THE GEOLOGICAL HISTORY OF THE RIVER DRAVA IN CARINTHIA (AUSTRIA) – KNOWN FACTS AND PROJECT DESCRIPTION

GEOLOŠKA POVIJEST RIJEKE DRAVE U KORUŠKOJ (AUSTRIJA) - POZNATE ČINJENICE I OPIS PROJEKTA

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ABSTRACT

The Drava is the largest and most important river of Carinthia (Austria), as it is used for economical as well as for recreation purposes. Hydrogeologically it is the main drainage system. As the information on the geology of the riverbed and its development are distributed in numerous publications and partly even hidden in unpublished geological reports the aim of the project is to summarize and replenish these data.

At present the Drava passes different petrographic areas following paths pre-sketched by older geological faults such as the Periadriatic Lineament. The geological history of a pre-existing Drava in the sense of the main drainage system from the High Tauern to the East begins roundabout 12 Mya ago when Carinthia gets continental. The general direction of the water runoff from the Northwest to the South and East is similar to the present as due to the rising of the Central Alps in Carinthia intramontane basin at lower levels has been established at that time. In the Pannonian or even already in the Sarmatian the river course in lower Carinthia is assumed north of its present riverbed, running through the Klagenfurt basin, which has been filled up by tertiary sediments.

During the Pleistocene Carinthia has been covered almost completely with ice and the valley and the river bed has been overprinted by the great Drava glacier. With the melting of the glaciers the valleys have been filled up with hundreds of meters of sediments. Nowadays the Drava is influenced by anthropogenic activities such as regulations.

Ključne riječi: Drava River, Carinthia, geological history, pleistocene, anthropogenic activities
Ključne riječi: Drava, Koruška, geološka povijest, pleistocen, antropogene aktivnosti

ZUSAMMENFASSUNG

Die Drau ist der längste und wichtigste Fluss in Kärnten (Österreich) und wird sowohl wirtschaftlich als auch touristisch bzw. als Erholungsflächen genutzt. Hydrogeologisch ist sie das Hauptentwässerungssystem. Die Informationen zur Geologie des Flussbettes und seiner Entwicklung sind in zahlreichen Publikationen verstreut und zum Teil in nicht publizierten geologischen Gutachten verborgen. Ziel des hier vorgestellten Projektes ist die Zusammenfassung und Ergänzung der bestehenden Daten.

Die heutige Drau verläuft durch unterschiedliche petrographische Gebiete und folgt dabei geologisch vorgezeichneten Störungen wie z.B. der Periadriatischen Naht. Die geologische Geschichte der »Ur-Drau« im Sinne eines Hauptentwässerungsflusses von den Hohen Tauern in den Osten Kärntens beginnt jedoch schon vor ca 12 Mio. J. als Kärnten festländisch wird. Die generelle Abflussrichtung

vom Nordwesten in den Süden und Osten war ähnlich wie heute, da schon damals wegen des Aufstiegs der Zentralalpen in Kärnten ein tieferliegendes intramontanes Becken entstand. Im Pannonium oder sogar schon im Sarmatium lag der Flusslauf in Unterkärnten vermutlich nördlich des heutigen Flussbettes im Klagenfurter Becken, dass damals mit tertiären Sedimenten aufgefüllt war.

Im Pleistozän war Kärnten fast vollständig vom Eis bedeckt, die Täler und Flussläufe wurden vom Draugletscher überprägt. Mit dem Abschmelzen des Eises wurden die Täler mit mehreren hundert Metern mächtigen Sedimenten aufgefüllt. Heute ist der Drauverlauf durch anthropogene Aktivitäten wie Regulierungen beeinflusst.

INTRODUCTION

Rivers have fascinated mankind since their early days. Being through water and fish content a vital source for living early people frequently built their homes near the river banks although high tides and flooding always threaten their existence. In the last centuries human settlements preferred the vicinity of the water as it provided transport, energy and food. Also nowadays most people are attracted to water, rivers and oceans, and moreover water is the most important provision for mankind. However, the risks through storm floods etc. have not really been diminished respectively are partly more dangerous because of the regulation of the river channels.

Nowadays, rivers seem to be changing little during time, but they are not as steady as they seem to be. Besides geological very short events such as floods, the river courses change through millions of years due to geological reasons. Also through generations their course has been changed due to regulations. E.g., the Tertiary river bed of the Drava in Carinthia has shifted southwards to a bed sketched through the Pleistocene Drava-Glacier and is today heavily influenced by anthropogenic activities such as stream regulations, which has been considered necessary because of annual flooding events. Several reservoir power stations and river power plants have been built along the Drava.

With a length of about 213 km in Carinthia the Drava is its largest and also most important river. It is used for economical purposes such as energy generation and shipping as well as for recreation purposes for tourists and locals. Moreover, the average hydrogeological discharges of about 670m^3/s makes the river the most important drainage system for the region. Although various data on this topic have been published in many scientific papers, no summarizing study focussing on the Geology exists. As regards the Upper Drava Valley in Carinthia and its general geology, geography and geomorphology and especially its fauna, flora and landscape Petuschnig & Honsig-Erlenburg (2004) is recommended.

The aim of the project presented here is to discover the geological and the historical past of the Drava River. Besides gathering existing data from engineering consultants (borehole logs and database),

Fig 1: The River Drava in Carinthia around the bay of Selkach, Ludmannsdorf (© LMK).

Fig 2: View from Tyrol to Carinthia through the Carinthian or Tyrolian Gate (© LMK).

Archives, University's and libraries, it might be necessary to generate new sedimentary data during field work. The project will focus on:

a) The drainage System of Carinthia in the Tertiary

b) The development of the River valley in the Quaternary and the glacial relicts along the river.

c) The Holocene history of the River as regards shifts of the Drava channel due to the age of the sediments on the river terraces and in the valley.

d) Possible relations of the sedimentary history in the Holocene to geological events such as earthquakes.

e) The river in the Anthropocene: changes due to anthropogenic activities such as regulation.

The present paper will give a brief overview about the existing data gathered so far. The compilation of the data will be published at the Natural Science Society of Carinthia (Naturwissenschaftlicher Verein für Kärnten), which funded a part of the study in 2017.

GEOGRAPHICAL OUTLINE

With a length of 749 km the River Drava is the forth-longest tributary stream of the Danube and with a length of about 213 km in Carinthia it is the most important river of the region. It is one of the three large west-east orientated valleys besides the Möll and Gail-Valley. The eastward drainage of the River follows a longitudinal valley, which is itself following a linear depression whose trend is subparallel to the strike of the Eastern Alps (Kuhlemann et al. 2001).

Four valleys in Carinthia are passaged by the Drava: the Upper Drava Valley which reaches from Lienz in Tyrol to Spittal in Carinthia, the Lower Drava Valley from Spittal to Villach, the Rosental from Villach up to Annabrücke near Gallizien and finally the Jauntal, which follows the latter up to Lavamünd.

The Drava enters Carinthia at an altitude of 632 m above sea level at the Carinthian or Tyrolian Gate (fig. 2), which is a valley narrowing near Ober Drauburg representing the border between Eastern Tyrol and Carinthia. The river takes course between the metamorphic Kreuzeck group in the North and the mainly calcareous Gailtal Alps in the South. Whereas the Kreuzeck group reach altitudes of about 2.700 m (Hochkreuz Mt. with 2.709 m, Kreuzeck Mt. 2.701 m), the highest Mountain in the southern Gailtal Alps is Mt. Reißkofel the highest point of which is 2.371 m. Several alluvial fans – gently-sloping

Figs. 3a, b: Alluvial Fans reaching into valleys are frequently used in Carinthia for settlements (orthophotos and stripped map, © Land Kärnten-KAGIS, www.kagis.ktn.gv.at)

masses of loose sediments brought by the creeks and ditches in the Kreuzeck area – are used by human settlements, as the valley floor have been regularly flooded by high waters.

At about Möllbrücke the Drava merges with the Möll and uses now the Mölltal fault to the South to Villach. On its way it separates the Nockberge area and the Goldeck respectively the north-eastern border of the Gailtal Alps. Behind Villach the river crosses the Villacher field (part of the Klagenfurt basin) and enters the Rosental, a valley between the Triassic Karavanks and the Tertiary Sattnitz range. At about Gallizien the Drava enters the Jaunfeld, which is the Eastern part of the Miocene-Pliocene Klagenfurt basin. It leaves the basin at about Lavamünd and follows now the northwest-southeast striking Lavanttal fault, changing thereby its course from east do south. It leaves Carinthia between Lavamünd and Dravograd (Unter Drauburg) at an altitude of about 390 m above sea level.

The upper Drava Valley is a typical flood-plain valley with a bottom width up to 1500 m at Lurnfeld near Möllbrücke. Characteristically for valleys south of the main watershed line are the comparatively large Mountain peaks surrounding them. The valley has been created already in the early Teriary using the Mölltal fault system but has been overprinted to a U-Valley by glaciers in the Pleistocene (compare Geology) and is filled up by post-glacial sediments from the Drava and its tributary rivers. Alluvial fans which reached deep into the valley floor force the river to meander.

Before the human influence the Drava has mainly been a braided river (furcated) in which alluvial fans causes the river to oscillate. Only in parts the river formed meander or was elongated.

Due to frequent disastrous flooding events in the 19th century with many human losses large regulation provisions started in April 1884 with a federal state law, but natural catastrophes occurred nonetheless as for example in 1965/66. However, the straightening and regulation forced a negative chain

Fig. 4: The course of the River Drava in Carinthia.

Fig. 5: View from the restaurant Karawankenblick near Völkermarkt to the shallow water biotope at Neudenstein (© LMK).

reaction: the stream velocity increased followed by strong bed erosion. Thereafter the groundwater level subsided and the few remaining flood plains dried out. As a consequence, even more disastrous flooding's occurred and the biodiversity along the Drava and its tributary streams decreased. Since the 1990s revitalization projects such as in Rosenheim, in Guntschach or in Neudenstein (fig. 5) try to antagonize these problems.

The significance of the River for energy generation has been recognized quite early: the first power plant has been erected in 1918 in Faal. At the present the course of the Drava in Carinthia is interrupted by 10 river power plants. Detailed information about the upper Drava valley can be found in Petutschnig & Honsig-Erlenburg (2004).

GEOLOGICAL OUTLINE

On its way from Tyrol to Slovenia the Drava passes different petrographic areas and follows various geological structures (e.g. the Periadriatic Lineament). In general north of the Drava crystalline rocks dominate, whereas in the South limestones are the main rocks.

Geologically, Carinthia is mainly built up by three tectonic superunits:

a) The Penninc superunit which is explored in the High Tauern area (Tauern window).

b) The Austroalpine superunit, which derived from the Adria continent. It comprises rocks of different age from possible Precambrian age and with certainty of Palaeozic and Mesozoic age giving a complete cross-section through a continental crust. Metamorphic rocks of different stage of overprint as well as different sedimentary rocks are exposed. To these belong the un-metamorphosed calcareous ranges of the Northern Karavank Mountains (Triassic) and the Gailtal Alps as well as the metamorphic Mountains of the Kreuzeck, Goldeck and the Nockberge.

c) The Southalpine superunit, which encompass the southern Karavank Mountains and the Carnic Alps.

Above the tectonic units in Basins and valleys thick sediments of Tertiary and especially Quaternary age can be found. Because of the various rocks in the catchment area, the bed load of the Drava is highly various. However, hard siliceous components from the Northern areas are more frequent as the weaker limestone components from the South (Habersack & Sereinig 2004).

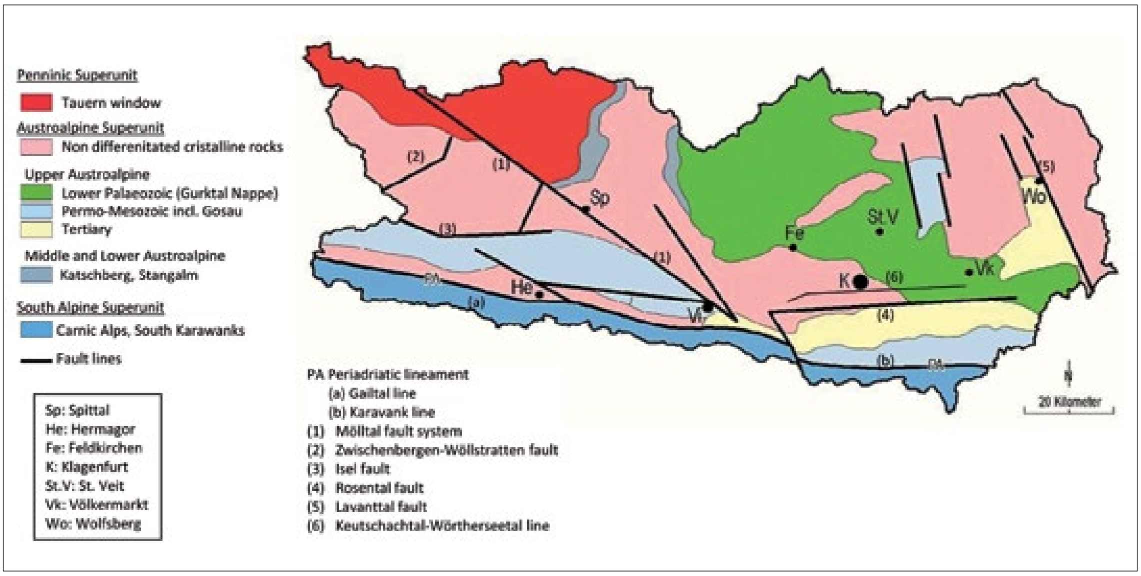

Fig 6: The (main) tectonic faults in Carinthia as regards the course of the Drava River (modified after Seger, 2010).

With view of the course of the Drava the river subdivides Carinthia more or less in a northern part with mainly metamorphic rocks of the Austroalpine unit (Kreuzeck group, Nockberge, Gurktal nappe, Saualpe and Koralpe) and a southern part with mainly sedimentary rocks (Gailtal Alps and the Northern Karavank Mountains). The exception is the metamorphic Goldeck group, which is located south of the Drava. The border between the Austroalpine and the Southalpine nappes is given by the Periadriatic lineament.

This apparent subdivision is no coincidence, but is sketched through pre-existing geological fault systems. The eastward drainage of the Drava follows a longitudinal valley, which is itself following a linear depression whose trend is subparallel to the strike of the Eastern Alps (Kuhlemann et al. 2001). Indeed, Carinthia is covered with large tectonic faults systems such as the Mölltal fault, which are mainly originated in the Neogene (Schuster & Stüwe 2010). These faults – being weak points in the Earth crust – lead to the installation of the alpine valleys through the rivers. The direction from the High Tauern to the East/Southeast is due to tectonic contractions in the Miocene and the subsequently rising of the Central Alps which led to peripheral intramontane basins developed in its North and South (Schuster & Stüwe 2010). This means, that in Carinthia topographically the highest mountains have been in the Miocene as at present in the Northwest and therefore the run-off direction is from Northwest to the South and East.

Coming from Tyrol with a SW-NE course to Lienz the Drava follows the Drautal fault (Drava valley fault), which divides the Altkristallin and the Lienz Dolomits and is therefore assumed to be at the southern side of the river Drava (Bauer & Bauer, 1993). At about Lienz the Drautal fault meets the Isel fault forcing the Drava into a more SE direction to Oberdrauburg, where the course changes to an East direction up to Kleblach. The valley follows now a short fault to the North until meeting the large Mölltal fault system at Möllbrücke. Here the course of the Drava changes again following now the large fault over 50 km to the SE to Villach. From Villach the Drava goes east following now the Rosental fault, a tectonical line between the outland of the Karavanks and the Sattnitz range. At about Lavamünd it meets the Lavanttal fault and changes again direction to the South until Dravograd.

During the Ice Age the valleys and the surrounding mountains have been geomorphologically overprinted by the glaciers. Subsequently the valley has then been filled up with hundreds of meters of mainly post-glacial sediments deposited due to the melting of the glaciers.

Hydrogeologically the Drava is the main drainage system of Carinthia. More information on the general hydrogeology can be found in Habersack & Sereinig (2004).

CARINTHIA AND THE DRAVA RIVER IN THE PLEISTOCENE

The Pleistocene in the Alps

For most of earth's long history it has been much warmer than at the present time, with average temperatures of 20 – 25°C. During these periods, the poles were not covered in ice, and if any land was near the poles, forests would be growing there. After the Cretaceous Thermal Maximum, the Cainozoic period (Palaeogene to Quaternary) remained warm for several millions of years. About 5 million years ago, the climate slowly began to become cooler until the beginning of the present glacial epoch at 2.6 million years. Since then, long glacial periods (in common parlance, »ice ages«) alternate with relatively short warm periods (interglacial, interglacial periods). In the glacial periods, the average annual temperatures are around 5°C lower than they are today, i.e. around 10°C. Ice sheets spread out rapidly from the poles and mountain areas within a few hundred years, covering large parts of the earth. As an ice age is a period of the earth's history in which at least one of the poles is covered with ice, we are nowadays still living in an ice age today, but in a warm phase. For an ice age, therefore, it is quite warm at the present time, but in relation to the entire climatic history of the earth it is actually very cold. The »normal condition« of the earth has average temperatures of 20-25°C, i.e. much higher than today's average.

Since the beginning of the present glacial epoch, the Alps have been (almost) completely covered with glaciers four times. The last glacial period began 115,000 years ago and is referred to in the Alps as the »Würm Ice Age«. The Alpine glaciers extended from Switzerland via Innsbruck up to the high Tauern and from almost to the Eastern border of Carinthia.

Shortly after this glacial period reached its coldest point, 20,000 years ago, the climate became warmer and the huge glaciers began to melt. About 16,000 years ago the Alpine glaciers were still much bigger than they are today, but they were no longer connected over the valleys. About 11,700 years ago, the present ice age warm period began, and the glaciers of the Alps slowly retreated to a few high-altitude locations such as the Grossglockner. With this time, our present interglacial period began. The powerful forces exerted by glaciers leave many traces on the earth's surface, making it possible for us to track the course they have followed in the past.

The Pleistocene in Carinthia

Glacial processes have formed the present landscape of Carinthia significantly having caused e.g. the development of the more than 1000 lakes, the wide valleys and roundish appearance of many mountain peaks.

From the High Tauern the so-called Drava glacier have been extended through the Drava valley. Distributional glaciers have been the Isel and Möll glaciers, which also transported the ice masses from the High Tauern. This net of glacial streams extended to the Eastern margin of the Klagenfurt basin at Griffen (about 10 km east of Völkermarkt), respectively to the Rinkensberg and Lettenstätten South of the River. Therefore, at this time and until 11700 bp most of Carinthia was covered in Ice except for few high Mountain peaks and crests; the Eastern areas such as e.g. the Lavanttal have been free of the ice cap.

The former saw-cut valleys (= V-valleys) have been overprinted by the glaciers to trough-shaped valleys (= U-valley), which later have been filled up with 100rds of meters of young sediments due to the melting of the glaciers. The rock surface is rarely discovered at the valley floor. E.g., according to Brückl et al. (2010) at the Carinthian gate the valley is eroded down to about 600 m below the valley floor (glacial over-deeping).

Countless remains of the Pleistocene glaciers and their subsequent melting are found in Carinthia and along the present Drava, which will not be repeated here (compare e.g. Bobek 1959; Lichtenberger 1953). Among them are erratic boulders, drumlins, dressed rocks, kettle holes, glacial-caused lakes, scarred gravel and boulders, glacial scratches and flutings, as well as different kinds of moraines and alluvial terraces. E.g., typical drumlins are found in the Drava valley around Lendorf – St. Peter in Holz. The hill with the church of Maria Bichl consists of overprinted moraine material and shows with its development parallel to the vally the direction of the ice stream of the former glacier as well as the drain

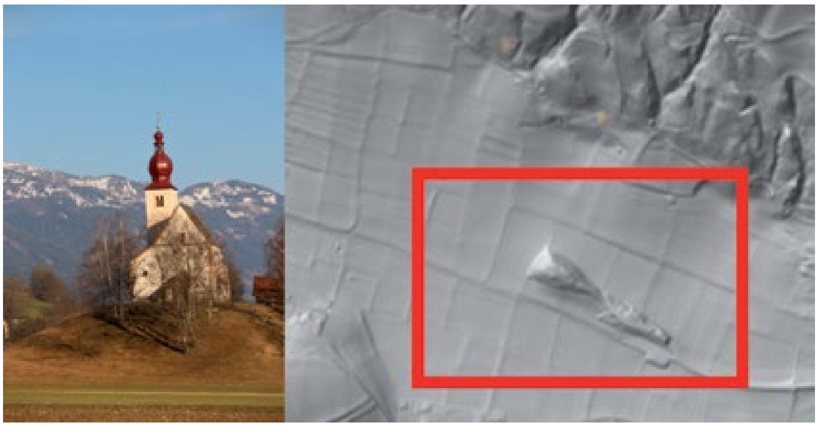

Fig 7: Church hill of Maria Bichl (left: photo ©J. Mörtl; right: stripped map © Land Kärnten-KAGIS, www.kagis.ktn.gv.at).

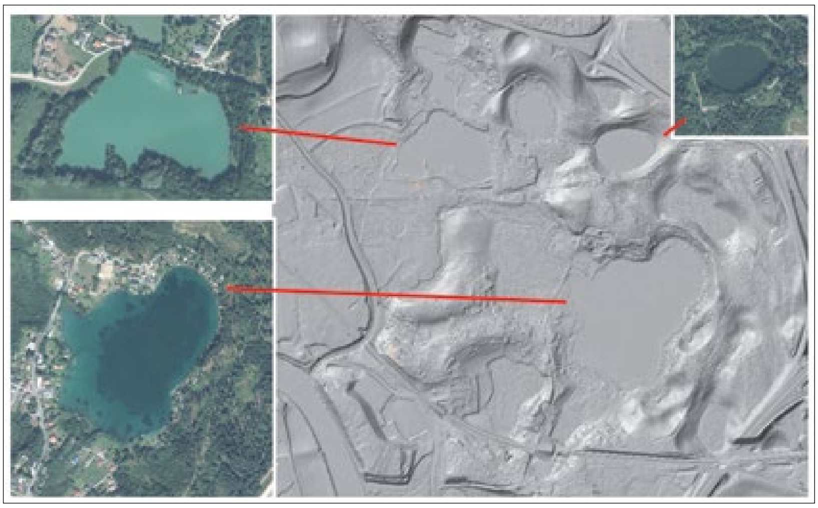

Fig 8: Kettles near Villach (Orthophotos and stripped map © Land Kärnten-KAGIS, www.kagis.ktn.gv.at).

of the glacial melting waters (Reitner 2005: 69; Reitner et al. 2005: 229-230). Well shaped kettles - shallow, sediment-filled body of water which are formed by retreating glaciers or draining floodwaters – are developed in the vicinity of Villach.

Carinthia and its drainage system in the Tertiary

The reconstruction of the pre-quaternary river currents in the Alps is not easy, as at that time the present geomorphology did not exist. The tectonic subdivision of nowadays Carinthia has been developed mainly in the middle Tertiary, starting at about 25 my. For example present mountain ranges with altitudes of more than 2000m such as the Sau- and Koralpe have been flat regions and were mainly covered with shallow seas. Additionally, the tertiary sediments including fluviatile remains have been removed by the pleistocene glaciers. Only the areas which have not been covered by ice such as the Lavanttal provide the geologists with tertiary archives. Thus, a reconstruction of the drainage system is – if at all – only possible in the continental sediments deposited after the alpine orogeny respectively the up-lift of the Alps.

In the Eocene, Carinthia was under the influence of a shallow marine environment. The true extension of the sea cannot be reconstructed thoroughly, as most of the sediments have been eroded by the later alpine orogeny and uplift (Thiedig 1999). Light yellow to white limestones and marls have been deposited in the Krappfeld, where large foraminifers (nummulites) can be found.

The following continental phase is shown by quartz sandgrains transported by rivers and deposited within the top layers of the Eocene nummulite limestone. Besides these, only red earth horizons remain from this roundabout 30 million years of continental era. They proof a subtropical Mediterranean climate as it is nowadays in the northafrican coastal zone (Thiedig 1999).

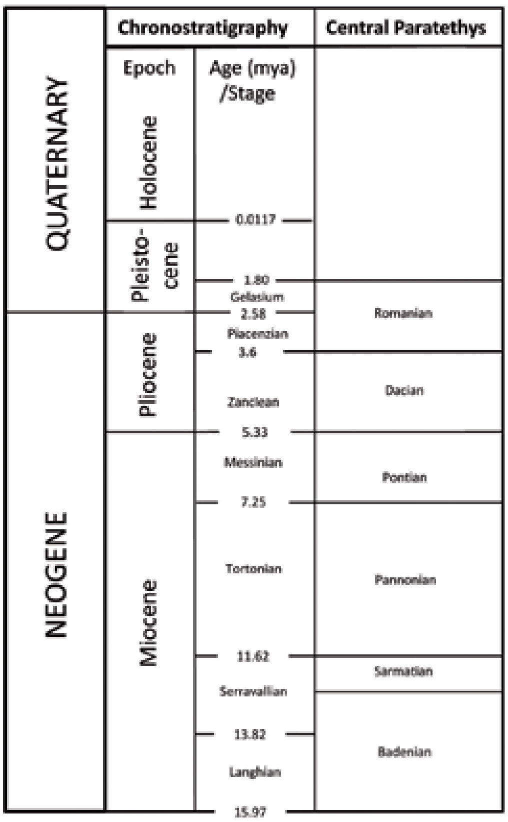

Fig. 9: Stratigraphical chart (modified after Harzhauser et al. 2015).

The fluvial gravel of the Granitztal Formation is assumed to be Lower Miocene in age. It is overlain by middle Miocene limnic sediments with non-marine fish fossils (lower Mühldorf Schichten) and by sediments of a marine ingression (upper Mühldorf Schichten) in the Badenian (about 15 million years ago). Within these marine strata gastropods, bivalves, corals, echinoderms and bryozoens have been found. Oysters, which reached a length of about 20 cm, show a fully marine shallow water coastal area with temperature comparable with the Mediterranean (Thiedig 1999).

In the late Badenian and the early Sarmatian the sea retreated and brackish water and fresh water environments take over. Peatlands in flat coastal areas develop and lignites beds are deposited.

With the late Sarmatian (late Middle Miocene) and the late Miocene as well as the Pliocene the general uplift of the mountain ranges in Carinthia begins. The uplift of the Karavanks e.g. causes the discharges of the conglomerates of the present Sattnitz and comparable conglomerates in the Klagenfurt basin, which has been completely filled by tertiary sediments (Krainer 2006). At this time, the main drainage of rivers in the late Miocene ran to the East (Pfiffner, 2010), following the main fault systems, which has been installed as soon as the late Oligocene (Kuhlemann et al. 2001).

As regards the Drava, Kahler (1953) assumed a main drainage system north of the present Drava following the Keutschachtal-Wörtherseetal line (fig. 6). Eicher (1982) confirmed this theory assuming for the Pannonian the foot zone of the glacis of the Karavanks at about the present Wörthersee-Glan depression, in which case the pre-existing Drava must have been found its way at the level constricted

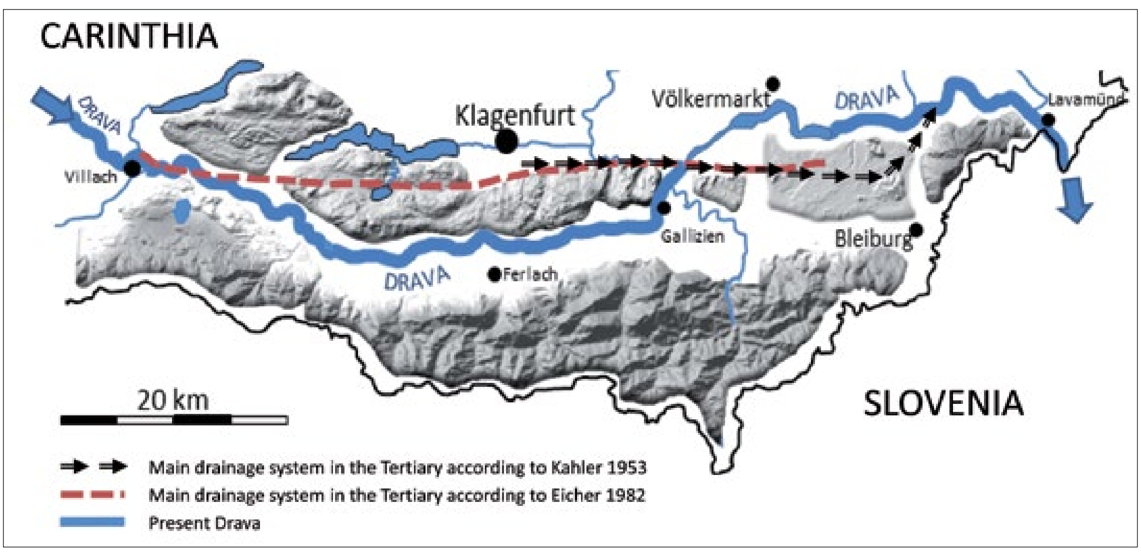

Fig. 10: Present day course of the Drava and the assumed main drainage system in the Tertiary projected on the nowadays landscape. In the Tertiary the area consists of a sediment filled basin. (map based on Land Kärnten-KAGIS).

between two Pannonian glacis toward the East. Due to the uplift and denudation a push impulse to the South might have been already present at that time. Winkler-Hermaden (1957) assumed a pre-existing Drava River already for the Sarmatian, which discharges gravel in a deltaic system as far as in the Styrian basin.

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REFERENCES

Bauer, Wilfried und Peter Bauer.1993. »Zur Geologie des metamorphen Kristallins zwischen Amiach und Lavant (Osttirol, Österreich)«. *Jahrbuch der Geologischen Bundesanstalt*, Bd. 136 (2): 299–306.

Bobeck, Hans. 1959. »Der Eisrückzug im östlichen Klagenfurter Becken«. *Mitteilung der Österreichischen Geographischen Gesellschaft* (110): 3-36.

Brückl, Ewald, Johanna Brückl, Werner Chwatal and Christian Ullrich (2010). »Deep alpine valleys: examples of geophysical explorations in Austria«. *Swiss Journal of Geosciences* (2010) 103: 329–344.

Eicher, Harald. 1982. »Zur Flußnetzentwicklung im Klagenfurter Becken und in der Norischen Senke«. *Carinthia II, 172./92 Jahrgang:* 153–172.

Habersack, Helmut und Norbert Sereinig. 2004. »Die Obere Drau – eine Flusscharakterisierung«. In *Das Obere Drautal* edited by Werner Petutschnig and Wolfgang Honsig-Erlenburg, 24–41. Klagenfurt: Verlag Naturwissenschaftlicher Verein für Kärnten, Carinthia II, Sonderheft Nr. 61.

Harzhauser , Mathias, Oleg Mandic, Thomas A. Neubauer, Elisavet Georgopoulou and Andreas Hassler. 2015. »Disjunct distribution of the Miocene limpet-like freshwater gastropod genus Delminiella«. *Journal of Molluscan Studies*, Vol. 82, Issue 1: 129–136.

Kahler, Franz. 1953. *Der Bau der Karawanken und des Klagenfurter Beckens*. Klagenfurt, Verlag des Naturwissenschaftlichen Vereins für Kärnten, 16. Sonderheft.

Krainer, Karl. 2006. »Geologie des Sattnitz-Höhenzuges«. In *Die Sattnitz, Konglomerat der Natur im Süden Kärntens. Ein Naturführer*« edited by Bettina Golob and Helmut Zwander, 93–108. Klagenfurt: Verlag Naturwissenschaftlicher Verein für Kärnten.

Kuhlemann, Joachim, Wolfgang Frisch and István Dunkl. 2001. »The Oligocene geologic and palaeotopographic evolution of the Eastern Alps«. In *The Paleogene of the Eastern Alps* edited by Werner Piller and Michael W. Rasser, 129–152. Schriftenreihe der Erdwissenschaftlichen Kommissionen der ÖAW, Bd 14.

Lichtenberger, Elisabeth. 1953. »Der Rückzug des Würm-Draugletschers aus dem Villacher Becken und im aufwärts anschließenden Drautal«. *Carinthia II, Naturwissenschaftliche Beiträge zur Heimatkunde Kärntens* Bd. 143./63: 7–14.

Petutschnig, Werner & Wolfgang Honsig-Erlenburg. 2004. *Das Obere Drautal. Tiere, Pflanzen und Lebensräume einer inneralpinen Flusslandschaft*. Klagenfurt: Verlag Naturwissenschaftlicher Verein für Kärnten, Carinthia II, Sonderheft Nr. 61.

Pfiffner, Adrian. 2010. *Geologie der Alpen*. Bern: Haupt Verlag.

Reitner, Jürgen. 2005. »Landschaftsentwicklung im Quartär«. *Arbeitstagung der Geologischen Bundesanstalt 2005, Gmünd*: 63–81.

Reitner, Jürgen, Volker Ertl, Gerlinde Ortner and Herbert Mandler. 2005. »Exkursion: Quartärgeologie Millstätter See – Unterdrautal (14.9.05)«. *Arbeitstagung der Geologischen Bundesanstalt 2005*, Gmünd. 227–231.

Seger, Martin (2010). *Kärnten. Landschaftsräume-Lebensräume*. Klagenfurt. Verlag des Geschichtsvereins und des Naturwissenschaftlichen Vereins für Kärnten.

Schuster, Ralf und Kurt Stüwe. 2010. »Die Geologie der Alpen im Zeitraffer«. *Mitteilungen des naturwissenschaftlichen Vereins für Steiermark,* Bd. 140: 5 –21.

Thiedig, Friedhelm. 1999. Das jüngste Meer in Kärnten. In *Kärnten Natur. Die Vielfalt eines Landes im Süden Österreichs* edited by Mildner, Paul and Helmut Zwander, 233–240. Verlag des Naturwissenschaftlichen Vereins für Kärnten.

Winkler-Hermaden, Arhur. 1957. *Geologische s Kräftespiel und Landformung*. Wien: Springer Verlag.

SAŽETAK

Drava je najveća i najvažnija rijeka u Koruškoj (Austrija), te se koristi u gospodarske svrhe i za rekreaciju. S hidrogeološkog aspekta rijeka Drava je glavni vodotok. Obzirom na činjenicu da su informacije o geologiji korita i njegovog razvoja prisutni u brojnim publikacijama, a neki su djelomično skriveni u neobjavljenim geološkim izvješćima, cilj ovog projekta je sažeti i nadopuniti te podatke.

Drava trenutno prolazi kroz različita petrografska područja kroz tokove koji su rezultat starijih geoloških nedostataka poput perijadranskog rasjeda. Geološka povijest prapovijesne Drave kao glavnog vodotoka s Visokih Tura prema istoku počinje prije 12 milijuna godina kada Koruška postaje kontinentalno područje. Glavni smjer otjecanja vode sa sjeverozapada prema jugu i istoku je sličan sadašnjem zbog tadašnjeg izdizanja Središnjih alpi u međuplanonskom bazenu Koruške. U panonskom i sarmacijskom periodu tok rijeke u Koruškoj bio je sjevernije od sadašnjeg korita i prolazio je kroz bazen u području Klagenfurta koji je bio ispunjen tercijarnim sedimentima.

Za vrijeme pleistocena Koruška je bila gotovo u potpunosti prekrivena ledom, a nizina i rijeka su bili prekriveni velikim Dravskim glečerom. Otapanjem glečera doline su bile zapunjene stotinama metara sedimenta. U današnje vrijeme na Dravu utječu antropogene aktivnosti poput zakonskih odredbi.