not 120 m as has been said.
74. See *Società degli alpinisti Triestini (Alpi Giulie). Memorie*. 1883–1885, p. 113, with plan and section at 1:1000. In this article Marcovich rejects the hypothesis of surface water, and gives as the origin of the caves; *roof collapse* and slow acting infiltrations (?!).

    On 6 March 1818 [it was 1816] the cave of Padrič[iano] was visited by the travellers Hoppe & Hornschuh (*Reisen ach der Küste des Adriatischen Meeres*, Ratisbon, 1818).

    The bottom was reached in 1840 by Lindner and Svetina, who left inscriptions there as proof. The inscriptions were found in 1883 and 1884 by Pazze, Hanke, Marinitsch and Müller.
75. On 28 October 1866 blasting was taking place to extend the bottom of the cave. The explosion was heard at the surface and three workers, believing it had misfired, went down to investigate. They never returned, overcome by the fumes. On 5 November the son of one of them descended to look for his father's body: at 70 m down he too fell dead. All four bodies remain in the cave and it was this catastrophe that gave it its name. It is a lesson for any future clearances in caves. (Information from Marinitsch: see also *Atti e Memorie delle Giulie*, vol. 3, 1893, p. 103).
76. The question of providing the town of Trieste with potable water is vital for the port. Among the projects planned but not carried out is the diverting of the Reka itself at the dolines of Škocjan. See Junker, *Project der Zuleitung des Recca-Flusses*, Wien, a pamphlet available from the author 1875. See also Bürkli's memoirs (Trieste 1871), Geiringer (Trieste, 1882), etc.
77. The third sink, 13 km from the first (Mahorčič): see Von Morlot, *Geologische Verhältnisse von litrien*, Wien. Haidinger's naturwissenschaftlsche Abhandlungen, vol. 4, p.270, 1848. – Müller, *Sanct* Canzian, p.55. – C. Morpurgo, Atti e *Mem. Soc. delle Giulie, 2*, 1887, p. 123–140: Pignoli, *Zeitschr*, Club alp. all.-autr. 1881, p.377–385.
78. Which makes a particularly interesting collection in the Natural History Museum of Trieste. One notices especially enormous ornamental vases of baked clay and bronze objects from the necropolises of Santa Lucia (500 years BC), also the great bronze helmet of the same period, found on 27 December 1886 near the 6th cascade of [Škocjanske jame]. See Müller's report/memoire of 1890, p. 57 and those of Dr Marchesetti in the *Atti del Museo di Storia naturale di Trieste* and the *Bollettino della Società adriatica di Scienze naturale di Trieste* (passim).
79. In two shafts near Opicina, more than 50 m and 80 m deep; the cave of *Briscki* [Grotta Gigante]; the shaft, more than 80 m deep at Repen; the cave at Gabrovizza; the Draga di Pliscovizza; the second cave of Tours (igue de Bar) at Slivo near Nabresina [Aurisina], altitude 110 m, total depth 52 m, total length 300 m, temperatures on 9 January 1885: outside air 4°c, inside air 9°, trickling water 6° according to Doria, *Atti e Memorie Soc. Alp.*, Trieste vol. 1, 1883–1885, p. 117; E. Taucer *Atti e Memorie Soc. delle Giulie*, vol. 3, 1893, pp. 103–109; - the cave of Lipica with its entrance shaft of 23 m; - [the cave of] Georg Schneider, near Trnoviza, 400 m long; the shafts of Ključ p. 29 and Schmidl, p. 194), etc. etc.
80. Auresina: temperature 11.2° to 14°; daily output 6400 m^3 to 20 000 m^3. The Timavo produces at least 2 300 000 m^3 per day. At the bottom of Trebiciano the figure for 24 hours is between 127,000 m^3 and 757,888 m^3. The Reka varies widely from 5000 m^3 to 6,300 m^3, with a mean of 90,000 m^3 in 24 hours (according to Marinitsch).
81. *Grottenbuch* (manuscript diaries of Hanke) of Saint-Canzian, 11, verso. See also *Chronik der Section Küstenland* 1873–1892 p. 220, Trieste, 1893.
82. And as far as Velika dolina, a 256 m drop over 12.5 km, that is 20.48 m per km (2.05%).
83. One of the smallest slopes for any underground river that I know, that of the Sorgues d'Aveyron (between the spring and the Gouffre de Mas-Raynal) is 0.625%, nearly 8 times greater than between Trebiciano and [the rising of] the Timavo (the windings of the stream not included in either case). I am inclined to believe that the water from Trebiciano to where it becomes the Timavo goes, partly to Aurisina, and partly to other little-known deep springs further out to sea. The beds of clay marked on Austrian maps at a great distance from the coast provide an argument in favour of this hypothesis.

84. On 12 June 1891 we threw 10 kg of an alkaline solution of fluorescein into the first fissures of the Reka, at Ober-Urem [not far from Buje] (see. p465). Ten hours later green-coloured water appeared at the bottom of Velika dolina at Škocjan, 8 km away. But nothing was seen either at the bottom of Trebiciano (watched continuously until 21 June) or at the springs at Aurisina and Timavo (watching ceased on 15 June). See C. Doria, *Attie Memorie Soc. delle Giulie* vol. 3, 1893, p. 245). Engineer Durand, in October 1877, on the contrary, had succeeded in proving the link between the Danube and the springs of Aach, 30 km away. 10 kg of fluorescein, had been thrown into the fissures where the Danube loses part of its water. It showed in the Aach the next day and remained coloured green for 24 hours (according to C. Doria). See also *Annales des ponts et chaussées,* April 1878 and Bover *la Fontaine de Vauchluse* (C.R. Assoc. franć., 1879).
85. And not 57 m (E. Reclus, *Geographie*, vol. 3, p. 259) Altitudes: railway station of Pazin 297 m; Pazin 262 m (Austrian Ordnance Survey map 1:75 000); Pazin market square 268 m; the top of the east wall 270 m; top of the west wall 320 m (BMI. 321 ordnance map); the sink of the Foiba at the cave entrance 190 m and not 240 m as stated by Stache (*Wasser-Versorung von Pola,* p. 44).
86. Ch. Yriarte records that the young Count Esdorff, in a little boat, found the walls so close together and the roof so low that he came back "lying down in the boat". This account (no date given) does not match the real form of the cave. Besides, Yriarte's big drawing of Pazin and its Foibe is utterly fantastic (*Les Bords de l'Adriatique,* pp. 110 and 121, Paris, Hachette 1878 and *Tour du Monde*, 1875, vol. 1, pp. 213 and 220). – There are two engravings, more accurate and less romantic of the Foiba of Pazin Schweiger-Lerchenfeld, *Die Adria*, pp. 153 and 161. Wien Hartleben, 1883. – G. Stacha stated in 1889 that the underground course of the Foiba was still unexplored (*Wasser-Versorgung von Pola*, p. 5, Wien, Hölder, 1889).
87. At the head of the Kvarner Gulf the Rijeka brings back to the surface the streams that sank in the poljes (Klana, etc.) reinforced by underground drainage fissures. To the west of Rijeka is the cave of Castua [Dimnice], 400 m long. To the east, on the other hand, between Snežnik and Kapela are the poljes of Cernilug, Lokve, Fužine, etc., at more than 700 m above sea level.
We mention here the following poljes: Dobra (a river sinking at Ogulin and reappearing at Popovo-Selo), Jasenak, Mrežnica, Drežnica, Gacka, Lika, Ričiće, Krbava, Bilopolje (between Zadar and the Kulpa [Krka]; lakes of Nadin and Vrana (not to be confused with lake Vrana on the island of Cherso). This last never dries up because it is linked to the sea. In the Otuka basin, O. Krifka has listed no fewer than 26 ponors (M.S.H.K., 1884, (3), p. 34). He has listed many others including the caves Pečina and Krajom and also Mamula in the Krbava basin.
Plate 17 of *Pysik Atlas*, of Berghaus gives two little maps (at 1: 1500 000 and 1: 5000 000) of underground water in the Karst. See also the Austrian Ordance Survey maps at 1: 750 000, 1: 300 000 and 1: 75 000.
88. Riedol has carried out, at government expense, several improvement works in the dolines of Herzegovina. *Wochenschrifl der Oesterr, Ingen. und Archit. Vereins*, nos. 17 and 18 of 1889. Tietze, *Geologische Darstellung der Gegend Zwigchen Carlsstadt und die Morlocca*, Jahrbuch der K.K. geology Reichsanstalt. 1873, **23** (important memoir with a good bibliography).
Daten zur Beschreibung der Schlundbachs; Mittheil, der Section Höhlenkunde de Oest. Tour. Clubs 1884, no. 2, p. 19 et seq. no. 3, p. 34 et seq. no. 4, p. 57 et seq. 1885, no. 1 p. 1; no. 2, p. 20 etc.
Wessely (J.) *Das Karstgebeit Militar-Kroatiens und die karst-Frage*, Agram, 1876.
89. Glamočko polje, Livansjko or Livn polje, Duvno polje, Topol Imofski etc., between Sarajevo and Split. There one sees the Cettina [Cetina] river coming from a stalactite cave. Between Livno and Sinj on mount Prolog there is, according to Jedliska, a 20 m deep shaft but the extent of any passages below is not known (H.K. 1884, vol. 2, p. 22). Near to Livna the Bistrica river emerges from a group of vast unexplored caves (J. Mathes, ibid, p. 27). This is the mountainous region called Črna gora; like Montenegro it is rich in unexplored underground rivers (see K. Schlacher, p. 28).
In Jezero Blato there is an island with the ruins of an ancient monastery. The archives and documents record that to guard against Turkish raids, the monks blocked the sink-holes in the plain around them and converted it into a lake (Ullmann, M.S.H.K. 1885, no. 1, p.12). In Herzegovina, Mostarsko Blato (west of Mostar, with nearly 100 ponors), Zalomska polje, Lubinje polje and Popovo polje, all three between Mostar and Dubrovnik, converge more or less directly to form wonderful spring caves, tributaries of the Narenta, which enlarge the river in the magnificent valley canyon which follows the Konjiča to Mostar and even as far as the sea.
Tietze also refers in Croatia to several intermittent lakes like that of Cerknica. Ami Boué (*Karst Trichter*) says that in Bosnia, between the villages of Ugra and Verbanja and south of Kotor there are many shafts 50 m to 60 m deep with red earth at the bottom. See Mojsisovics, Tietze and Bittner: *Grundlinien der Geologie von Bosnien und Herzegovina*, Wien, Hölder, 1880. – Reclus vol. 1, p. 200. Ami Boué *Mémoire sur la Constitution Géologique des Provinces illyriennes* (Mémoires de la Soc. Géolog. de France vol. 2, 1835) and *Turquie d'Europe,* 4 vols., Paris, Arthur Bertrand, 1840, vol. 1, p. 43 (several words on the ponors of Herzegovina) and vol. 2, p. 266. –

Partsch, *Bericht über die Detonation's Phaenomene der Insel Meleda*, 1826, Wien. – Tietze (Dolines of Serbia), *Jahrbuch der Geolog*. Reichsanstalt, 1872, p. 83, Cvijić, *Karst Phaenomen*, p. 76 (surface of the Polje), etc.

90. According to the Austrian Ordnance Survey maps, 18884–1885, Sarajevo sheet.
91. Ph. Ballifi *Ergebnisse der meteorologische Beobachtungen in Bosnien und Hercegovina*, 1889. Extract from *Wissensch. Mittheil, aus Bosnien* etc., Wien, Gerold vol. 1, 1893. Information from Dr Koeschet.
92. I have noted that, for an altitude of only 30 m, this is extraordinarily cold: 9.9° (air 19.7°), a temperature 5.2° lower than the annual mean at Mostar 15.1° at altitude 59 m, based on four annual measurements (1886–1889 according to P. Ballif. This water comes from a great height, without any mixing.
93. *Les pays sud slaves de l'Autriche-Hongrie*, Paris, Plon, 1883. The legend is confirmed by a helpful communication from Th. Schadeloock in which "popular tradition is always seeking the continuation of the Polje's water in caves where springs have produced skulls and bodies".
94. In times of flood it even exceeds 20 m and reaches Hutovo-polje, beyond Popovo polje.
95. Steeply sloping at first, it then continues as a narrow horizontal channel, 1.5 m high and 3.25 m wide. Von Groller was stopped after 120 m because to go any further he would have had to lie flat (M.S.H.K., 1884, pt. 1, p. 9 and *Mitt. geogr. Gesells*, Wien, 1889, p. 80, *Das Popovo-Polje*) and he did not know if it went any further (to the west). But he was told that it led to a great underground lake (Jezero), no doubt a repeat of the Foiba di Pisino. He even added that a young man several years before had come out at Gabele polje (see later), the usual legend and the usual exaggeration. This main sink usually ceases to function between June and September, the upstream sinks being then sufficient to absorb all the water. Not far from there, near the Zavala monastery, Von Groller followed the easy cave of Vretrnica, between 3 m and 50 m high, for 3 hours without coming to the end.
96. The [water] temperature of 13.5° (on 14 October 1893, with the sea at 18° and the air at 21°) is 3.3° lower than the mean annual temperature at Dubrovnik (16.8° according to Ballif) and in no way disagrees with the 3rd hypothesis.
97. This water, coming from so high, is still very cold: 10.5°C at *Fiumara* and 9.5° at *Gordicchio*; littoral springs whose water mixes immediately with that of the sea (16° on 9 October 1893) in the very channels beneath the north and south gates of the city of Kotor. The mean annual temperature of the gulf must reach at least 17°, for the *Bocche* are south of Dubrovnik and some of their towns and villages know no winter. But the springs are colder than 6.5° to 7.5°.

    Thus the temperature of all the springs I have studied in Bosnia, Herzegovina, Dalmatia and beyond are at least 1° and often more below the mean annual temperature of the places where they occur. Lorenz has already drawn attention to this anomaly in the Kvarner gulf: springs at 7.5° to 9° C with a mean average temperature between 14° and 15.25°: 14° at Trieste, 8.5° at Postojna (altitude 545 m according to Seidl, *Ueber das Klima des Karstes* in *Mittheil des Museal Verlines Laibach*, 1890). It seems general throughout the region and is explained by the origin of the spring water which is the reappearance of water sinking or absorbed into the ground often 1000 m high on the mountains or cold plateaux. From these facts it results that the meteorological law according to which the mean temperature of a region is that of its springs is not universal.

    This conclusion, thus confirmed, should be noted by meteorologists.

    Lorenz has also demonstrated (*Petermann's Mittheilungen*, December 1859, p. 510) that the Vrana lake on the island of Cherso, without any supply of surface water, is fed underground by the issue of a colossal underground sump supplied by rainwater on the high mountains of Istria or Dalmatia. Springs on the island have a temperature between 12.5° and 13.75°C, while the lake water (12 m above sea level) measures 9.4° at the surface and 7.4° at the depth of 60 m (see Lorenz *Physikalische Verhältnisse in Quarnero*, Wien 1863, based on Gerold, *Programme des Obergymnasium in Fiume*, Zagreb, 1860, p. 6; also *Die Quellen des Riburnischen Karstes*, Mitth. geog. Gesellsch, Wien,1859, p. 103, and *Verhandlungen der geolog. Reichsanstalt*, 1866, p. 66).

    In this connection we must not forget that the Karst also has natural ice-pits and holes where snow persists throughout the year (Marzla jama near Reifnitz [Ribnica], the Friedrichstein cave near Gottschee [Kočevje], ice shafts on the Ternovan forest [Trnoski gost], Paradana [ice caves] etc., the subject of a thorough investigation that we do not wish to go into here (see p. 396. Tietze, *Memoire sur la Croatie*, 1873, p. 55; W. Urbas, *Oro-hydrographie von Krain*; Moser, *Chronik Section Küstenland*, 1873–1892, p. 248, etc.).

    To avoid repeats, all too common in this book, we refer to our chapter on meteorology and the discussion about the temperatures recorded in the caves of the Karst by Schmidl, Morpurgo, Müller, ourselves, etc.
98. I do not wish you to believe that the Montenegrins are in any way lacking in boldness. They are a brave race and have no fear. Their feelings are most commendable: not used to this kind of expedition and faced with a passage that was really difficult and unknown, they feared that some accident had occurred to me, for which they would be held responsible. They simply wished to hinder, by their inaction, an enterprise which in their experience they considered dangerous. That, I am sure, was the motive for their refusal.

99. On this subject it is perhaps useful to provide here some information which I realized too late myself. In Montenegro, land of wars of independence, the men, fierce fighters, never carry anything other than their arms, always ready to defend their country. Manual work and carrying things falls to the women. One can imagine that this traditional custom made it difficult to recruit assistance for my work and especially in unexplored caves.
100. *Le Dictionaire de Géographie* of Vivien de Saint-Martin gives a general bibliography for Montenegro up to 1885. I ought to add the recent work (in Russian) of Professor Rovinsky УЕРНОГОРІЯ (Cerna-Gora, le Montenégro) of which volume 1 appeared at Saint Petersburg in 1888 (880 pp.), with a new map in 1889 (1=294 000, also in Russian). See also Tietze, *Geologie von Montengro*, Jahbuch der Geol. Reichsanst., 1884. For bibliography of Dalmatia, etc., see Hartleben *Illustrirter Führer durch Dalmatien*, etc., Wien, 1892, 2nd ed., p. 25, Joanne, *État de Danube*, vol. 1, introduction.
101. See Reclus, *Géographie*, vol. 1, p. 179
102. Carapanos, *Dodone et ses ruines*, with Atlas, Paris, Hachette, 1878.
103. Additional Bibliography.
Stache (G.), *Die Eocän Gebiete in Inner Krain und Istrien.* Jahrb. der Geolog. Reichsanstalt, 1864, p. 21, Wien, - Stache (Guido). *Geologisches Landschaftsbild des istrichen Karstlandes,* Œsterreichische Revue, V11 – V1, 1864. – Vierthaler (Prof. O.), *Ueber die Höhlen des Territoriums von Triest,* Bollettino della Soc. Adriatica di scienze naturale, Trieste, 1883–1884. – Marenzi, Der Karst, ein geologisches Fragment, Trieste,1864. – Bayer (A.), Tietze, Pilar, *Die Wassernoth in die Carlstadter Militär-Grenze,* Agram, 1874, Albrecht+Fiedler, - Taramelli, *Descrizione geologica del Carso.* - Kraus, *Der Karst, in Œsterreich in Wort und Bild.* – Moser, *Der Karst, Jahresbericht des k. k. Gymnasiums*, Trieste, 1890. – Neumayer, *Erdgeschichte*, 1, p. 453–461. – Reyer, *Studien ueber das Karst-relief*, Mittheil, k. k. geogr. Gesellschaft, Vienne, 1881, p. 4, 76+ 101. – Stache, *Die liburnische Stufe und deren Grenzhorisonte*. Abhandl. der geol. Reichsanst., v XIII, 1, 1889. – Kner. *Kleine Beiträge zur geolog. Verhältnisse Istrien*, Jahrbuch geolog. Reichsanst., 1853, p. 224 – Zittel, *Die Morlakei,* Œsterr. Revue, 1864, v II. – Farkas. *Das Lika und Krbava Thal*., Sitz. Ber. Akad. der Wiss., cl. sc. math. natur., v. XXV 2e part 1857, p. 522–540. – *Reiserouten in Bosnien und Herzegovina* (guide), Vienne, Hartleben, 1892. – Schwarz (B.). *Montenegro*, Leipzig, 1888. – Hassert, *Landschaftsformen von Montenegro*. Peterm. Mittheil., Feb. 1894, p. 34 (+ bibliography). – Hassert, *Der Durmitor*, Zeitsch. Club. alp. all.-autr., 1892, p. 124–170. – Hassert. *Reise durch Montenegro*, 235 p + 30 grav., Wien, Hartleben, 1893. – *Neue spezial. Karte von Montenegro*, 1:75,000°, in 19 parts K.K. *mil. geogr. Institut,* Wien, Lechner, 1893 + *General Karte von Bosnien und Hercegovina* 600,000°, Vienne, *K.K. mil. geogr Institut,* 1893 (see also, chap. XXIX)
104. "Water is not alone in underground channels, air also circulates in the system of fissures. Flowing continuously on damp walls, it causes rapid evaporation and humidity, consequently cooling the surface of the rock and the water itself. (E. Reclus, *la Terre* vol. 1, p. 325). I have positively verified the influence of evaporation on trickles in Tabourel, Dargilan, Črna jama and in shafts with 2 openings and hence strong air currents (Rabanel, Biau, Fosse-Mobile, etc.).
Here are the precautions to take when measuring temperature in caves: do not place the thermometer near any source of heat (light, human body, tobacco smoke, etc.), leave it in place for long enough (at least 3 or 4 minutes in water and 10 in air) to bring it into equilibrium with the ambient air, do not take readings in chambers and passages that have already been warmed by the presence of several people or many visitors, prolonged lighting, etc.
105. At Škocjan in the Karst in the winter of 1889–90, the Reka was at 0°. Marinitsch saw ice stalactites as far in as the 17th cascade (1000 m from the 3rd sink); in summer the Reka reaches 27°.
At Trebiciano the air temperature (11° to 16°) and that of the water (5° to 13°) varies with the seasons (according to Morpurgo). On 26 October 1884, air at a depth of 259 m was 14°; air at the bottom 12.9°, water 11.2° (Müller). On 17 March 1886, water 7.25°; 26 May 1886 water 12.8° etc., etc., etc. Here are the curious readings made in *Črna jama* by Schmidl and Rudolf in 1850 and by me in 1893: 16 September 1850, outside air 13.9°, inside air 7°, inside water (dormant) 7.4°; 27 September 1893, outside air 12.8°, inside air 11° (in the eastern branch, rewarmed by the flowing water at 12.3°),6° and 6.8° in the closed southern branch); pools of dripping water 4.8° (southern branch), 8.6° and 8° (western branch connected with the flowing water on that day). It showed that the arrival of running water from the open air rewarmed the cave air. The low temperature is due to the shape of the entrance which makes the cold air sink and results in currents of air.
Postojnska jama gave these results to the same observers.

	27 Aug. 1852	middle air	8.9°	pools of drop water	8.5°
Pisani rov	22 Sept. 1893	"	8.0°	" " "	7.0°
		entrance	8.5°	" " "	8.2°
	30 Aug. 1852	St. Etienne	9.75°	" " "	8.5°
other parts	various 1850–52		8.9° to 10.25°		
	22 Sept. 1893	Kongresna dvorana	9°	Lepe jame air, water	8.5°

This is confirmation of all we have said above; some notable exceptions, with a mean for each place (8.5° at Postojna according to Seidl *Klima des Karstes, Mitt. Museal vereins*, Ljubljama 1890): - changes and variations of a year or of a point concerning air or water, dripping water colder than the air; - on the contrary, the Pivka (in summer at least) is warmer than the air in the passages where it penetrates, and these are cooler than the upper passages because he flow makes the cause of the warming permanent:

		m from entrance	air	running water	outside air
Pivka passages	11 Sept. 1850	400	12.9°	13.9°	13.9°
	9 Sept. 1850	600	13.1°	14°	
	16 Sept. 1893	2000	14°	16°	
	27 Sept. 1893	Črna jama	11°	12.3°	12.8°
	27 Sept. 1893	Pivka jama	10.6°	12.2°	

(p.565) In August and September 1850, Schmidl and Rudolf had both seen the flowing water (Pivka), warmer (13.1° to 14.25°) than the air (12° to 12.9°) in the west branch of Planinska jama. At the same time they found it, on the contrary, colder (9° to 9.75°) than the air (10.75° to 11°) in the south-east (Cerknica) branch. In the combined river on 27 August 1850, the air was at 12.5° and the water 13.25°. On 18 September 1893 I found the air to be 12° and the water 11.2°. It is hardly possible at present to present a satisfactory explanation of all these variations; it is sufficient to say that they are an indication of the influences of the outside temperature: Planinska jama is, besides, very largely open, very big and [outside] air can penetrate easily.

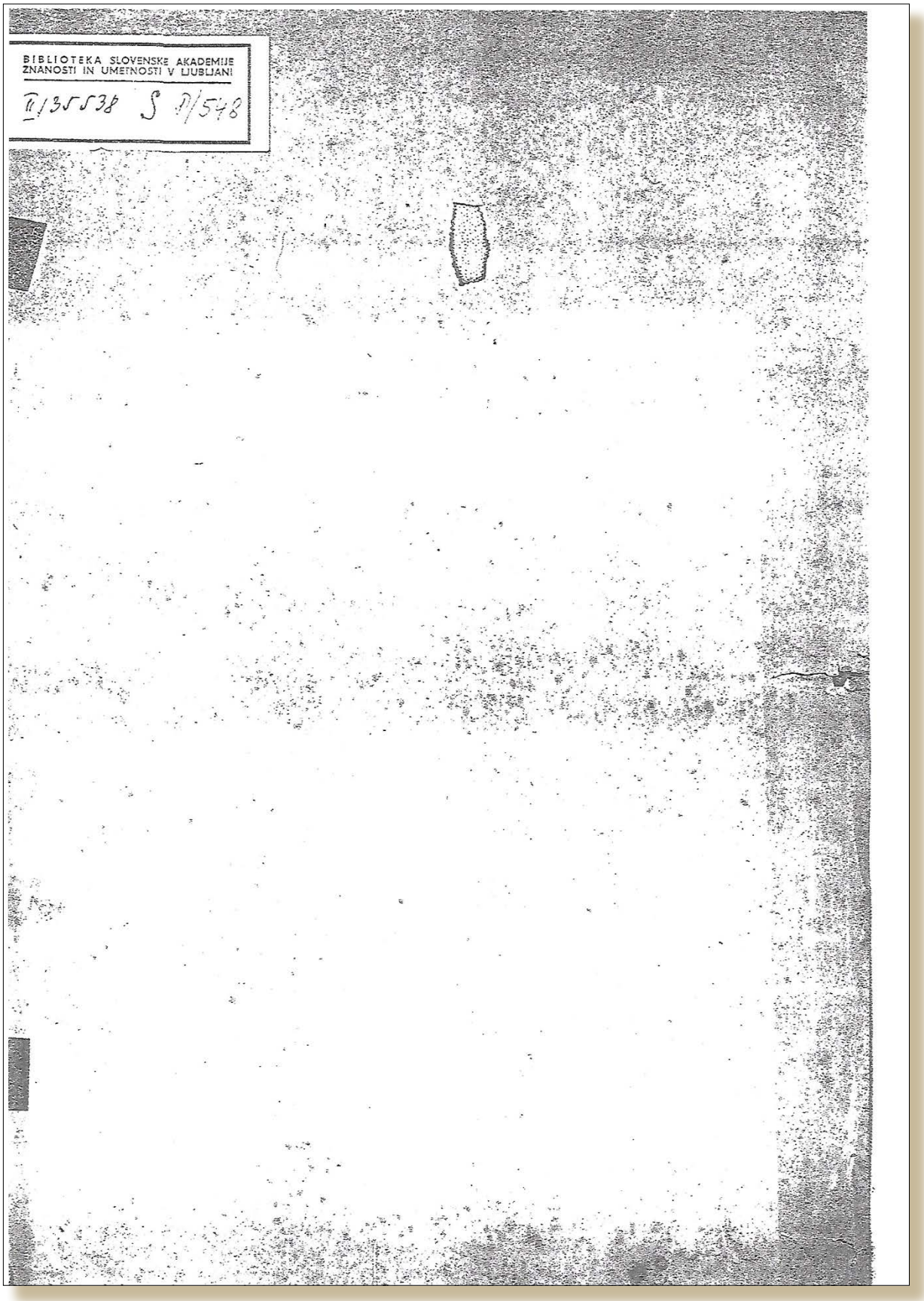
(p.565, notes 1–4)

106. The cave of Monsumano, near Pistoja Toscane, receives from fissures hot vapours which raise its temperature to 32.5° or 35° C. It is used to treat certain diseases (Fruwirth, *Uber Höhlen*, 1883. Daubrée, *Eaux Souterraines,* vol. 1, p. 358).
In Monteils's study north-west of Montpellier, a big natural shaft was discovered with almost vertical walls of inclined limestone. On 16 May 1837 the following temperatures were recorded outside air 14° C, at 15 m down 18°; at the bottom (50 m) 22.5°. In July and August 1838, 22.5° for the rock and 21.6° for the reddish mud". De Serres believed that thermal waters from below caused the warming. 400 m away from that shaft, according to Astier, there was a limestone fissure from which came vapour at 18° C (*C.R.Ac.5c*). 29 May 1837 and *Essai sur les cavernes à ossements,* 3rd edn. p. 22). See pp. 162 and 163.
107. Barometric observation over 24 hours on 14 August 1852 showed Schmidl that the extent of the variation was a little greater in Postojnska jama where the air temperature was between 7° and 5°.
108. [Studies] on falling bodies done by Humboldt at Icononzo (see p. 542) and by Caillotet in 1892, from the 2nd level of the Eiffel tower should be repeated, protected from all external influences, in the shafts of Rabanel, Trouechiols and Jean-Nouveau (130m – 160 m). The same for gravity.
"Theory indicates that the force of gravity is less strong at the bottom of a mine than at the surface of the earth. The English astronomer Airy (d. 2 January 1892 at the age of 90) undertook to measure the difference. He found a difference of 2'25" in total duration of an equal number of pendulum oscillations recorded on the surface over 24 hours. This good work deserves to be repeated in France".
(Annual public meeting of the Académie des Sciences of 19 December 1892. Statement by d'Abbadie). Commandant Deforges came to prove that the power of gravity was less in a mountain region and more by the sea (*C.R.Ac.Sc.* 24 July and 4 September 1893 and 29 January 1894).
109. See *Nature* (part 2, 1892) no. 1005 and 1017, summary of the experiments of Lenard, Elster and Geitel on the production of electricity from the underground waterfalls of the Reka, etc. The 6th waterfall in Bramabiau (see p. 193) is very suitable for research of this kind.

ILLUSTRATIONS

APPENDIX

Martel letter 9 November 1893
facsimile
translation
Martel report with the above
facsimile
translation
Martel letter 26 January 1894
facsimile
German text
English translation
bibliography of Martel's other publications on the region



"undated but after 9 Nov. 1893" according to La Plume et les Gouffres" but think it was enclosed with the letter of that date.

XII/6168

Paris, le 9 Novembre 1893

Copie

Monsieur le Ministre,

Par votre arrêté en date du 16 Août 1893 vous avez bien voulu me confier une mission scientifique à l'effet d'étudier les grottes et rivières souterraines du Karst (Carniole, Istrie, Dalmatie, Bosnie, Herzégovine et Monténégro) pour les comparer à celles de la France.

En vous remerciant à nouveau de votre extrême bienveillance, j'ai l'honneur de vous adresser, Monsieur le Ministre, un résumé sommaire et provisoire du voyage de recherches que j'ai effectué dans ces pays du huit Septembre au vingt-quatre Octobre 1893.

Revenu depuis quinze jours seulement, mes occupations professionnelles m'ont empêché et m'empêcheront pendant quelque temps encore de mettre en œuvre les notes et observations que j'ai rapportées et les coupes et plans que j'ai dressés. Je vous demanderai donc la permission de vous soumettre ultérieurement un rapport plus détaillé, avec figures à l'appui. Ce sera sans doute sous la forme d'un chapitre inédit de l'ouvrage général que je prépare en ce moment (Les Abîmes) sur la spéléologie.

Mais, si je n'ai pas voulu tarder à vous rendre très brièvement compte des principaux résultats que j'ai obtenus, c'est surtout pour attirer très particulièrement votre indulgente attention sur l'accueil extrêmement flatteur et sympathique que j'ai trouvé en Autriche.

Comme j'ai eu l'honneur de vous en informer au mois d'Août dernier, son Excellence le comte Falkenhayn, alors ministre de l'Agriculture à Vienne, avait mis à ma disposition M. Wilhelm Pulick, inspecteur adjoint des forêts à Villach (Carinthie); ce dernier était, par ordre supérieur, chargé de me conduire dans les principales et les plus intéressantes des cavernes qu'il avait découvertes et explorées de 1886 à 1888 au cours des études et travaux d'assèchement entrepris à cette époque en Carniole par le gouvernement autrichien; des aménagements spéciaux avaient même été effectués, par ordre également et avant mon arrivée, pour me faciliter l'accès des cavités

où Mr. Putick seul avait pénétré ; Mr le conseiller aulique avait été délégué par le ministre pour m'accueillir à Adelsberg et me présenter à Mr. Putick ; — son Excellence le comte Falkenhayn m'avait remis des lettres de recommandation manuscrites pour les autorités civiles et militaires de toute la région ; — enfin deux sociétés privées, vouées à l'étude des grottes du Karst, l'Anthron Verein (d'Adelsberg) et la section Kustenland du Club Alpin-allemand-autrichien (de Trieste) m'ont encore, avec la meilleure grâce, rendu possible la visite de plusieurs excavations impraticables pour le public.

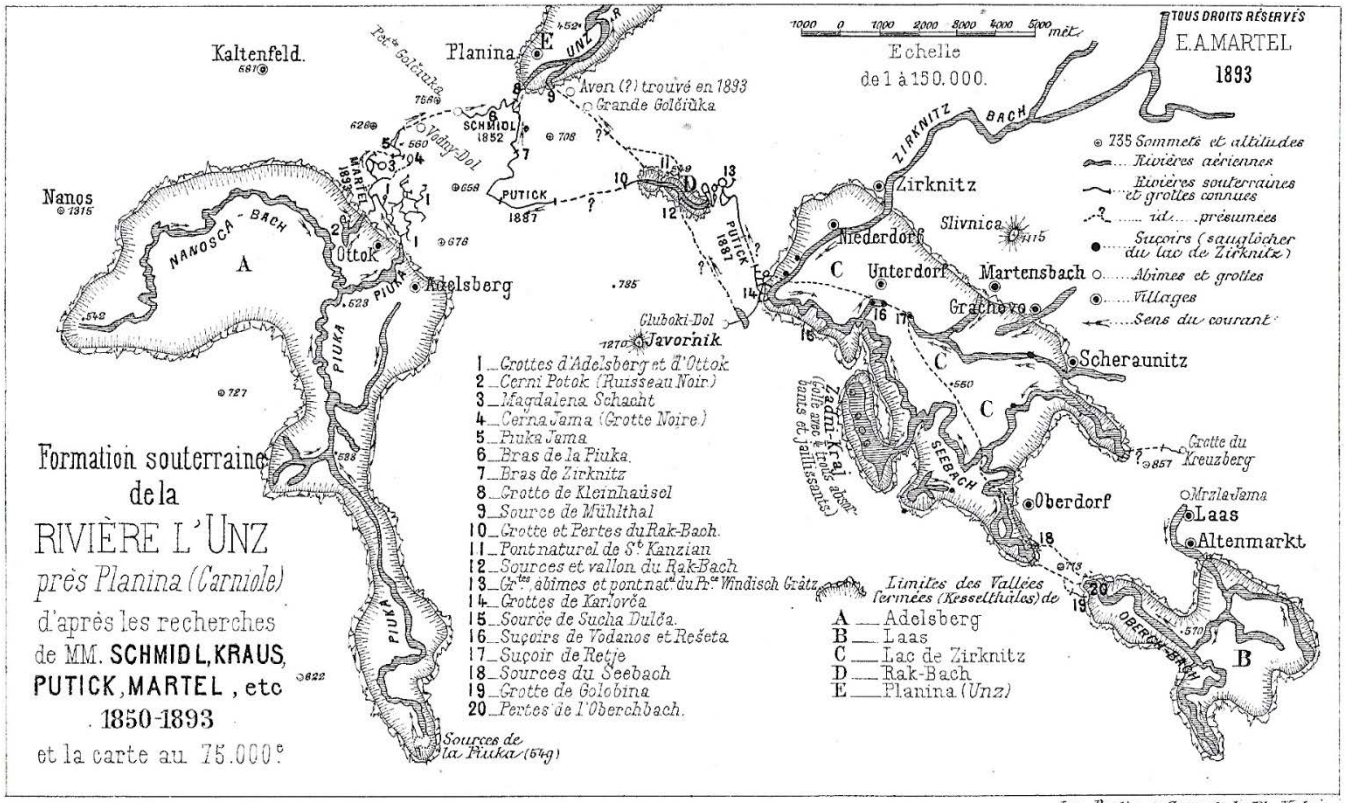
Si j'insiste sur les attentions dont je me suis ainsi trouvé l'objet c'est qu'elles étaient particulièrement agréables en pays de langue allemande. Ce n'est d'ailleurs pas la première fois que j'ai l'occasion de constater la sympathie des Autrichiens à l'égard des voyageurs français.

Mr l'Ingénieur Putick mériterait surtout d'être remercié d'une façon toute spéciale pour la cordialité, le désintéressement et le dévouement avec lesquels il m'a mis à même de connaître ses beaux travaux, de refaire ses difficiles explorations et de réunir les matériaux nécessaires à la vulgarisation en France des phénomènes et des curiosités du Karst souterrain.

Je ne fais donc, Monsieur le Ministre, que remplir un devoir de reconnaissance en vous faisant part, sans délai, de l'impression si agréable que j'ai rapportée ainsi de l'étranger.

Daignez agréer, Monsieur le Ministre,
l'assurance de mes sentiments les plus respectueux et reconnaissants.

E. A. Martel


Formation souterraine de la RIVIÈRE L'UNZ près Planina (Carniole) d'après les recherches de MM. SCHMIDL, KRAUS, PUTICK, MARTEL, etc 1850-1893 et la carte au 75.000e
Kaltenfeld.
Planina
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Javornik
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TOUS DROITS RÉSERVÉS
E.A.MARTEL
1893
1 Grottes d'Adelsberg et d'Ottok
2 Cerni Potok (Ruisseau Noir)
3 Magdalena Schacht
4 Cerna Jama (Grotte Noire)
5 Piuka Jama
6 Bras de la Piuka.
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20 Pertes de l'Oberchbach.
Limites des Vallées fermées (Kesselthäler) de
A Adelsberg
B Laas
C Lac de Zirknitz
D Rak-Bach
E Planina (Unz)
735 Sommets et altitudes
Rivières aériennes
Rivières souterraines et grottes connues
id présumées
Suçoirs (saugslöcher du lac de Zirknitz)
Abimes et grottes
Villages
Sens du courant
Imp. Bastien & Georget, 4, Pl. Valois

Paris 9 November 1893

[to] The Minister of Education

By your decree of 16 August 1893 you entrusted me with a scientific mission to study the caves and underground rivers of the Karst (Carniola, Istria, Dalmatia, Bosnia, Herzegovina and Montenegro) to compare them with those of France.

In thanking you once again for your kindness, I have the honour to provide you with a short provisional report on the research journey that I made in these countries from 8 September to 24 October. 1893.

That being only 15 days ago, my professional work has not allowed me enough time to make use of all the notes and observations that I recorded and the plans and sections that I made. I shall therefore ask your permission to submit a later more detailed report with illustrations to support it. This will no doubt form a chapter in the general book on speleology (*Les Abîmes*) that I am now preparing.

But I do not wish to delay providing you with a very brief account of the main results I have obtained, and above all to draw your attention most particularly to the extremely pleasant and sympathetic welcome that I received in Austria.

As I had the honour of telling you last August, his Excellency Count Falkenhayn, then Minister of Agriculture in Wien, made available to me Mr. Wilhelm Putick, joint Inspector of Forests at Villach (in Carinthia). He was instructed to take me to the principal and most interesting caves that he had discovered and explored between 1886 and 1888 in the course of his work for the Austrian government on flood control in Carniola. Special arrangements had been made before my arrival to provide me with easy access to caves that only Mr. Putick had reached before. The councillor himself had been instructed by the Minister to welcome me at Adelsberg [Postojna] and to introduce me to Mr. Putick. His Excellency Count Falkenhayn had given me letters of recommendation to the civil and military authorities of the whole region. Finally, two private societies devoted to the study of Karst and caves, the Anthron Verein (of Adelsberg) and the Section Küstenland of the Deutsche und Österreichische Alpenverein (of Trieste), with the greatest courtesy enabled me to visit many caves that were inaccessible to the public.

I emphasize the care that was taken to enable me to achieve by objective because it was specially appreciated in a country where German was the usual language. This is not the first time that I have been able to remark on the congeniality of the Austrians with French visitors.

Engineer Putick merits special thanks for the friendship and care with which I was given information, for arranging the difficult explorations and for providing the material necessary to make knowledge of underground Karst phenomena available to the French.

Consequently, Minister, I am only fulfilling my duty in telling you without delay, the most agreeable impression that I, as a foreign visitor, carry away.

Please accept, Minister, my most respectful and grateful feelings.

E. A. Martel

A Monsieur
le Ministre
l'Instruction publique

Rapport sommaire
sur mes recherches
dans les Cavernes du Karst &c.
Septembre Octobre 1893.

J'avais choisi pour mon étude le mois de Septembre afin d'examiner, si cela était possible, les grottes des environs d'Adelsberg (Carniole) avant et après les pluies de l'Equinoxe, c'est-à-dire dans les deux états de sécheresse et de crues intérieures.

En effet, la principale rivière souterraine du Karst l'Unz, qui inonde trop souvent la vallée de Planina est, comme on le sait depuis les belles explorations du Docteur A. Schmidl en 1852, formée de deux cours d'eau qui, par une disposition singulière, se réunissent sous terre même, dans l'immense grotte de Kleinhäusel (6 Kilomètres de ramifications connues). Schmidl avait prétendu que ces deux courants provenaient de la région d'Adelsberg (bras de Kaltenfeld et bras d'Adelsberg) M.r l'Ingénieur Lutick, au contraire, avait cru reconnaître en 1887 que le bras du Nord seul arrivait d'Adelsberg, et que le bras du Sud, où il s'était avancé un Kilomètre plus loin que Schmidl, était l'un des émissaires du célèbre lac intermittent de Zirknitz.

Les circonstances météorologiques m'ont admirablement servi et permis de résoudre cette question en donnant raison à M. Lutick.

Le 17 Septembre 1893, le lac de Zirknitz et ses émissaires étaient à sec, et un orage éclatait le soir sur Adelsberg, gonflant la rivière de la Pinka, qui traverse la grotte d'Adelsberg, pour ressortir, d'après M. Putick, par le bras nord de la grotte de Kleinkaïssel.

Le 18 Septembre, nous procédâmes, M. Putick et moi, à une nouvelle investigation de cette dernière grotte, à l'aide d'un solide bateau en bois construit exprès par ordre du Ministère de l'Agriculture d'Autriche et constatâmes que l'eau dans la branche Nord montait à vue d'œil tandis que la branche Sud était complètement à sec ce qui ne s'était jamais vu.

Cela démontre péremptoirement que l'appréciation de M. Putick est fondée, que la Pinka et l'un des émissaires du lac de Zirknitz ont leur confluent sous terre et que l'opinion de Schmidl (reproduite dans la géographie de Reclus) n'était pas conforme à la réalité.

Tel est le premier résultat de mes recherches avec M. Putick (V. la carte ci-contre)

Un second a été la découverte du prolongement pendant quinze cent mètres (2 Kilomètres avec les ramifications latérales) du cours souterrain de la Pinka dans la grotte d'Adelsberg, et l'établissement de la communication entre cette grotte et deux abîmes (Magdalena Schacht et Cerna-Jama) situés à un Kilomètre au Nord (V. la carte ci-contre) La grotte d'Adelsberg, où les recherches ont commencé en 1818 et ne sont certainement pas finies est donc maintenant la plus longue d'Europe (dix Kilomètres d'étendue totale d'un seul tenant; Aggtelek en Hongrie 8700 mèt.)

Je n'ai pu effectuer ce parcours difficile, qui a demandé trois jours de travail, que grâce au concours dévoué de MM. Putick F. Kraus, Kraigher, Dietrich, Schäber &c et à l'emploi de mes téléphones et bateaux

démontables en toile; les grottistes autrichiens ont pu apprécier alors les avantages de ces deux instruments et s'en serviront désormais pour continuer leurs explorations.

Car la survenance des pluies faisant gonfler la Pinka a élevé son niveau de plus d'un mètre, accru la force de son courant et rendu impossible pour moi toute navigation souterraine subséquente. Mais mon but était atteint; d'une part, j'avais démontré que, malgré 75 ans de recherches, la grotte d'Adelsberg n'a pas encore livré tous ses secrets; d'autre part, les différences de niveau et de courants que j'ai pu observer dans les cavités voisines, indirectement reliées avec elle m'ont clairement fait comprendre le mode de circulation de ces eaux souterraines.

J'expliquerai en détail dans un prochain ouvrage "Les Abîmes" comment ce mode est exactement le même que dans les plateaux calcaires de la France: les fissures primitives du sol ont été élargies en grottes par les eaux intérieures, les avens (puits naturels, qui drainent les pluies superficielles ont fait office d'affluents, et les rétrécissements et dépressions des cavernes ont formé de place en place des siphons qui retardent l'écoulement des rivières souterraines et constituent les réservoirs des sources; enfin, il y a cette différence que dans le Kurst les terrains de craie étant plus tendres que les calcaires jurassiques et les rivières étant plus puissantes, les effondrements de routes, (dolines) ont été beaucoup plus fréquents et ont obstrué la plupart des cavités naturelles.

Comme en France (Vaucluse & Jura) connaissance approfondie du cours des rivières souterraines est importante au point de vue de la régularisation du débit des sources.

Parmi les trente autres grottes, sources et abîmes que j'ai explorés ou étudiés je ne citerai pour

le moment que ce qui suit :

La Foibe de Pisino en Istrie est un précipice de 130 mètres de profondeur, ouvert d'un seul côté, par où s'absorbe un ruisseau fort capricieux. On voit parfois l'eau s'élever de 140 mètres en 24 heures dans cet entonnoir qui met alors trois jours à se vider. J'ai eu l'explication de ce fait en pénétrant, ce qu'on n'avait jamais fait jusqu'alors, au fond de la grotte qui s'ouvre dans le bas du gouffre ; c'est une perte en gouffre comme celles de l'Ardèche et des Causses, longue de 200 mètres seulement, et terminée par un lac ; ce lac, fermé de toutes parts, mesure 80 mètres de longueur sur 30 de largeur seulement, mais sa profondeur en temps de sécheresse atteint 13m.50 ; il y a là une tête de siphon dont l'autre extrémité libre est inconnue.

En Bosnie, Herzégovine & Dalmatie, l'abondance des eaux m'a empêché d'entrer dans l'intérieur des magnifiques sources que j'ai étudiées (Bosna, Comadina Buna, Ombla, Bieno, Ljuta, Finmara, Gordicchio &c.) ; d'ailleurs la plupart sont des sources de fond comme le Loiret en France et si quelques unes sortent de cavernes à ouverture libre aux basses eaux, il faudrait pour les explorer des ressources dont je ne disposais pas ; car les indigènes auxquels ces recherches ne sont pas familières ne consentiraient pas à s'avancer loin sous la terre et il serait nécessaire d'amener là, à grands frais, des ouvriers grottistes expérimentés soit de France soit d'Adelsberg.

J'ai néanmoins pu constater trois choses : les sources sont ici, comme dans les calcaires et la craie de France, de Grèce et du Karst Autrichien, la disparition des pluies absorbées dans les fentes des montagnes superposées et des rivières engouffrées dans les cavernes des plateaux supérieurs (Listika, Zabonska, Ljubinje, Trebinjica, Ljuta &c.) et la loi générale de l'utilisation des fissures du sol par les eaux qui circulent sous terre s'est trouvée partout vérifiée à

nouveau.

2° Entre Raguse et Cattaro, la Ljuta qui arrose la vallée de Canale se perd dans un gouffre vertical en deux cascades de 5 mètres de hauteur ; l'eau, occupant toute la section du puits, rend l'accès de celui-ci impossible ; mais cette chûte démontre péremptoirement que les puits naturels (avens de la France) ont parfaitement pu être formés par l'érosion superficielle d'une masse d'eau absorbée, ce que mes explorations dans les Causses depuis 1888 n'ont cessé d'établir.-
La Ljuta reparaît à 13 Kilomètres au N.O dans le golfe de Breno, sous forme de source impénétrable

3° La température de beaucoup de sources littorales de la Dalmatie est inférieure de plusieurs degrés à la moyenne température annuelle du lieu où elles sourdent. M.r Lorenz avait déjà signalé cette anomalie dans le golfe de Quarnero... Elle paraît générale dans la région et elle s'explique par l'origine de ces sources qui font reparaître des eaux engouffrées ou infiltrées souvent à plus de 1000 mètres plus haut sur des montagnes ou des plateaux froids. Il résulte de ces faits que la Loi météorologique, d'après laquelle on déduit la température moyenne d'une localité de celle de ses sources, n'est pas universelle.

En Montenegro enfin, j'ai pu grâce à l'obligeance de M. le Comte de Sercey attaché d'ambassade, de M. le Chargé d'affaires de Russie et de M.r le Professeur Rovinsky, constater que là aussi, l'absorption des eaux météoriques s'effectue par les fissures du sol et que toute une série d'excavations & rivières souterraines mériterait d'être explorée à fond.

A la grotte source de la Rjeka, qui est un véritable Vaucluse pénétrable, j'ai même découvert le cours navigable du ruisseau qui draine toutes les pluies de Cettinje. Mais il m'a été impossible de décider les indigènes que j'avais emmenés à me suivre et même à porter mon bateau démontable jusqu'au bassin d'eau ainsi trouvé et infranchissable à pied.

J'ai donc dû renoncer en Herzégovine à une exploration complète ; on ne pourra l'effectuer qu'avec de grands sacrifices de temps & d'argent.

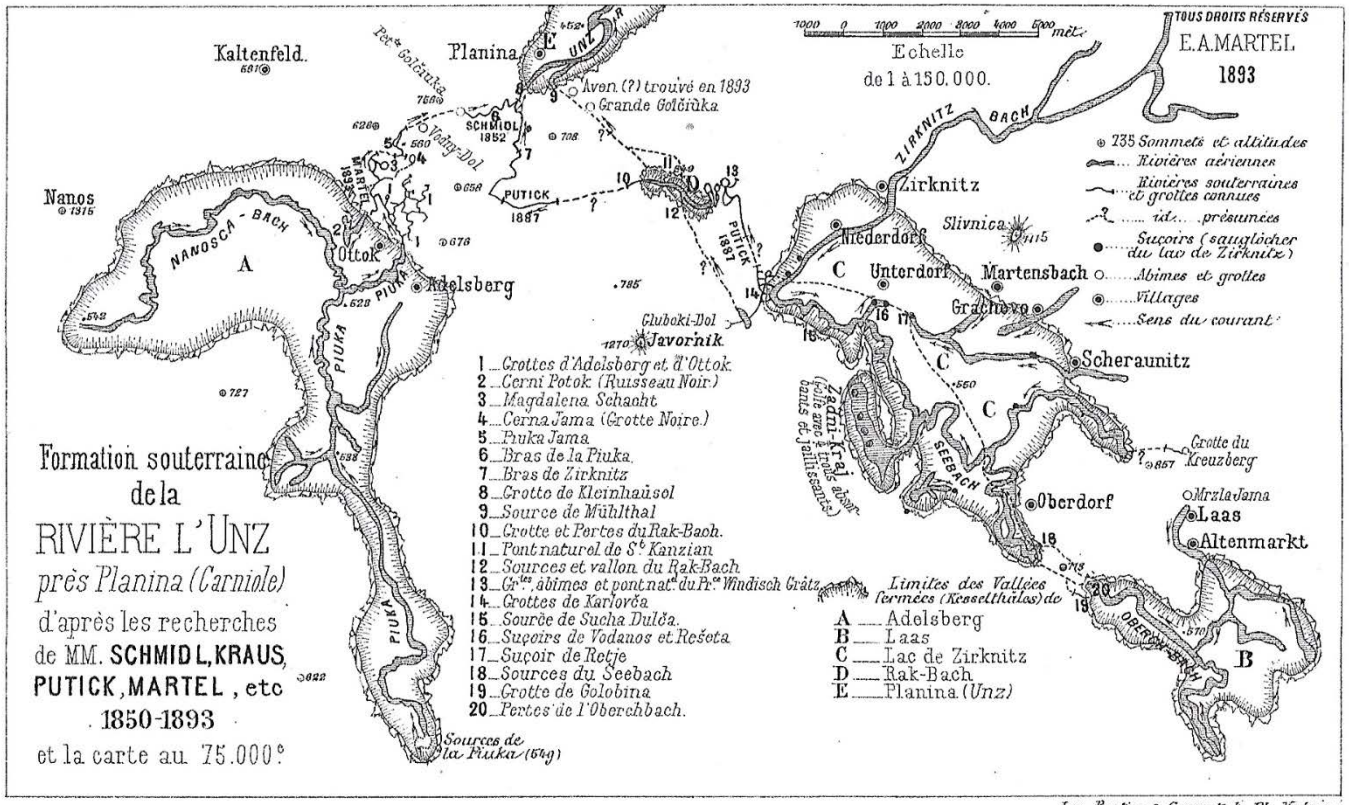
En résumé, les phénomènes hydrologiques souterrains du Karst et de toute la partie occidentale de la Péninsule des Balkans, sont les mêmes que dans les régions calcaires de France de Belgique, de Grèce et probablement de toutes les formations géologiques analogues.

Bien que les Autrichiens s'occupent depuis plus de 50 ans d'étudier le sous sol de l'Istrie et de la Carniole, ils sont encore loin d'avoir terminé ce genre d'investigations ; en se servant des deux instruments dont j'ai inauguré l'emploi en France les bateaux démontables et le téléphone on ouvrira partout pour la géographie souterraine, pour la spéléologie, une ère nouvelle.

Les explorations que M^rs Sidéridès a effectuées en 1892 dans les Katavothres du Péloponèse, à ma suite et d'après mes indications, l'ont déjà prouvé.

Et les buts pratiques de cette branche de la science sont multiples : ici on découvrira pour l'alimentation et l'Agriculture des réserves cachées ; là on régularisera des rivières souterraines pour éviter à la fois les sécheresses et les inondations ; ailleurs, on réussira à dessécher des marais et à supprimer des fièvres ; enfin dans tous les terrains calcaires, si abondants à la surface du globe, on se rendra de mieux en mieux maître d'une des plus puissantes forces de la nature, l'eau ; force, qui, livrée à elle même, est trop souvent dévastatrice (soit par manque soit par pléthore) et qui, bien connue et bien mise en œuvre, est l'un des principaux éléments de la santé et de la richesse humaines.

E. A. Martel.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Laas
Altenmarkt
Mrzla Jama
Grotte du Kreuzberg
Sources de la Piuka (Unz)
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2 Cerni Potok (Ruisseau Noir.)
3 Magdalena Schacht
4 Cerna Jama (Grotte Noire.)
5 Piuka Jama
6 Bras de la Piuka.
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11 Pont naturel de St Kanzian
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TOUS DROITS RÉSERVÉS
E.A.MARTEL
1893
Sommets et altitudes
Rivières aériennes
Rivières souterraines et grottes connues
id. présumées
Suçoirs (sauglöcher du lac de Zirknitz)
Abîmes et grottes
Villages
Sens du courant
Imp. Bastien & Georget, 4, Pl. Valois.

[p.1]

To the Minister of Education

Short Report on my Researches on the Caves of the Karst, etc.
September October 1893

I chose the month of September for my study so as to examine in Carniola before and after the autumn rains; that is to say when their interiors are both dry and flooded.

The river Unica which too often floods Planinsko polje is, as we know from Dr A.Schmidl's explorations in 1852, fed by two streams which, by a curious arrangement, are reunited underground in the immense cave of Planinksa jama, with 6 km of passages known. Schmidl claimed that these two come from the Postojna district (the Kaltenfeld [Studeno]) branch and the Postojna branch respectively.*

[* translators' note]

Schmidl did indeed identify the branches thus. In plate 10 of the atlas volume of his 1854 book *Die Grotten und Höhlen von Adelsberg, Lueg, Planina und Laas*, he names the eastern branch "Die unterirdische Lauf der Poik [Pivka]" and the other "Kaltenfelder [Studeno] Arm". Having mistakenly assumed that the eastern branch received the Pivka water from Postojna (via Kolišuka), rather than the water from Cerknisko jezero and Rakov Škocjan, he had no alternative but to name the other branch after some place to the west. Studeno is an ancient village in that direction (with only a tiny stream) but it gives its name also to the unpopulated land near it, as it does in the Martel plan on p. 456 of his *Les Abîmes* of 1894. Perhaps he had in mind the water sinking at Predjama, a little further west.

Putick, on the other hand, recognized in 1887 that it was the northern [i.e. western] branch alone that came from Postojna and that the southern [i.e. eastern] branch, where he had gone one km further than Schmidl, was one of the outlets of the famous intermittent lake of Cerknica.

The weather aided me and allowed me to resolve those questions in favour of Putick.

[p.2] On 17 September 1893 the Cerknica lake and its outlets were dry. That evening a thunder-storm burst over Postojna, causing the Pivka river in Postojnska jamato rise and to reappear, just as Putick had said, in the northern branch of Planinska jama.

On 18 September Putick and I made a new observation in Planinska jama, using a good wooden boat made by order of the Austrian Ministry of Agriculture. We verified that the water level in the northern branch rose while the southern branch remained completely dry *which we had never before seen.*

That demonstrates decisively that Putick's conclusion is sound, that the Pivka river and the outflow from the Cerknica lake merge underground and that Schmidl's opinion (repeated in Reclus's geography) does not match reality.

This is the first result of my research with Putick (see the plan opposite [=attached]. [This is the same printed map as is printed on p. [456] of his *Les Abîmes* of 1894.

A second result was the discovery of an extension of 500 m (2 km with the side passages) in the underground course of the Pivka in Postojnska jama and finding the link between that cave and two shafts, Magdalenska jama and Črna jama one km to the north (see the plan). Postojnska jama, where investigations started in 1818 and are certainly not yet finished, is consequently the longest in Europe (10 km in total), with only one competitor – Aggtelek in Hungary at 8700 m).

I was only able to complete these difficult tasks, which took three days of effort, thanks to the devoted co-operation of Putick, F. Kraus, Kraigher, Dietrich, Schäber, etc. and the use of my telephone and collapsible [p.3] canvas boats. The Austrian explorers were thus able to appreciate these two things and in future they will use them to continue their own explorations.

As the unexpected rains made the water level of the Pivka rise by more than a metre above normal, the force of its current made it impossible for me to make any further explorations. But my objective had been reached. On the one hand I had shown that, despite 75 years of exploration, Postojnska jama had not given up all its secrets. Also the differences in water speed that I had seen in adjacent cave passages enabled me to understand the flow of these underground waters.

In my next book, *Les Abîmes*, I shall explain how this system is exactly the same as in the limestone regions of France. The original fissures in the ground have been enlarged into caves by the underground waters coming from the natural shafts that drain the rain-water from the surface. In places, narrowing of the passages and lowering of the cave roofs have formed sumps which restrict the flow of the underground water from the storage area behind springs. Finally then is this difference: that in the Karst the limestones are softer than Jurassic limestones and the rivers are more powerful. Dolines are a lot more common and obscure many of the places where the water sinks.

As in France (at Vaucluse, etc.) a thorough knowledge of the underground rivers is important to allow control of the output of springs or risings.

Among the 30 other caves, springs and shafts that I have explored or studied [here], I mention [p.4] only the following.

The Foibe di Pisino [Pazinska jama] in Istria is a 130 m deep pit into one side of which there flows a very unusual river. Sometimes the water level will rise by 40 m in 24 hours, and three days later the place will be empty again. I have an explanation for this which has never been made before. At the bottom of the pit is an opening like those in Ardèche in the [French] Causses. The cave is only 200 m long and ends in a lake which, closed on all sides, is 80 m long and 30 m wide. But its depth, even in dry periods, is 13.5 m. It is one end of a sump of which the other end is unknown.

In Bosna, Hercegovina and Dalmacija the amount of water prevented me from going inside the caves that are the big risings that I was investigating (Bosna, Comadina Buna [Komadina Buna], Ombla, Ljuta, Finmara [?]. Gordicchio [Gorič], etc.). Moreover most of them are springs, supplied from deep down like the Loire in France. Even where they do come out from an open cave entrance when the floor is low, it would be necessary to have equipment that was not available. The local people are not used to such explorations and do not go far underground. It would be necessary to bring, at great cost, experienced cave explorers like those of France or Postojna.

Nevertheless I can say three things. [1] The springs here, like those of France, Greece and the Austrian Karst, are the re-appearance of rain-water absorbed by fissures in mountains above and also of rivers that have sunk into caves on the higher plateaux (Listika [Lištica], Zalomska, Ljubinje, Trebinjica [Trebišnjica], etc. The general law of underground water circulating through fissures in the ground is found to be applicable /[p.5] here once again.

[2] Between Ragusa [Dubrovnik] and Cattaro [Kotor] the Ljuta, which rises in the Canale valley, sinks into a vertical shaft in two 5 m cascades. The water filling the whole width of the shaft makes entry impossible but it shows decisively that natural shafts are well able to be formed by erosion from a mass of sinking water, as my explorations in the [French] Causses since 1888 continue to prove. The Ljuta reappears as an impenetrable spring 13 km to the north-west in the bay of Breno [Brelo?].

[3] The temperature of many of the coastal springs in Dalmacija is lower by several degrees than the mean annual temperature at the place where they appear. Lorenz has already noted this anomaly in the Kvarner Gulf. It seems to be general in the region and is explained by the origin of these springs whose water often went underground more than 1000 m higher up on mountains or cold plains. It shows that the meteorological law which states that the mean temperature of a place is that of its springs is not universal.

Finally in Montenegro, thanks to the kindness of the Count of Sercey, attaché at the Russian embassy, and of Professor Rovinsky, I am able to state that there too rain-water sinking into fissures in the ground and a whole series of caves and underground rivers deserve to be explored at a lower level.

At the cave where the Rjeka rises, a penetrable version of the Fontaine de Vaucluse, I have even discovered a navigable [underground] river which drains all the rain-water of Cettinje [Cetinje]. But it has been impossible to persuade the local people to follow me or even to carry my collapsible boat as far as the water where progress on foot was impossible.

[p.6] I should then have gone to Hercegovina to make my exploration complete but it could only have been done at the cost of much time and money.

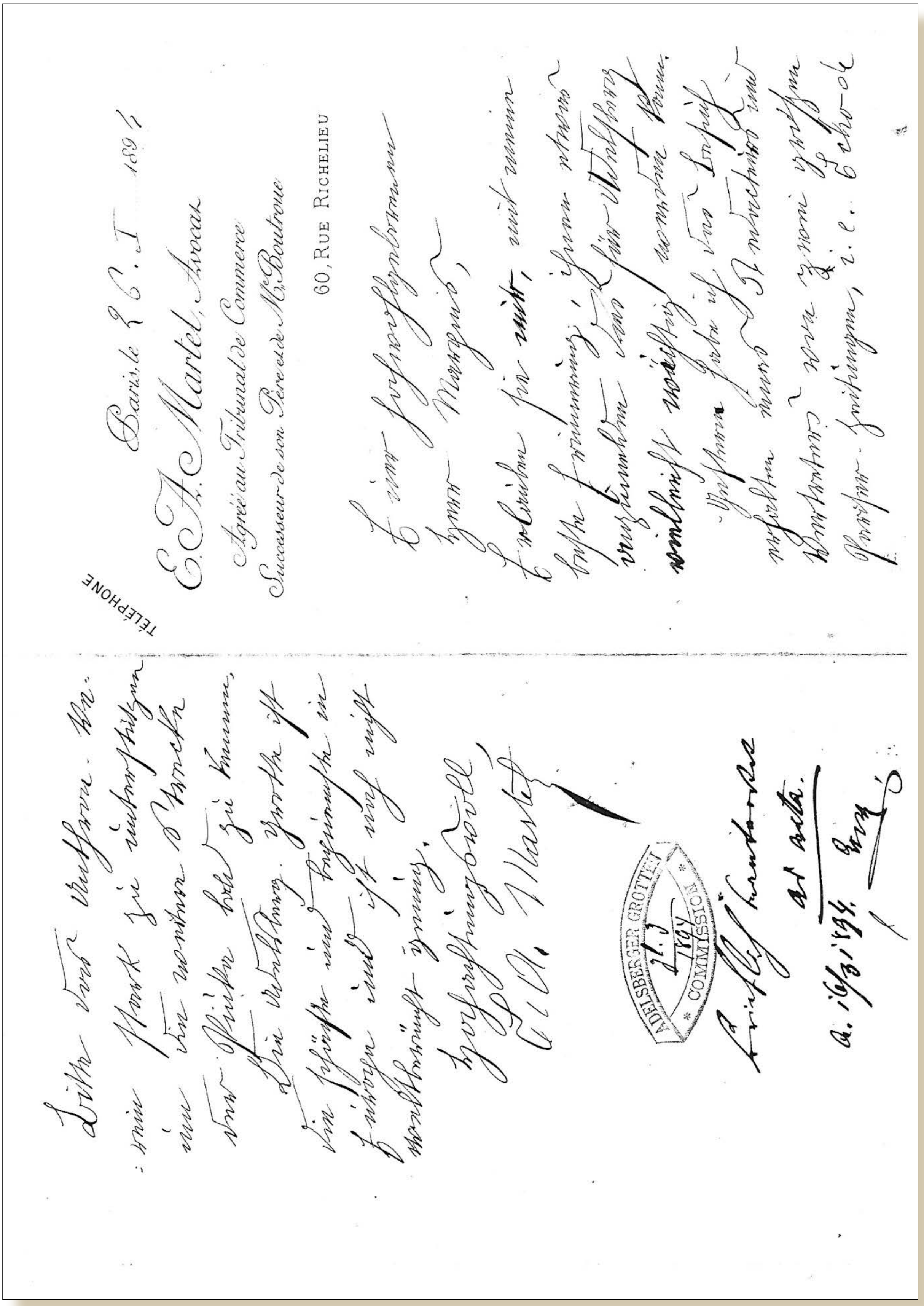
In summary, the phenomena of underground hydrology in the Karst and the whole of the western part of the Balkan Peninsula are the same as in the limestone regions of France, Belgium, Greece and probably of all geologically similar formations.

Although the Austrians have spent more than 50 years studying the underworld of Istria and Carniola, they are still far from completing their investigations. They would benefit from the two pieces of equipment whose use I have pioneered in France – collapsible boats and the telephone. Using these for underground geography, for *speleology*, would, initiate a new era.

The explorations that Sidérides made in 1892 in the katavothra of the Peleponese, following my example and with my advice, have already proved this.

And the practical advantages of this branch of science are many. Here we discover hidden reserves for food supply and agriculture. Control of underground rivers avoids at the same time both drought and flooding. Besides, we can drain marshes and so reduce sickness. In fact, in all limestone terrain, so common in the world, we can more and more control one of the most powerful forces of nature, *water;* a force which, left to itself, is too often devastating (by its lack or its excess) and which, well studied and put to work is one of the main elements of human health and wealth.

E. A. Martel.


Paris, le 26. I. 189
E. A. Martel, Avocat
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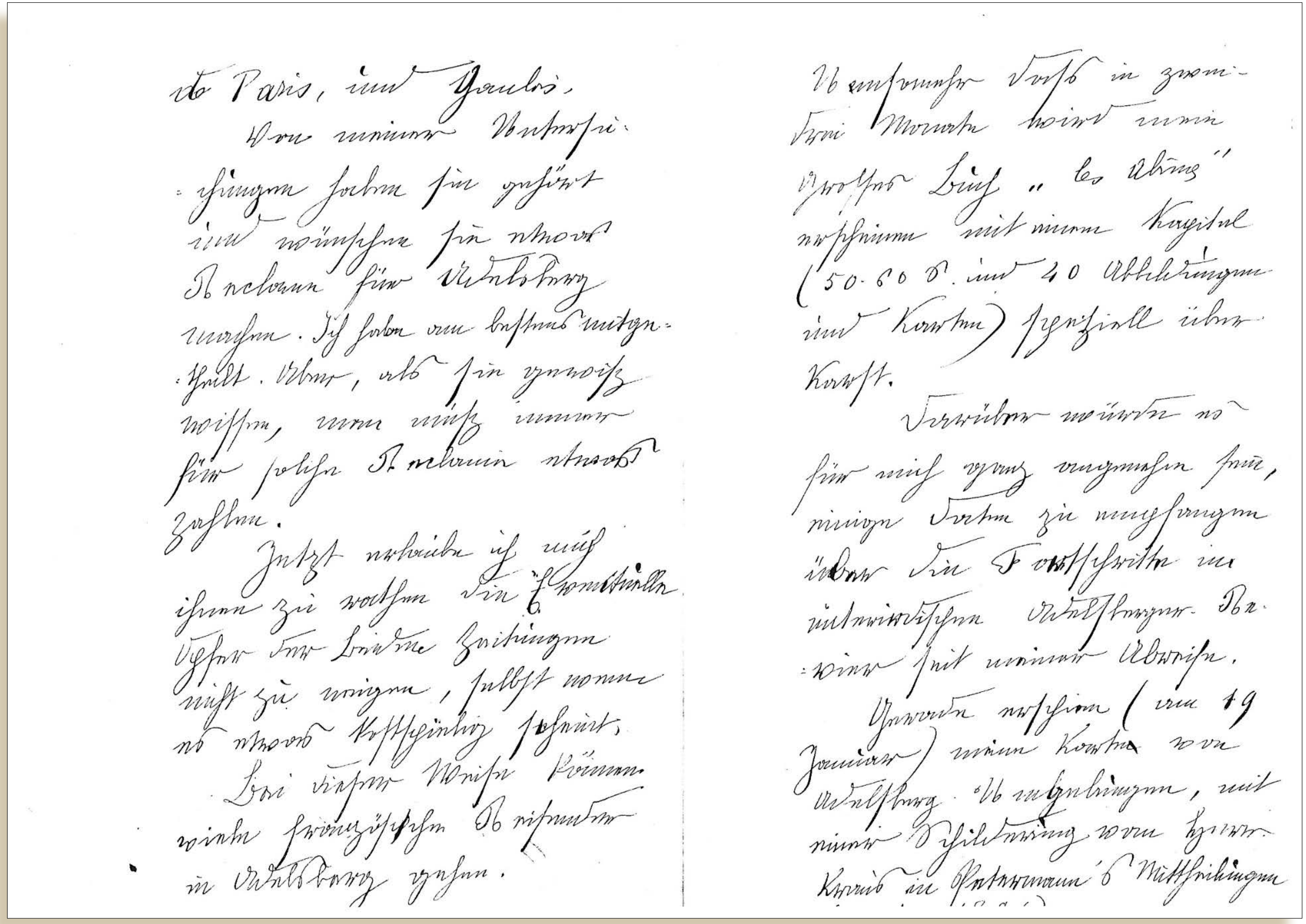
Adelsberger Grotten Commission


de Paris, und Gaulois.
Von meinen Untersu-
chungen haben sie gehört
und wünschen sie etwas
Reclame für Adelsberg
machen. Ich habe den besten mitge-
fühlt. Aber, als sie gewiß
wissen, man muß immer
für solche Reclame etwas
zahlen.
Jetzt erlaube ich mich
ihnen zu rathen die [illegible]
Chefs der beiden Zeitungen
nicht zu zeigen, selbst wenn
es etwas kostspielig scheint.
Bei dieser Weise können
viele französische Reisende
in Adelsberg gehen.

[illegible] in zwei-
drei Monate wird mein
großes Buch „les Abîmes“
erscheinen mit einem Kapitel
(50-60 S. und 40 Abbildungen
und Karten) speziell über
Karst.
Darüber würde es
für mich ganz angenehm sein,
einige Daten zu empfangen
über die Fortschritte im
unterirdischen Adelsberger Re-
vier seit meiner Abreise.
Gestern erschien (am 19
Januar) meine Karte von
Adelsberg-Grotten, mit
einer Schilderung von Herrn
Kraus in Petermann's Mittheilungen
(1894)

r 26.4.20

Paris, 6.1.1894

E. A. Martel, Avocat
Agréé au Tribunal de Commerce
Successeur de son Pére et de Me Boutroue

60. Rue Richelieu

Sehr geehrter Herr *Martel*

erlauben sie mir, Ihnen etwas mitzuteilen, das für Adelsberg vielleicht wichtig werden kann.

Gestern hatte ich den Besuch eines Redakteurs und Vertreters von zwei großen Pariser Zeitungen, Echo de Paris und Le Gaulois.

Sie hatten von meinen Forschungen gehört und wünschen sich, etwas Werbung für Adelsberg zu machen. Ich habe sie gut informiert. Aber wie Sie wissen, kostet solche Reklame immer etwas.

Ich erlaube mir, Ihnen zu raten, sich hier finanziell zu engagieren, selbst wenn es etwas kostspielig scheint. So kommen mehr Gäste aus Frankreich nach Adelsberg.

Umso mehr, als in zwei bis drei Monaten mein großes Buch „Les Abimes" mit einem Kapitel (50 - 60 Seiten und 40 Abbildungen und Karten) speziell über den Karst erscheinen wird. Daher würde ich mich freuen, wenn Sie mir Daten über die Fortschritte im unterirdischen Adelsberger Revier seit meiner Abreise mitteilen würden.

Am 19. Januar erschien meine Karte der Region Adelsberg mit einer Schilderung von Herrn Kraus in Petermann's Mitteilungen.

Bitte unterstützen Sie den Anthron-Verein, um den weiteren Verlauf Strecke der Piuka bald zu erforschen.

Die Adelsberger Grotte ist die schönste und bequemste in Europa und noch nicht weltberühmt genug.

Hochachtungsvoll,
E. A. Martel

*(Stempel) Adelsberger Grotten * Commission **
Brieflich beantwortet
ad acta
A. 16/3 1894 (unleserliche Signatur)

Paris, le 6 janvier 1894

E. A. Martel, avocat
Agréé au Tribunal de Commerce
Successeur de son Pére et de Me Boutroue

60 Rue Richelieu

Paris, 6 January 1894

E.A. Martel, Barrister
Member of the Commercial Tribunal
Successor to his father and to M. Boutroue
60 rue Richelieu

Dear M. Marinitsch,
Allow me to inform you about something which may become important for Postojna.
I was visited yesterday by an editor-in-chief and a reporter of two great Paris newspapers, the *Echo de Paris* and *Le Gaulois*.
They wished to talk about my researches and wanted to provide publicity for Postojna. I gave them all the information they required. But, as you know, such publicity always comes at a cost.
I ask you to advise me about making a financial agreement, even if it is only for a small sum. This would, besides, encourage French visitors to come to Postojna.
All the more because in 2 or 3 months my great work *Les Abîmes*, with a chapter of 50 to 60 pages and 40 illustrations and maps specially devoted to Karst, will be published. I would be happy if you would allow me to give them also information about progress made in the underworld of Postojna since I left there.
On 19 January, my map of the Postojna region will be published, together with a description by M. Kraus, in *Petermann's Mittheilungen*.
Thanks are due to the Anthron group for further exploration of the [underground] course of the Pivka.
Postojnska jama is the most beautiful and most agreeable cave to visit in Europe and is still not well enough known throughout the world.

Respectfully,
E.A. Martel

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