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PALAEOMAGNETIC RESEARCH OF CAVE SEDIMENTS IN SW SLOVENIA

PALEOMAGNETNE RAZISKAVE JAMSKIH SEDIMENTOV V JZ SLOVENIJI

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Pavel Bosák & Petr Pruner & Nadja Zupan Hajna: Paleomagnetne raziskave jamskih sedimentov v JZ Sloveniji

Trije profili jamskih sedimentov (v fosilni jami blizu Divače, v Divaški jami in v Trhlovci) so bili preučeni na Krasu blizu Divače. Mineraloška analiza izpričuje relativno enotno sestavo lahke frakcije in kaže na glavni izvor v preperelih ostankih eocenskega fliša. Nekaj mineralov je produkt preparevanja (npr. gibbsit). Podrobna magnetostratigrafska raziskava treh profilov kaže na normalno in reverzno polarnost magnetocon in kaže na korelacijo med profiloma v Divaški jami in Trhlovci. Ozke normalne magnetocone verjetno sovpadajo z Jaramillo polarnostjo (0.90 do 0.97 Ma) v Matuyama epohi. Podatki kažejo na precejšnjo starost jame, v kateri je nastopilo zadnje obdobje zapolnjevanja pred 0,97 Ma in se končalo pred mejo med Brunhes/Matuyama, pred približno 0.73 Ma. Magnetostratigrafski podatki profila pri Divači so zabeležili dve ozki normalni magnetoconi v dolgi reverzni polarni coni, kar verjetno sovpada z Olduvai oz. Reunion (okrog 1.67 do 1.87 Ma) reverzne Matuyama epohe ali z normalnimi magnetoconami (okrog 3.8 d0 5.0 Ma) v reverzni Gilbert epohi. Podatki nakazujejo možnost, da je jama nastala v mesinski stopnji, za katero je značilen padec morske gladine in razvoj globokega krasa v Mediteranu.

Ključne besede: magnetostratigrafija, fosilne jame, jamski sedimenti, Kras, Slovenija.

Abstract UDC: 551.44:552.54(497.4)
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Pavel Bosák & Petr Pruner & Nadja Zupan Hajna: Palaeomagnetic research of cave sediments in SW Slovenia

Three profiles of caves sediments (Divača fossil cave, Divaška Jama and Trhlovca Cave) were studied in the Kras near Divača village. Mineralogical study proved relatively uniform mineral composition of the light fraction indicating the main source from weathered sediments of Eocene flysch. Some minerals are derived from weathering profiles and crusts (e.g. gibbsite). Detailed magnetostratigraphic investigations of three profiles defined normal and reverse polarity magnetozones and shows the correlation between the profiles in the Divaška Jama and Trhlovca Cave. The narrow normal magnetozones probably correlate with the Jaramillo polarity event (0.90 to 0.97 Ma) of the Matuyama epoch. Those data indicate the substantial age of cave in which the last phase of filling started before 0.97 Ma and finished before the Brunhes/Matuyama boundary, i.e. around 0.73 Ma. Magnetostratigraphic data of the Divača profile detected two narrow normal magnetozones in the long reverse polarity zone which probably correlate with Olduvai and Reunion polarity events (about 1.67 to 1.87 Ma) of reverse Matuyama epoch or with some of normal magnetozones (about 3.8 to 5.0 Ma) within reverse Gilbert epoch. Data indicate the possibility that the cave was originated during the Messinian period characteristic by sea-level fall and evolution of deep karst in the Mediterranean Basin.

Key words: magnetostratigraphy, fossil caves, cave sediments, Kras, Slovenia.

INTRODUCTION

During the motorway construction in the territory of the Kras Plateau, SW Slovenia (Fig. 1), a large number of inactive cave passages filled by fluvial sediments was uncovered. Some parts of roof are preserved in some of such old caves, nevertheless a number of others is now roofless because of denudation processes, especially due to the chemical denudation of limestones.

Our knowledge concerning the origin of sediments, the time of their deposition and the proper age of host cave has been still very low. The speleothems we found in these caves are too old to be dated by U-series method (A. Mihevc, pers. comm.). Similar situation can be found also on other sites over the Kras; even more, there are no fossils in cave fills. Therefore we decided to apply the palaeomagnetic method to obtain, at least, the time frame for sedimentation processes within caves. We selected three profiles in sediments in the Kras near village of Divača (Fig. 1): one was situated at the motorway line and two in caves, i.e. in the Divaška Jama and Trhlovca. The sampling for palaeomagnetic analyses were accompanied by sampling for mineralogical and palynological research. Samples of limestones and marls from Mesozoic carbonate sequences and Tertiary flysch were also taken in the vicinity of selected sites for comparison of their palaeomagnetic and other properties.

Palaeomagnetic analyses were completed at the Institute of Geology of the Academy of Sciences of the Czech Republic, mineralogical analyses were performed at the Karst Research Institute ZRC SAZU and Geological Institute of NTF - Ljubljana University, and palynological analyses were made at the Jovan Hadži Institute of Biology ZRC SAZU in Ljubljana. The costs of the research were covered by Državna družba za ceste - Engineering Company for Public Roads.

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We are grateful especially to Državna družba za ceste for covering of expenses of this study. Palaeomagnetic analyses were performed by Mrs. Daniela Venhodová, Jana Slepičková, and Jana Drahotová. Figures were drawn by Mrs. Vìra Havlíková and Mr. Josef Forman, tables were typed by Mrs. J. Čadková (all from the Institute of Geology, CAS, Praha). Palynological analyses were completed by Mrs. Metka Culiberg (Institute of Biology, SAZU, Ljubljana). Mineralogical analyses were performed by Mrs. Meta Bole (Geological Institute of NTF, Ljubljana).

LOCATION AND GEOLOGY

The Kras is the carbonate plateau lying above the Trieste Bay and has the typical „Dinaric" direction from NW to SE. The Plateau is situated at 200 to 500 m a.s.l. The Plateau is built by Cretaceous and Tertiary limestones and dolomites. In the stratigraphic sequence, they compose following formations: Brje (K_1), Povir ($K_{1,2}$), Repen ($K_2^{1,2}$), Sežana (K_2^{2-4}), Lipica (K_2^{4-5}), Liburnian (K-Pc) and Alveolinid-nummulitid limestone (E). These carbonate rocks were deposited in shallow, warm-water carbonate shelf environments in the NW part of the Dinaric Carbonate Platform. Layers form an anticline, known as the Trieste-Komen Anticline, which is tectonised mostly in the „Dinaric" direction. Raša and Divača faults are the most prominent. The carbonate plateau is encircled by flysch sediments (E).

The Divača Karst is situated in the SE edge of the Kras Plateau. There are known numerous caves but Škocjanske Jame, Kačna Jama, Divaška Jama and Trhlovca Caves take special place among them. The Reka River sinks in the Škocjanske Jame and flows into the active passages of the Kačna Jama Cave. Explored passages of the Divaška Jama and Trhlovca Cave are situated about 200 m above the underground water course in this part of the Kras and they contain a lot of fluvial sediments.

A fossil cave completely filled with sediments was uncovered during the motorway construction between villages of Divača and Kozina, South of Divača (Fig. 1). The profile was named the Divača profile. It was sampled for palaeomagnetic and other analyses. Samples of the sediments from caves Divaška Jama and Trhlovca were also taken for the comparison. The entrances of Divaška Jama and Trhlovca Caves (Fig. 1) are also situated near the line of new motorway. They are lying at approximately the same altitude and sediments in them also appear to be old.

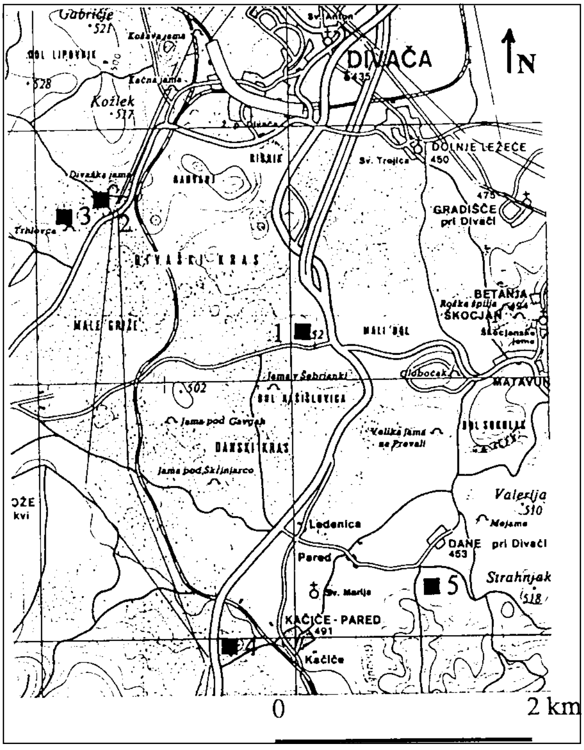

Fig. 1: Location of analysed samples.
1 - Divača profile, cave sediments, 2 - Divaška Jama, cave sediments, 3 - Trhlovca Cave, cave sediments, 4 - motorway profile, limestone of the Liburnian Formation, 5 - Dane profile, flysch rocks.
Sl. 1: Položaj analiziranih vzorcev.
1 - Profil Divača, jamski sedimenti, 2 - Divaška jama, jamski sedimenti, 3 - Jama Trhlovca, jamski sedimenti, 4 - Profil avtocesta, apnenec Liburnijske formacije, 5 - Profil Dane, flišne kamnine.

Divača profile

The profile is situated South of Divača, on the E border of a new motorway at the profile No. 30, on the S slope of bigger doline (Fig. 1). Co-ordinates of the top of profile are as follows: *x* 5 058 400, *y* 5 420 100, *z* 453 m. The profile is about 6 m high and represents the cross-section of a fossil cave completely filled by fluvial sediments. Cave was developed in Lower Palaeocene limestones (Liburnian Formation [K-Pc]), with dip of beds of about 10^0 towards the S.

Divaška Jama

The broader vicinity of the Divaška Jama Cave (Fig. 1) is built by micritic and sparitic limestone of the Turonian age (Sežana Formation, [K_2^{2-4}]). The beds dip from 15^0 to 20^0 towards the S and SW. The entrance to the cave is situated in two collapse dolines. The accessible channels are about 700 long and they are lying transversely to bedding. They follow faults having more or less the N-S direction. The Divaška Jama is filled by lithologically variable sediments and speleothem of different generations in the thickness at least of 30 m.

About 2 m deep profile was excavated at the end of the cave in the Žibernova Dvorana Hall. For the sampling of laminated fluvial/fluvial-lacustrine laminated sediment. The co-ordinates of the excavated profile are: *x* 5 059 260, *y* 5 418 340, *z* 370 m (Fig. 2).

Trhlovca

The Trhlovca Cave represents the continuation of the Divaška jama (Fig. 2). Its channel is located at different altitude and it contains different sediments. Both caves are separated by collapsed doline. The entrance to the Trhlovca Cave is situated in the collapsed doline under its W wall. About 60 m long main channel follows the N-S direction.

About 3 m high profile in fluvial sediments was sampled at the end of the cave. The co-ordinates of the profile are: *x* 5 059 230, *y* 5 418 265, *z* 410.

Rocks samples

Samples of dark limestones belonging to the Liburnian Formation, were sampled on the new motorway between its profiles No. 202 - 204 with following co-ordinates *x* 5 056 000, *y* 5 419 550, *z* 545 m (Fig. 1).

The Eocene flysch rocks were sampled S of village of Dane near Divača with following co-ordinates *x* 5 056 500, *y* 5 421 250, *z* 460 m (Fig. 1).

DESCRIPTION OF SEDIMENTARY PROFILES

Divača profile

Four sedimentary sequences were distinguished in the profile (Fig. 3). They are separated by distinct breaks. The lower sequence No. I is separated from above lying sediments by thicker ferruginised zone with limonite crust. The sequence is composed of variegated clays and silty clays with some sandy admixture. The middle sequence No. II is built of variegated clayey silts to clays, sometimes with sandy admixture. It terminates by thin ferrugineous crust which makes more distinct the erosional base of the sequence No. III. The upper sequence No. III is characterised by

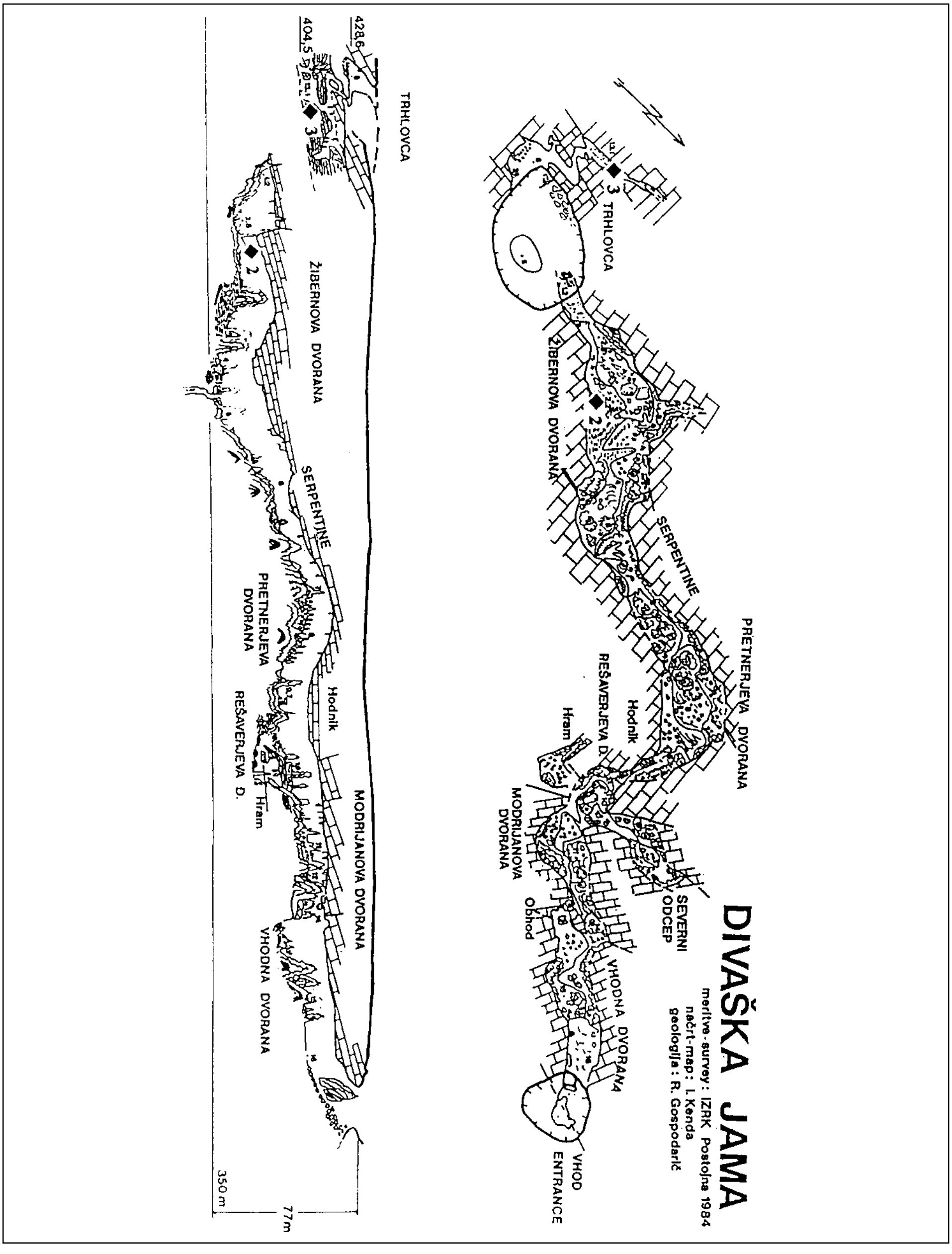

Fig. 2: Location of profiles in the system of Divaška Jama-Trhlovca Cave.
2 - Divaška Jama, 3 - Trhlovca.
Sl. 2: Položaj profilov v sistemu Divaška jama - jama Trhlovca.
2 - Divaška jama, 3 - Trhlovca.

typical fluvial cycles from 4 to 40 cm thick consisting of whitish beige, beige and ochre's sands, with light-coloured clayey and silty terminations of individual cycles. Sands are mostly fine-grained, cross-bedded, sometimes with small scale cross-lamination. Lutites are often show planar-, hummock-, cross- or flaser-lamination. Bases of individual cycles are sharp, often with erosion. The profile terminates by about 30 cm thick layer of redeposited soils of the terra rossa type (sequence No. IV). Red soil were covered by partly decomposed cave ceiling formed by dark grey Paleogene limestones.

Sediments of the cave fill are slightly indurated. Some sandy layers, especially white and beige, show contact type of carbonate cementation. Some parts are strongly cemented by poikilitic calcite cement composed of crystals up to several centimetres in size. The shape of cemented bodies is irregularly ovate. The transition to uncemented sediment is often abrupt. The shape of the contact with loose sediment resembles irregular front of decalcification.

Strong secondary ferruginisation is typical for the whole sedimentary section, especially Liesegang features are abundant. Ferrugineous concretions are connected with Liesegang features. They are filled with loose sand.

The profile was strongly tectonised as the consequence of collapse of the right side of the cave fill (?caused by rejuvenated karstification). Network of parallel fissures developed. They are sometimes characterised by several mm up to 10-15 cm thick „crushed" zones. Zones are typical by the presence of white carbonate „pseudomycelia", development of carbonate cement and infiltration of terracota-coloured clay. Some fissures filled with reddish-coloured material with sandy admixture are probably older and can be connected with the tectonic disturbation of limestones with developed cave network.

Divaška Jama

The profile in the Divaška Jama Cave was represented by a shallow pit, about 2 m deep, excavated in the Žibernova Dvorana Hall (Fig. 4).

Four sequences can be distinguished in this profile. The lower sequence is composed of brownish clays to silty clays with upward increased admixture of sandy fraction. Sediments are finely laminated (varvite-like clays). Above erosional contact, the sequence No. II starts with light-coloured sands, only several centimetres thick. Sands are overlain by „collapsed" clay with numerous small-scale fissures and slides. Next layer is built of sand. The whole sequence is terminated by clays. Sequence No. III is composed of speleothem layer (flowstone) with protruded stalagmite. Speleothem is covered by laminated brownish clays.

Trhlovca Cave

The sedimentary profile about 3 m high has a very complicated internal structure (Fig. 5). It is represented by blocks separated by fissures. Blocks are moved. The disturbation of the profile is caused by the collapse of the right side of the profile. Sampling was performed in left part of the profile close to the limestone wall in a uniform sequence of sediments, and in the central part of the profile in sequence lying above original sediments and deposited only after the collapse. The profile in the left side is composed of variegated cave sediments with complicated lithology and internal structure. Clayey layers alternate with sandy beds. Black clay intercalations are very distinct feature here. Younger fill is composed of silty clays.

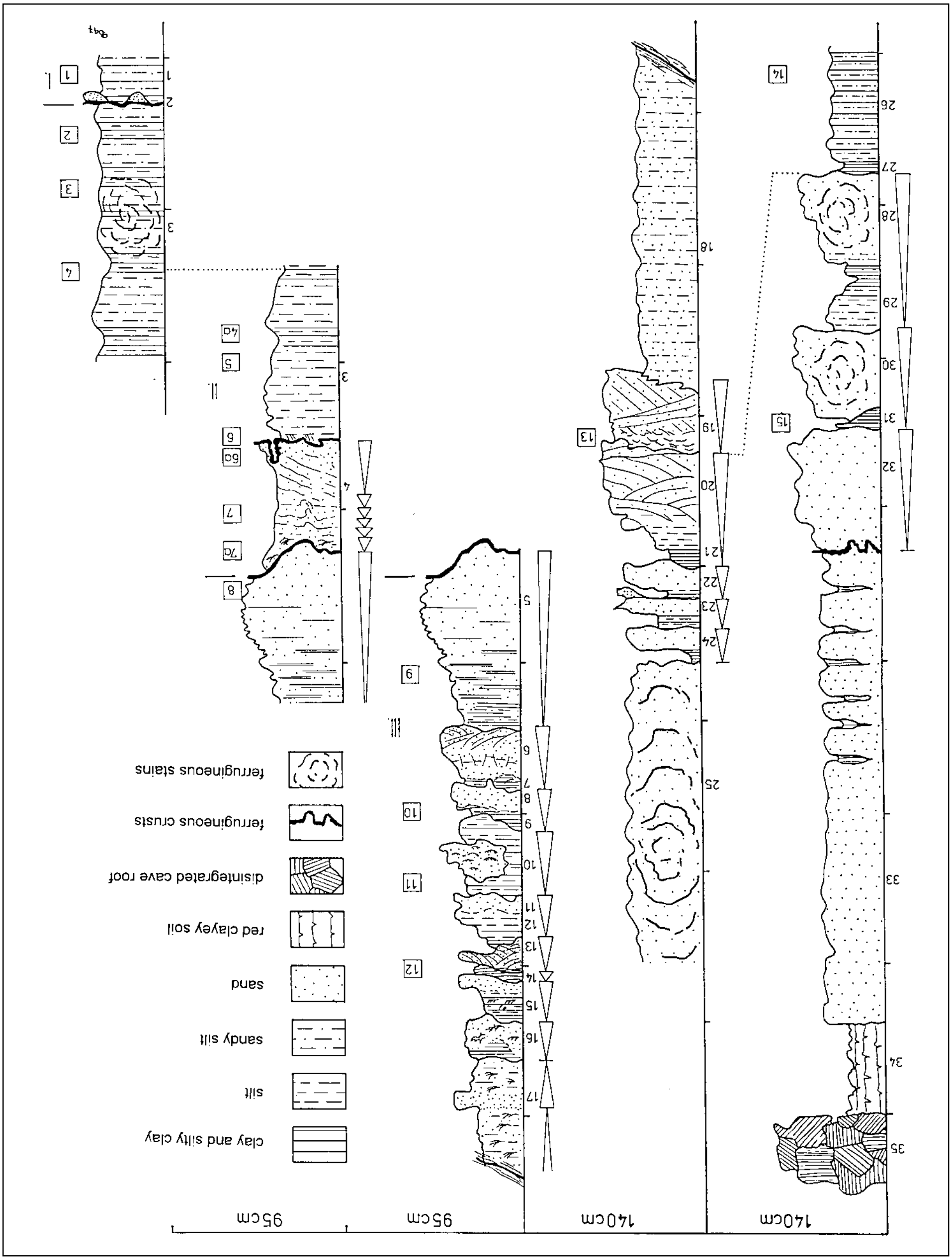

Fig. 3: Lithological log of the Divača profile (P. Bosák).
Number in squares refer to palaeomagnetic samples, small numbers refer to number of layer in the text.
Sl. 3: Litološki stolpec profila Divača (P. Bosak).
Številke v kvadratkih se nanašajo na paleomagnetne vzorce, majhne številke pa na številko plasti v tekstu.

MINERALOGICAL ANALYSES

Mineralogical analyses were completed on 16 samples. Samples were analysed by X-ray diffraction in the Geological Institute of NTF, Ljubljana University by Meta Bole. Some minerals which are probably present in the samples are not described because they are in too low quantity to be detected and thin sections were not done. The quantity of the minerals is given in respect to the height of the main reflection of a particular mineral in the X-ray record.

Divača profile

Twenty one samples were taken from the profile (Fig. 3) uncovered during construction of motorway. All samples contain: quartz from 62 % to 93 %, muscovite/illite from 4 % to 11 % and chlorite from 4 % to 15 %. Microcline was found in relative high quantity in one sample (10 %), and in traces in two samples. Plagioclase was found in traces in one sample. Minerals with mixed structure were detected in one sample (2 %), and in traces in another sample. Goethite was found in two samples (4 to 5 %). Calcite was found just in one (24 %).

Quartz, muscovite, microcline and plagioclase are derived from flysch rocks. Illite and chlorite probably originated in weathered remains of flysch rocks. Limonite crust in the cave was formed during longer break in sedimentation and also in red soil. Minerals with mixed structure were determined in both samples. Calcite represents white concretions which were formed by the cementation of sand.

Divaška Jama

Nine samples were taken from the excavated pit (Fig. 4) at the top of big hall called Žibernova Dvorana, at the end of Divaška Jama. All samples contain: quartz from 56 % to 74 %, chlorite from 13 % to 28 % and muscovite/illite from 11 % to 13 %. Plagioclase was found in two samples (about 2 %). Plagioclases in traces was found in one sample. Hematite was found in one sample (4 %) and goethit was detected in traces in another sample. Apatite was determined in traces in three samples.

Quartz, muscovite and plagioclase were derived from flysch rocks, illite and chlorite probably originated in weathered remains of flysch rocks. Hematite thinly coated individual particles is presents in sediments which were re deposited from surface red soil down to the cave. Apatite may indicate some organic material which came into the contact with sediment. P_2O_5 from apatite was also determined by chemical analyse in one sample (0,127 %).

Trhlovca Cave

Nine sample were taken from profile in the cave (Fig. 5). All samples contain: quartz from 41 to 92 % (in one sample only), muscovite/illite (traces to 5 %). Calcite is presented in all samples, except of one (4 to 48 %). Montmorillonite was found in two samples (about 2 %), and in traces in another two samples. Chlorite was detected in three samples (traces to 4 %). Goethite is present in three samples (traces to 6 %). Hematite was detected from traces to 3 % in two samples. Microcline was found in three samples (traces to 3 %). Gibbsite was presented, i.e. in layer with red clasts in amount of 8 %.

The Trhlovca profile shows the most heterogeneous mineral composition of all analysed sections here. Quartz, muscovite and microcline were derived again from flysch rocks and illite and chlorite were probably generated in weathered remains of flysch rocks. Hematite is probably redeposited from surface red soil down to the cave. Gibbsite composes red clasts and it represents mature product of weathering (formation of red soils and/or bauxite). Gibbsite and montmorillonite were found only in this profile. Calcite is presented in relatively high amount like secondary cement.

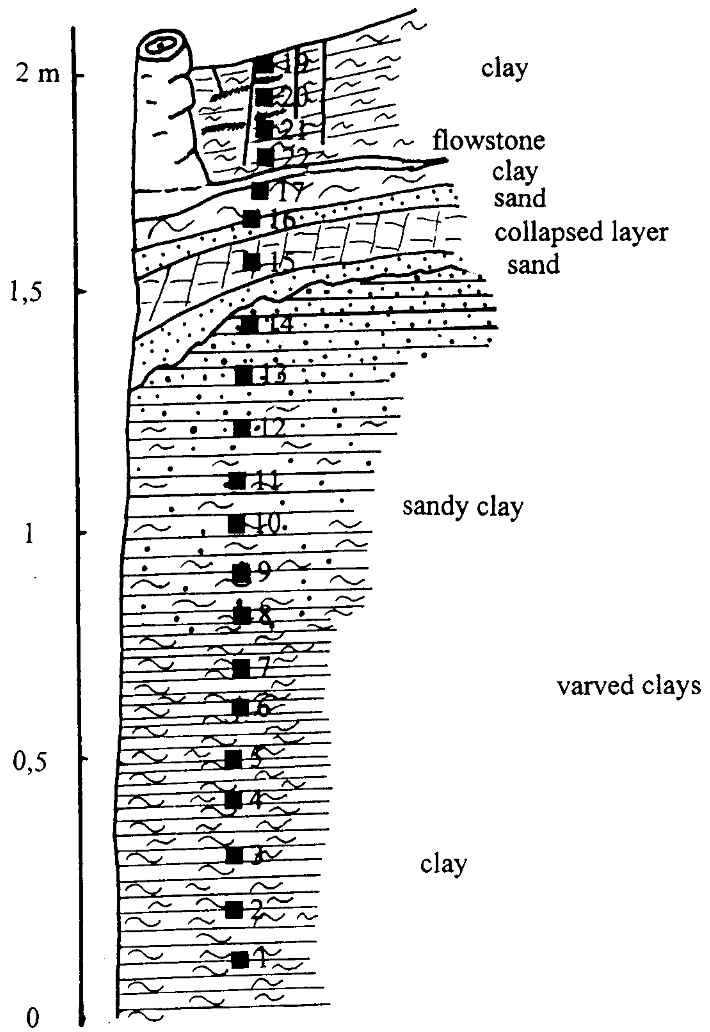

Fig. 4: Lithological log of the profile in the Divaška Jama (N. Zupan Hajna).
Black squares - samples for palaeomagnetic analyses, black dots (DJ) - sedimentological samples.
Sl. 4: Litološki stolpec profila v Divaški jami (N. Zupan Hajna).
Črni kvadrati - vzorci za paleomagnetne analize, črne pike (DJ) - sedimentološki vzorci.

Comparison of mineralogical composition

Sediments of all three profiles show different composition, nevertheless the mineral contents are too different as the main volume of the clastic material in studied sediments were derived from rocks of Eocene flysch, which is the main source area from which allogenic streams enter the Karst. The degree of weathering of the source rocks differed, feldspars indicate low weathering of source rock and some clay minerals indicate higher degree of weathering or developments from weathering/soil profiles. Gibbsite rarely found was presumably derived from red soils or bauxites which form abundant small clasts in some beds of the Trhlovca profile. The simplest mineral composition was defined in the Divaška Jama consisting of 5 different minerals and the most complex mineral composition was defined in the Trhlovca profile with 9 different minerals.

PALYNOLOGICAL ANALYSIS

Palynological analysis was performed with the respect to enable more precise dating of sediments from the Divača profile. The analyse was carried out in The Jovan Hadži Institute of Biology ZRC SAZU at Ljubljana by Dr. Metka Culiberg. Two pilot samples from the Divača profile were selected to be analysed. Samples were treated by a common palynological maceration.

No spores and pollen grains were found in microscopic examination of 4 sections from each sample.

PALAEOMAGNETIC ANALYSIS

Seventy nine oriented laboratory specimen of clay, sand, limestones and flysch rocks were investigated for their palaeomagnetic properties.

LABORATORY PROCEDURES

Laboratory procedures were combined in a way enabling the derivation of the respective components of magnetic remanence in different temperature intervals, during progressive thermal demagnetisation (TD) and demagnetisation by alternating field (AFD), the determination of moduli and directions of the remanent magnetisation. The volume of magnetic susceptibility as well as the determination of minerals - carriers of respective remanence components and phase or mineral changes.

Oriented hand samples were collected in the field from individual beds. Laboratory specimen in the form of small cubes 20 by 20 by 20 mm were prepared directly in the field (using plastic cubes) or cut from the rock samples. Specimen were measured on the spinner magnetometers JR-4 and JR-5 (Jelínek 1966).

Laboratory specimen in their natural state were subjected to progressive thermal demagnetisation using the MAVACS (Magnetic Vacuum Control System) apparatus securing the generation of a high magnetic vacuum in a medium of thermally demagnetised specimen (Pøíhoda et al. 1989). All of specimen were also demagnetised by the alternating field procedures, up to the field of 1,000 Oe. The apparatus Schonstedt GSD-1 was applied for AF demagnetisation. This procedure was more effective than the thermal demagnetisation, consequently, it was applied to the whole set of specimens.

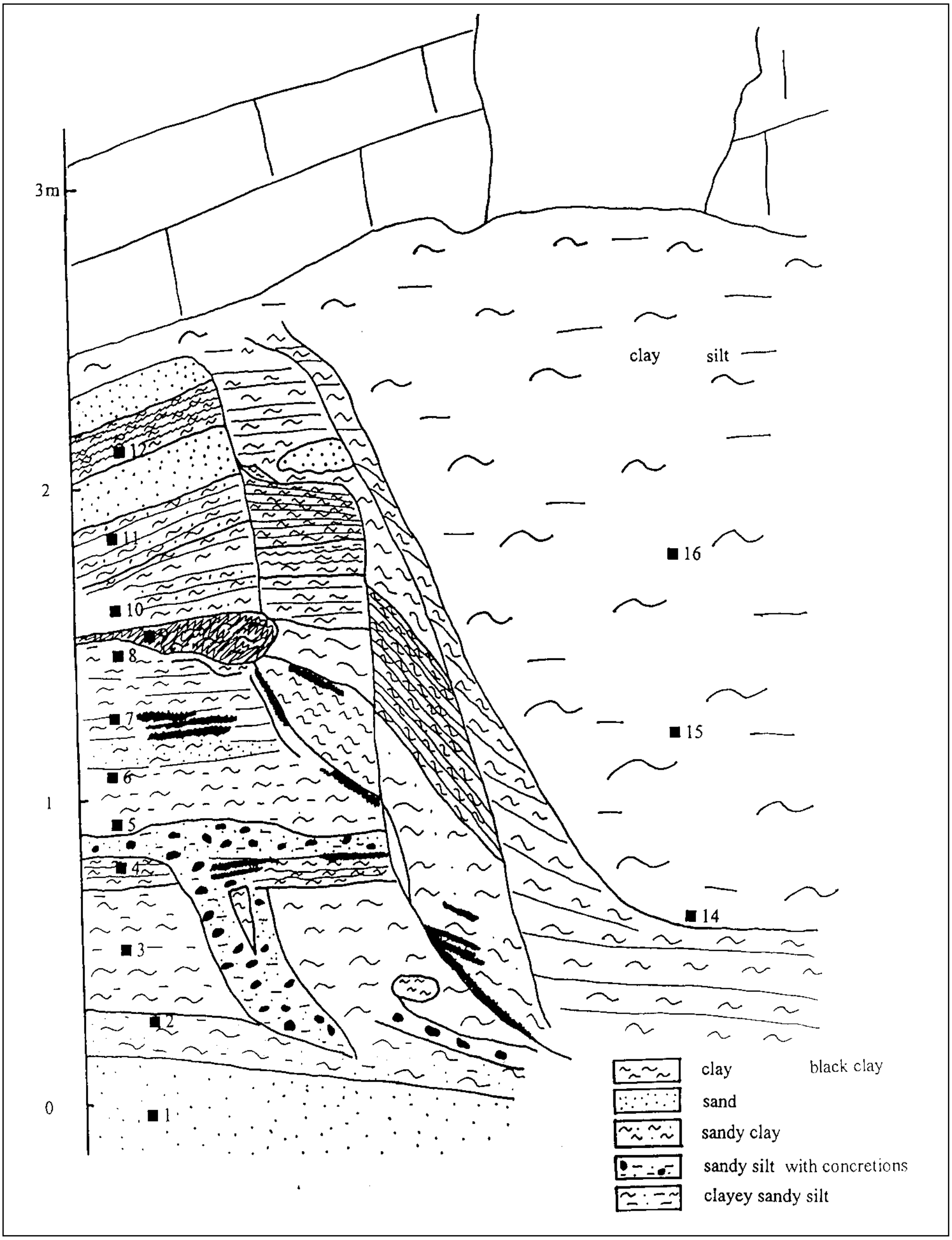

Fig. 5: Lithological log of the profile in the Trhlovca Cave (N. Zupan Hajna).
Black squares - samples for palaeomagnetic analyses.
Sl. 5: Litološki stolpec profila v jami Trhlovca (N. Zupan Hajna).
Črni kvadrati - vzorci za paleomagnetne analize.

The remanent magnetisation of speciments in their natural state (NRM) is identified by the symbol J_n the corresponding remanent magnetic moment by the symbol M. Graphs of normalized values of $M/M_o = F(t)$ were constructed for each analysed specimen.

The directions of J_n and those of the remanent magnetisation of the thermally or AF demagnetised specimens in the course of progressive demagnetisation procedures are shown in the stereographic projection. The full (blank) small square designates projection onto the lower (upper) hemisphere.

The orthogonal projection of the remanent magnetisation vectors is shown by the Zijderveld´s diagrams, where full small square indicates projection onto a horizontal plane (XY) and a blank small square indicates projection onto a north-south vertical plane (XZ). The natural state of the specimens is designated by NS.

Phase or mineralogical changes of magnetically active minerals (mostly Fe-oxides) frequently occur during the laboratory thermal tests, especially at low temperature intervals. These changes can be derived from the graphs of normalised values of $k_t/k_n = f(t)$, where k_n designates the volume magnetic susceptibility of the specimen in natural state and k_t is the susceptibility of specimen demagnetised at temperature t°C. The k_t and k_n values were measured on a kappa-bridge KLY-2 (Jelínek 1973). All specimen were measured for palaeomagnetic study are presented in the Catalogues of Primary Petromagnetic and Palaeomagnetic Data.

Separation of the respective remanent magnetisation components was carried out by using the multi-component analysis of Kirschvink (1980). The statistics of Fisher (1953) was employed for calculation of mean directions of the pertinent remanence components derived by the multi-component analysis.

Results

All collected samples were subjected to detailed demagnetisation by the alternating field (partly thermal), due to a complexity of the problem. However, basic magnetic properties of investigated rocks also yield some information useful for next geological considerations.

According to the values of moduli of J_n and k_n, samples may be divided into four categories:

(i) Samples from dark limestones of the Liburnian Formation have extremely low magnetisations and negative magnetic susceptibilities (resulting from the dominance of diamagnetic calcite). The mean values of moduli of remanent magnetization J_n and of magnetic susceptibility k_n in their natural state from the eight samples are $J_n = 0.009 \pm 0.003$ [nT], $k_n = -13 \pm 0.4 \times 10^{-6}$ [SI]. Owing to NRM values, samples were not subjected to detailed demagnetisation.

(ii) Samples of Eocene flysch rocks from village of Dane, near Divača, are characterised by low magnetic mean values of $J_n = 0.118 \pm 0.037$ [nT], $k_n = 67 \pm 10.10^{-6}$ [SI], $n = 5$. The low magnetic samples from the Divača profile show also the mean values of $J_n = 0.844 \pm 0.735$ [nT], $k_n = 103 \pm 26.10^{-6}$ [SI], $n = 29$. The symbol n represents the number of samples used for calculation. The J_n values were measured in a natural state with the sufficient degree of confidence.

(iii) Samples from the Trhlovca Cave are characterised by low up to intermediate magnetic J_n values The mean moduli values of $J_n = 4.03 \pm 3.89$ [nT], $k_n = 156 \pm 75.10^{-6}$ [SI], $n = 16$.

(iv) This category of samples are intermediate magnetic with reverse palaeomagnetic polarity from the Divaška Jama. The mean values for this group are as follows: $J_n = 7.93 \pm 5.06$ [nT], $k_n = 267 \pm 75.10^{-6}$ [SI], $n = 14$. Samples with normal polarity show considerably lower mean volume susceptibility values and the moduli of $J_n = 99.72 \pm 97.79$ [nT], $k_n = 1\,341 \pm 102.10^{-6}$ [SI], $n = 7$.

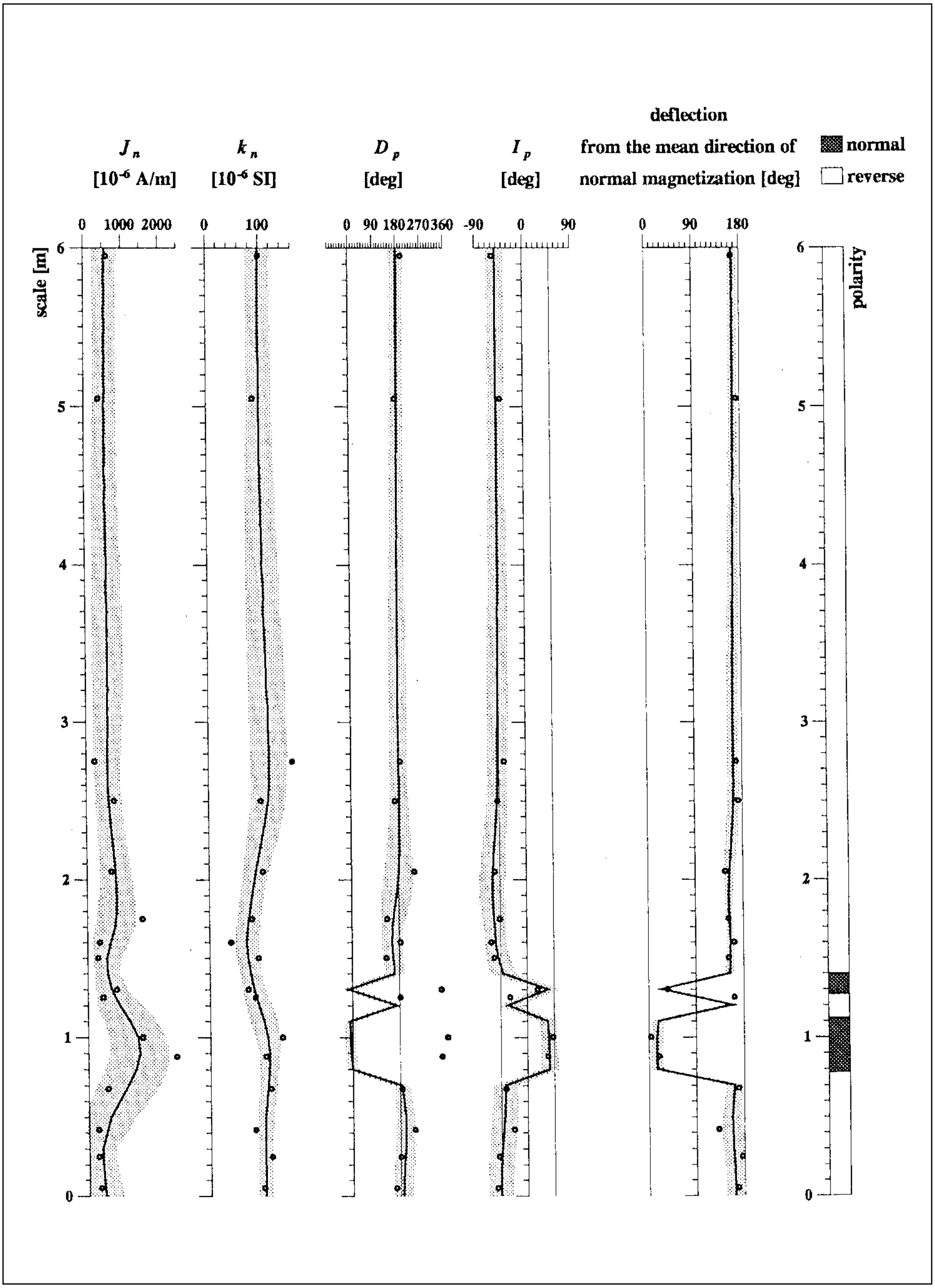

Fig. 6: Basic magnetic parameters of the samples from the Divača profile.
Sl. 6: Osnovni magnetni parametri vzorcev iz profila Divača.

Magnetic susceptibility values in dependence on temperature t, $k_t/k_n = \mathrm{f}(t)$, were investigated in all samples subjected to the progressive thermal demagnetisation.

Divača profile

Values of the J_n moduli of studied sediments in their natural state are exceptionally low, largely depending on the origin of the magnetisation. Values of volume magnetic susceptibility are also low but show smaller dispersion than J_n values. Basic magnetic parameters are documented for the about 6 m high profile (cf. Fig. 3) in Table 2. Selected samples (Nos. 4a/2 and 15/2) were progressively isothermally magnetised by a direct field with intensities of 1, 2, 4 up to 900 mT (19 steps). The values of saturated remanent magnetisation (J_s) reached high values - several hundreds of [nT].

All specimen were demagnetised by the AF (alternating field) procedures, up to the field of 1,000 Oe (14 steps). Several specimen were also experimentally subjected to thermal demagnetisation (TD) up to 500^{o}C, but generally less effective than by the AF demagnetisation.

The directions of remanent magnetisation inferred by the above given procedures were tested using the multi-component analysis (Kirschvink 1980). Samples showed three remanence components, in general: A, B and C. The *A-components* are mostly of viscous or chemoremanent (weathering) origin. They can be removed by an alternating field with the intensity up to 30 Oe.

Normal and reverse *C-component* directions of samples (marked by small full squares in Fig. 7) form two defined sets of samples with fisherian distribution. The number of normal components is only three, that means bigger value of a_{95} for the mean direction calculated after Fisher (1953) for the 95% probability level.

In the profile, this interval represents only 6 m of the thickness of strata. Two narrow normal magnetozones were detected in the lower part of reverse palaeomagnetic directions. The remanence components were not defined for two samples (Nos. 2 and 3) and two specimen disintegrated (Nos. 12 and 14).

Divaška Jama

The basic magnetic parameters are documented for about 2 m high log and totally 21 samples were taken (Tab. 2 and Figs. 4 and 7). All specimen were demagnetised by the AF procedures, up to the field of 1,000 Oe (14 steps). Selected samples (Nos. 8D/2 and 16D/2) were progressively isothermally magnetised by a direct field with intensities of 1, 2, 4 up to 900 mT (19 steps). The values of saturated remanent magnetisation (J_s) reached high values - several thousands of [nT].

The directions of remanent magnetisation inferred by the above given procedures were tested using a multi-component analysis (Kirschvink 1980). Samples showed also three remanence components, in general: A, B and C. The *A-components* are mostly of viscous or chemoremanent (weathering) origin and they can be removed by an alternating field of 10 up to 30 Oe.

The normal and reverse *C-component* directions of samples (Fig. 8) form two defined sets of samples with fisherian distribution. The top of the profile shows normal magnetozone. The narrow reverse and normal magnetozones are situated in the upper part of the log. The middle and lower parts of the profile show reverse palaeomagnetic directions. The remanence componet was defined by question mark for specimen No. 13.

Trhlovca Cave

The values of the J_n moduli of studied rocks in their natural state show big dispersion (see Tab. 3). The values of volume magnetic susceptibility are low but show a smaller dispersion than J_n values. Basic magnetic parameters are documented for the about 4 m high log (cf. Fig. 5) in Figure 9.

All specimen were demagnetised by the AF procedures, up to the field of 1,000 Oe (14 steps). Selected samples (Nos. 6T/2 and 8T/2) were progressively isothermally magnetised by a direct field with intensities of 1, 2, 4 up to 900 mT (19 steps). Saturated remanent magnetisation (J_s) reached values of several hundreds to about thousand of [nT].

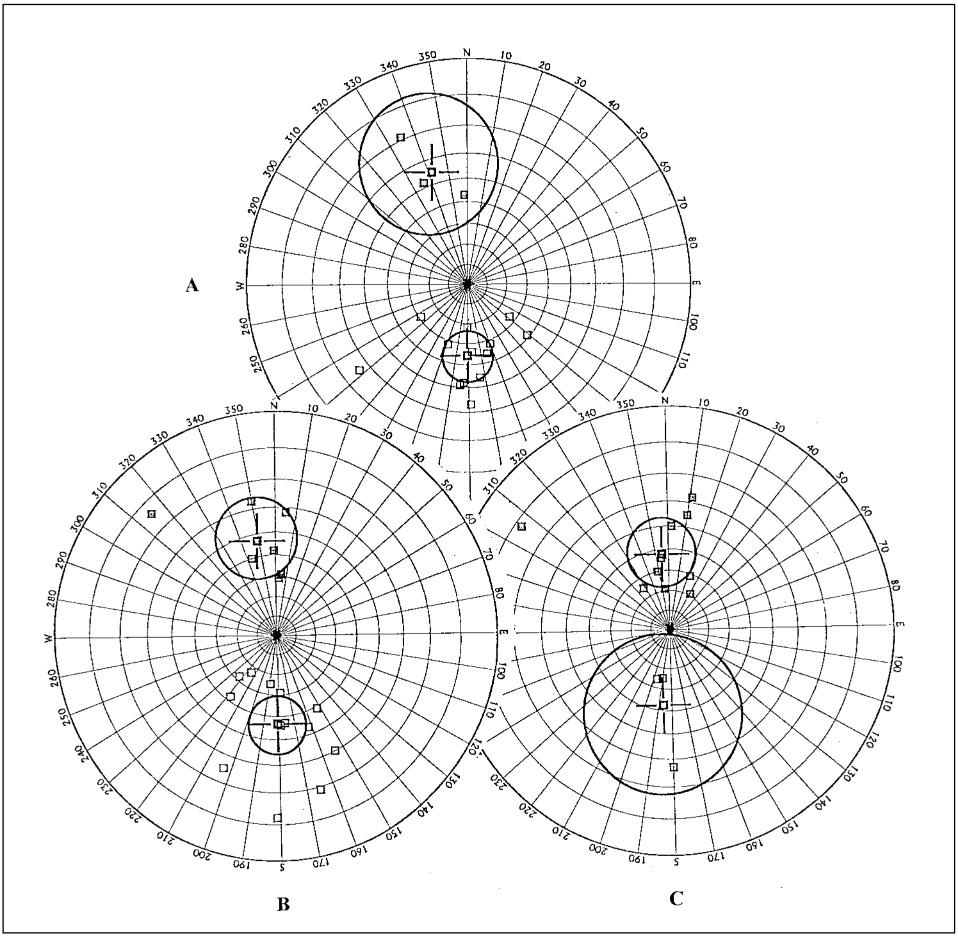

Fig. 7: Palaeomagnetic directions of C-components of remanent magnetisation of samples from Divača profile (A), Divaška Jama (B), and Trhlovca Cave (C).
Sl. 7: Paleomagnetne smeri C-elementov remanentnega magnetizma v vzorcih iz profila Divača (A), Divaške jame (B), in jame Trhlovce (C).

The directions of remanent magnetisation inferred by the above given procedures were tested using a multi-component analysis (Kirschvink 1980). Samples showed again three remanence components: A, B and C. The *A-components* are mostly of viscous or chemoremanent (weathering) origin. They can be removed by an alternating field of 10 to 30 Oe.

The normal and reverse *C-component* directions of samples (Fig. 7) form two defined sets of samples with fisherian distribution. A multi-component analysis of the normal components gives results of the lower range of the alternating field than for the reverse components. The long normal magnetozone was interpreted from the top across the middle part of the 4 m high log. The lower part of the profile shows reverse palaeomagnetic directions. The remanence component was defined by question mark for five specimen.

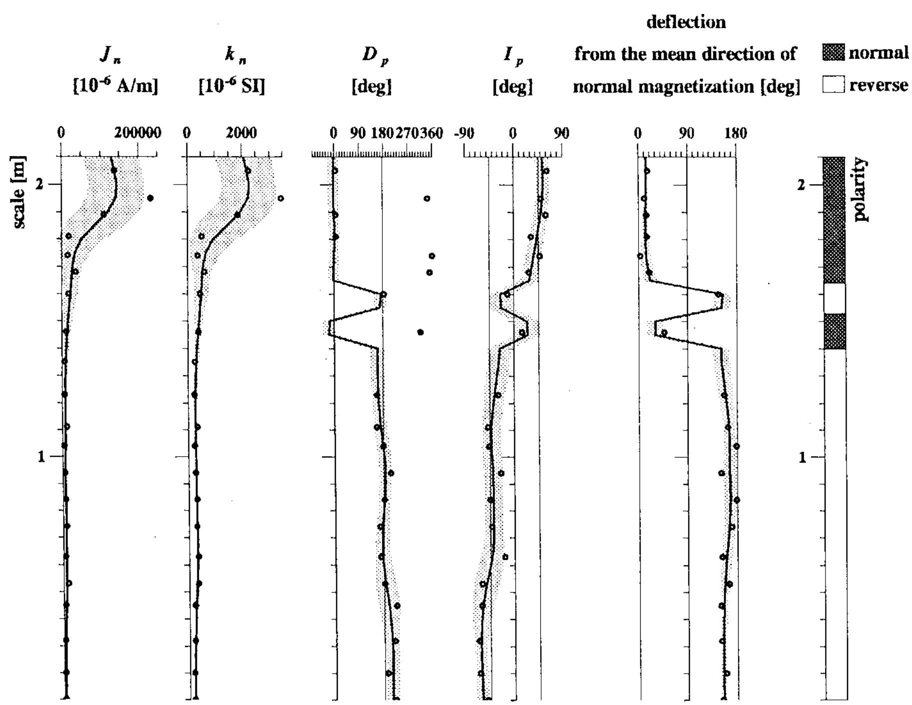

Fig. 8: Basic magnetic parameters of the samples from the Divaška Jama.
Sl. 8: Osnovni magnetni parametri vzorcev iz Divaške jame.

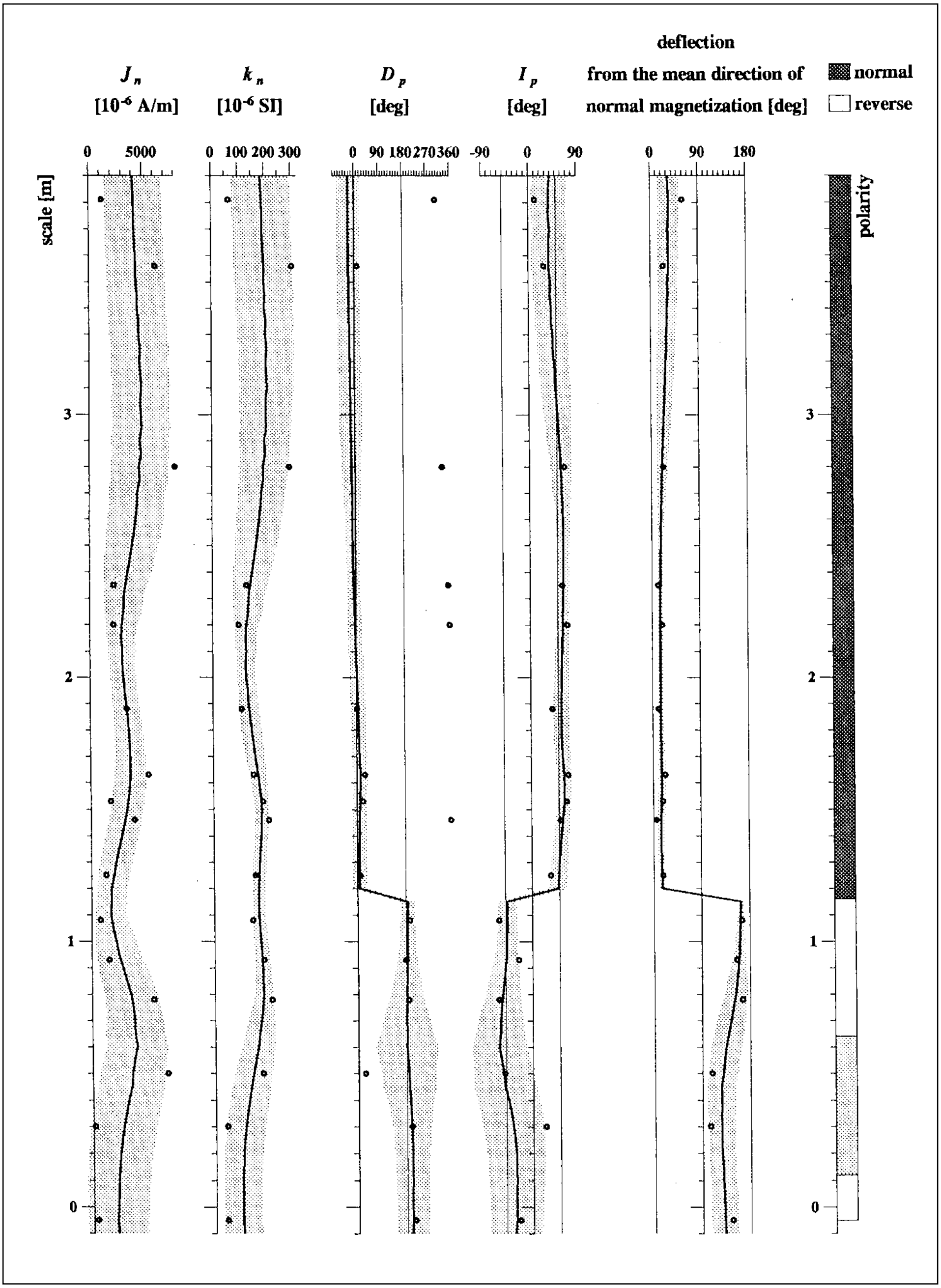

Fig. 9: Basic magnetic parameters of the samples from the Trhlovca Cave.
Sl. 9: Osnovni magnetni parametri vzorcev iz jame Trhlovca.

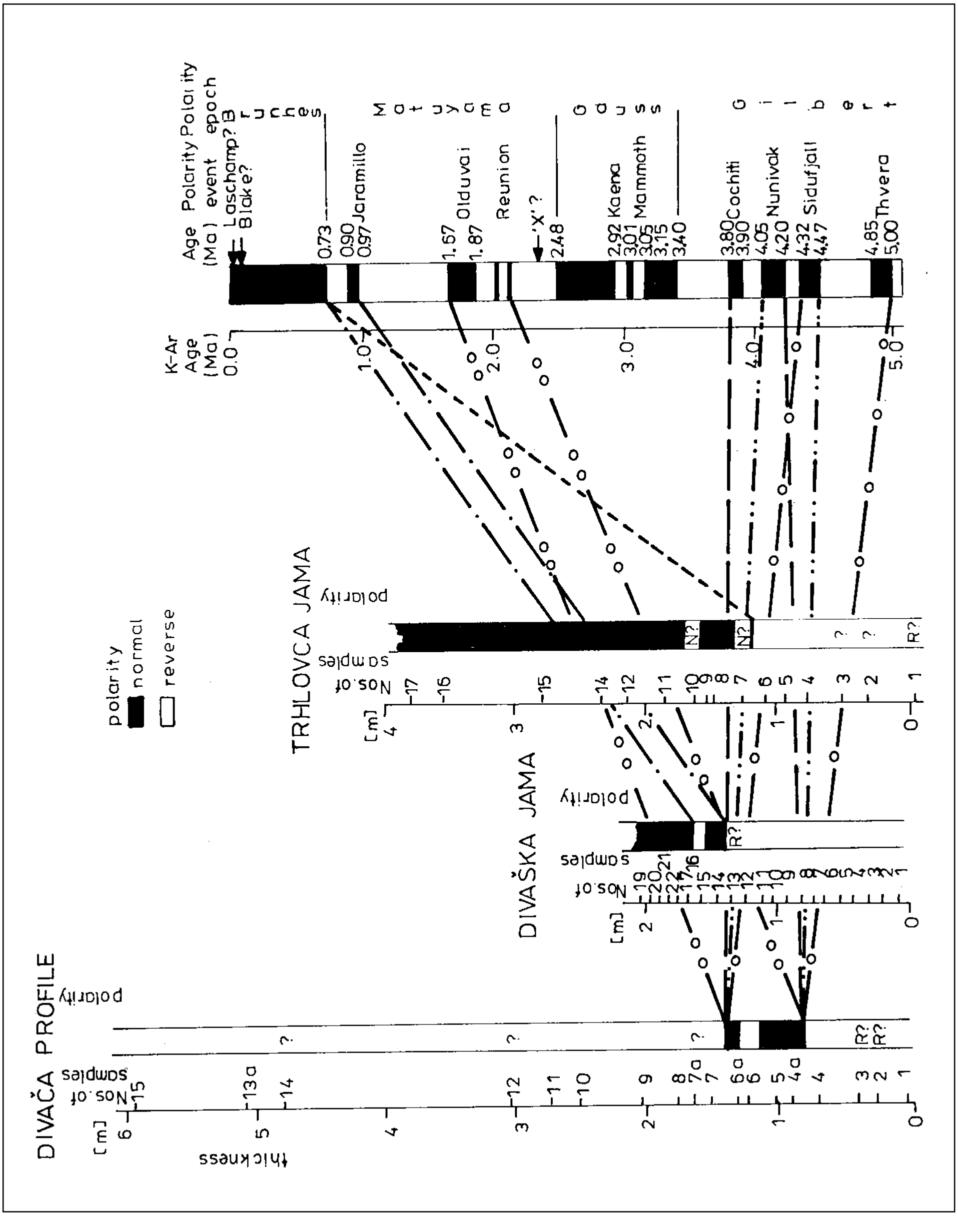

Fig. 10: Magnetostratigraphic data for three cross-sections and the correlation according to Pliocene-Pleistocene geomagnetic polarity time scale (Mankinen and Dalrymple 1979 and Butler 1991).

Sl. 10: Magnetostratigrafski podatki za tri preseke in korelacija glede na Pliocen-pleistocensko geomagnetno polarnostno časovno skalo (Mankinen in Dalrymple 1979 in Butler 1991).

	D1	D2	D5	D11	D19	D21	DJ4	DJ6	DJ7	DJ8	T1	T3	T4	T5	T7	T9
K	85	79	76	93	62	70	68	74	56	67	70	70	90	90	92	41
Ca	0	0	0	0	24	0	0	0	0	0	22	7	0	5	4	48
Mu/IL	8	11	9	4	6	10	11	11	13	11	4	5	3	2	1	4
Mo	0	0	0	0	0	0	0	0	0	0	2	0	2	1	1	0
Kl	5	4	6	3	6	15	18	13	28	22	0	4	2	0	1	4
Mi	1	0	10	0	1	0	0	0	0	0	3	0	0	1	1	0
PL	1	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0
H	0	0	0	0	0	0	0	0	4	0	0	0,001	0	0	0	3
G	0	4	0	0	0	5	0	0	0	1	0	6	3	0	0	0
Gi	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0
ML	0	2	0	0	0	0,001	0	0	0	0	0	0	0	0	0	0
Ap	0	0	0	0	0	0	0,001	0,001	0,001	0	0	0	0	0	0	0

Table 1: Mineral composition of clastic sediments in the Divača profile, Divaška Jama and Trhlovca Cave; % are defined with regards to the main intensity peaks of minerals.
Legend: K-quartz, Ca-calcite, Mu/IL-muscovite/illite, Mo-montmorillonite, Kl-chlorite, Mi-microcline, PL-plagioclase, H-hematite, G-goethite, Gi-gibbsite, ML-minerals with mixed structure, Ap-apatite.
Tabela 1: Mineralna sestava klastičnih sedimentov v profilu Divača, Divaški jami in Trhlovci; % vsebnosti mineralov so relativni, določeni glede na intenziteto njihovega glavnega odboja.
Legenda: K-kremen, Ca-kalcit, Mu/IL-muskovit/illit, Mo-montmorillonit, KL-klorit, Mi-mikroklin, PL-plagioklaz, H-hematit, G-goethit, Gi-gibbsit, ML-minerali z zmesno strukturo, Ap-apatit.

Eocene flysch rocks

Five specimen were demagnetised by the AF procedures, up to the field of 1,000 Oe (14 steps). The directions of remanent magnetisation inferred by the above given procedures were tested using a multi-component analysis (Kirschvink 1980). Samples showed again three remanence components: A, B and C. The *A-components* are mostly of viscous or chemoremanent (weathering) origin. They can be removed by an alternating field of 10 to 30 Oe.

The normal and reverse *C-component* directions of the samples form two defined sets of samples with Fisherian distribution. The number of reverse components is only two, that means the value of a_{95} for the mean direction calculated after Fisher (1953) for the 95% probability level was not calculated.

Liburnian Formation

Samples of dark limestones were not subjected to detailed demagnetisation because of their extremely low magnetisation (see Tab. 3). The mean values of remanent magnetisation in their natural state from eight samples is 0.009 [nT]. The directions of remanent magnetisation are impossible to be defined. The mean direction RM, including interpreted the range of AF field are documented in Table 4 for all investigated localities.

Magnetostratigraphic results

Palaeomagnetic and magnetostratigraphic investigations carried out on 79 oriented laboratory speciments of cave sediments (clays, sands), limestones of the Liburnian Formation and Eocene flysch rocks yield data concerning basic magnetic properties and identification of palaeomagnetic directions:

(i) Preliminary data derived from pilot samples collected from cave profiles in SW Slovenia indicates that, by means by alternating field of demagnetisation, data suitable for multi-component analysis of remanence may be reliably derived and palaeomagnetic directions tested.

(ii) The thermal demagnetisation proved to be non-effective on these samples, but good results were obtained by alternating field.

(iii) Magnetostratigraphic investigations of three profiles in caves defined normal and reverse polarity magnetozones (see Fig. 10), black parts of columns show magnetozones with normal polarity, white columns show magnetozones with reverse polarity.

(iv) Magnetostratigraphic results indicates also question marks (N? or R?) in polarity poorly defined.

(v) Magnetostratigraphic data in the Divača profile show two narrow normal magnetozones in the lower part of reverse palaeomagnetic directions.

(vi) Magnetostratigraphic results of samples from the Divaška Jama and Trhlovca Cave show the correlation between both profiles. The normal magnetozones were interpreted for the upper part of the profiles. The lower part of the profile show reverse polarity.

(vii) The narrow reverse and normal magnetozones are indicated in the upper part of the profile in the Divaška Jama.

Divača profile

No. of samples	J_n [nT]	k_n [10^{-6}SI]
1/1	0.424	105
1/2	0.381	100
2/1	0.689	91
2/2	0.300	115
3/1	0.748	99
3/2	0.304	84
4/2	0.643	114
5/1	1.174	153
5/2	1.830	136
6/2	0.503	86
7/2	0.330	92
8/1	0.342	112
8/2	1.853	80
9/1	0.556	134
9/2	0.812	101
10/1	0.553	123
10/2	0.913	98
11/1	0.311	138
11/2	0.263	158
15/1	0.345	108
15/2	0.761	99
4a/1	2.545	115
4a/2	2.972	105
6a/1	2.431	101
6a/2	0.961	72
7a/1	0.372	46
7a/2	0.399	40
13a/1	0.284	92
13a/2	0.478	87

Divaška Jama

No. of samples	J_n [nT]	k_n [10^{-6}SI]
1D/2	3.230	177
2D/2	3.031	164
3D/2	2.722	202
4D/2	4.980	210
5D/2	14.391	333
6D/2	5.939	339
7D/2	10.624	287
8D/2	7.469	302
9D/2	5.935	258
10D/2	4.393	226
11D/2	13.461	327
12D/2	6.868	224
13D/2	6.853	244
14D/2	12.804	392
15D/2	21.112	448
16D/2	43.860	603
17D/2	17.937	363
19D/2	172.753	2 229
20D/2	291.484	3 435
21D/2	137.312	1 844
22D/2	21.910	520

Table 2: Natural remanent magnetisation (J_n) and volume magnetic susceptibility (k_n) of samples from the Divača profile and Divaška Jama.
Sample No. .../1 - thermal demagnetisation; Sample No. .../2 - alternating field demagnetisation.
Tabela 2: Naravna remanentna magnetizacija (J_n) in obseg magnetne susceptibilnosti (k_n) v vzorcih iz profila Divača in Divaške jame.
Vzorec No. .../1 - termalna demagnetizacija; Vzorec No. .../2 - izmenično poljska demagnetizacija.

DISCUSSION

During the construction of the motorway in the SW part of Slovenia, fossil caves filled by different types of sediments were found. Some of them lost their original roof due to intensive denudation processes, especially by chemical denudation of carbonate surface of the Kras. Caves are dominantly filled with fluvial cave sediments, which deposited in the inner cave facies. Such facies are commonly highly depleted in fossil remains, not only in the Kras. Three profiles of cave sediments were investigated. Profiles through inner cave facies in the Divaška Jama-Trhlovca Cave system were selected to be compared with fill of fossil cave found near Divača, not only for correlations of magnetostratigraphy, but also for sedimentological purposes.

Divača profile

So-called Divača profile, uncovered directly by construction operations in a shallow surface depression, represents fossil cave completely choked by a sequence of fluvial deposits. The sequence can be divided into four parts, i.e. lower one composed mostly of laminated clays and silty clays, the second one built of silty clays to silts with sandy admixture, the third one consisting of typical sandy-clayey fluvial cycles 4 to 40 cm thick, and the last one represented by redeposited red soils. The roof of cave was partly disintegrated. The total thickness of the uncovered fill was about 6 m, the rocky bottom was not reached by the excavator.

Sediments are highly ferruginised and in places strongly cemented by poikilitic calcite cement. The profile is disturbed by fissures originated during slumping caused by the collapse probably due to rejuvenated karstification. In the lower part of the log, there are three distinct ferruginised zones (ferricretes). Sediments above the ferricretes differ more or less from those below these zones. The lower ferricrete divides the sequence I from the sequence II. Just below it, there are preserved rests of sandy channel fills. The middle ferricrete separates lutites of the lower part of the log from fluvial cyclic and dominantly sandy upper part of the log. The upper ferricrete is situated in the lower part of the cyclic sequence III. Only above this zone, there are developed typical cycles. Without any doubts, ferruginised zones represent breaks in deposition. The breaks in deposition were accompanied by infiltration of solutions enriched in iron coming most probably from intensive surface weathering.

The change from relatively calm deposition of the sequences I and II in the lower portion of the log into cyclic sandy deposition of the sequence III indicates important change of hydraulic conditions caused by some external change, which can be classified as climatic change and/or the change of hydraulic/relief gradient. It was the real start of the fossilisation of the cave resulting in its complete filling. Nevertheless, the change was not abrupt. It started slowly in two pulses as identified by two ferruginised zones at the base of the cyclic sequence III. It cannot be completely excluded, that sequences I and II are results of two-phase deposition in calm phreatic environment with slow sedimentation from turbid currents, as indicated by very fine-grained lithology with only some sandy admixture. Deciphering from ages of possible respective normal magnetozones (lasting from 80 to 150 ka) and from the thickness of studied zone (40 cm with samples Nos. 4a and 5, cf. Fig. 10), than the depositional rate of the sequence II was relatively very slow - 1 mm (of compacted sediment) per 200-375 years.

Magnetostratigraphic data in the Divača profile detected two narrow normal magnetozones

Trhlovca Cave

No. of samples	J_n [nT]	k_n [10^{-6}SI]
1T/2	0.417	44
2T/2	0.172	43
3T/2	8.818	180
4T/2	7.212	215
5T/2	1.993	185
6T/2	0.988	145
7T/2	1.690	155
8T/2	5..092	207
9T/2	2.283	185
10T/2	6.761	150
11T/2	4.240	107
12T/2	2.725	98
14T/2	2.786	128
15T/2	10.063	291
16T/2	7.767	304
17T/2	1.465	65

Liburnian Formation

No. of samples	J_n [nT]	k_n [10^{-6}SI]
SLO 1/1	0.007	-13
SLO 1/2	0.009	-13
SLO 2/1	0.005	-13
SLO 2/2	0.010	-13
SLO 3/1	0.008	-13
SLO 3/2	0.012	-13
SLO 4/1	0.014	-13
SLO 4/2	0.010	-12

Eocene flysh

No. of samples	J_n [nT]	k_n [10^{-6}SI]
SLO 5/1	0.136	55
SLO 5/2	0.134	54
SLO 6/1	0.165	76
SLO 7/1	0.098	76
SLO 7/2	0.058	74

Table 3: Natural remanent magnetisation (J_n) and volume magnetic susceptibility (k_n) of samples from the Trhlovca Cave, Liburnian Formation and Eocene flysch.
Tabela 3: Naravna remanentna magnetizacija (J_n) in obseg magnetne susceptibilnosti (k_n) v vzorcih iz jame Trhlovca, Liburnijske formacije in eocenskega fliša.

separated by reverse magnetozone within long reverse polarity zone. The interpretation of such picture is problematic, as there were not detected any palaeontological finds in pilot samples. Two narrow normal magnetozones probably correlate with Olduvai and Reunion polarity events (about 1.67 to 1.87 Ma) of the reverse Matuyama epoch or with some of four normal magnetozones (Cochiti about 3.80 to 3.90 Ma, Nunivak 4.05 to 4.20 Ma, Sidufjall 4.32 to 4.47 or Thvera 4.85 to 5.00) within the reverse Gilbert epoch.

Magnetostratigraphic dating indicate some possibilities concerning the speleogenesis of the cave. The interpretation of normal and reverse polarities detected in the profile show the pre-Quaternary age of the sedimentary fill. Sediments were deposited during Pliocene, without any doubts, dating the fossilisation of the cave. Therefore, the cave itself was formed before the deposition of sediments and complete filling.

Thus, the speleogenesis could be connected with the Messinian period (especially if normal magnetozones are correlated within the reverse Gilbert epoch), when the sea level of the Mediterranean rapidly fallen down to the level of -1,500 m (Hsü, Cita and Ryan 1973, Hsü et al. 1977). This period is connected with deep entrenchment of valleys in regions surrounding the Mediterranean Basin, e.g. valleys of Ebro, Durance, Var, Po or Orontes Rivers, valley of Rhône River in southern France with extreme thickness of Pliocene-Quaternary fill (Clauzon 1973, 1980), Nile Valley in Egypt (Khumakov 1967, 1971), valleys in carbonate plateau of Cyrenaika in Libya or in carbonate-flysch region of Istria in Croatia (e.g. „Limfjord"). Deep karst developed in the whole Mediterranean region (G3azek 1993) as a result of underground karst drainage directed into the Mediterranean Basin from its foreland. Now submerged parts of such systems are often expressed by large submarine springs (vrjula on the Adriatic coast, Cyrenaica, Apulia, southern France, etc.). Very probably, the Divača fossil cave is a result of this phase. More, it is situated in relatively high altitude and its roof is presently relatively very thin indicating substantial thinning by chemical denudation. Its fossilisation resulted from changes in regional base level and hydrological situation due to gradual relief/neotectonic evolution of this part of the Kras and sea level changes in the Mediterranean Basin.

Divaška Jama

The profile was 2 m high and was lithologically relatively uniform, representing typical inner cave facies. Two general parts can be distinguished, separated by speleothem horizon (flowstone with stalagmite, which was dated by the U-series method to over 350 ka, A. Mihevc, pers. comm.). Both sedimentary sequences are more or less composed of lutitic laminites. Just below the speleothem, lamitites alternate with sands. The lower sequence can be described as the sediment of very calm sedimentary environment with gradually increased agitation (increased sandy input). Prior the deposition of speleothem, the environment changed abruptly. Laminites are overlain by two sandy layers separated by clay with „collapse" structures. The contact of laminites and lower sandy layer is distinctly erosional. „Collapse" structures indicate movement of fresh sediment, probably owing to lateral erosion of channel. The rate of deposition deciphered from palaeomagnetic data was low in laminites, i.e. 1 mm (of compacted sediment) per 100 years (70 mm around sample No. 14 during 7 ka of Jaramillo) or 2,65 mm (of compacted sediment) per 100 years (185 mm around samples Nos. 13 and 14 during 7 ka of Jaramillo, if sample No. 13 has normal polarisation).

The sequence of laminites above the speleothem highly resemble cave lacustrine deposits known from some other caves.

Trhlovca Cave

The profile in this site is highly lithologically complicated inner cave facies with the dominance of clay and silt layers, sometimes of highly irregular geometry. Two features are very distinct, i.e. layers of black clays (most probably enriched in Mn-minerals) and layer with reddish clasts with abundant gibbsite. There are developed several erosional boundaries. The most prominent one,

Locality	Polarity	Mean palaeomagnetic directions		α_{95} [°]	k	n	* AF [Oe] ** AF [Oe]
		D [°]	I [°]				
DIVAČA PROFILE	N	341.8	35.1	27.2	21.5	3	* 650-1000
	R	180.8	- 54.2	11.9	13.1	13	* 200-1000
DIVAŠKA JAMA	N	349.2	43.1	17.4	13.0	7	* 150-1000
	R	180.9	- 46.7	12.7	11.7	13	* 200-1000
TRHLOVCA	N	354.8	52.3	15.8	10.3	10	* 120-1000
	R	186.4	- 52.4	35.0	13.4	3	** 200-650
DANE NEAR DIVAČA	N	331.4	61.1	15.3	66.0	3	* 150-1000
	R	219.5	- 47.1	-	-	2	* 200-1000

Table 4: Mean palaeomagnetic directions for investigated localities.
*D, I - declination, inclination of the remanent magnetisation after dip correction, a_{95} - semi-vertical angle of the cone of confidence calculated according to Fisher (1953) at the 95% probability level, k - precision parameter, n - number of samples analysed, * - multi-component analysis by Kirschvink, ** - statistics according to Fischer.*
Tabela 4: Povprečne paleomagnetne smeri za preiskovane lokacije.

accompanied by widely open fracture, is overlain by sandy silt with gibbsite-bearing clasts. Another erosion occurs at the base of layer with palaeomagnetic sample No. 9 (cf. Fig. 5). After the cave was completely filled by this variegated sequence, the fill was eroded by channel and margins of our profile slumped which was accompanied by the origin of subparallel fissures cutting the section. The channel was later filled with a sequence of silty clays. The rate of deposition deciphered from palaeomagnetic data was low, i.e. 3.2 mm (of compacted sediment) per 100 years (220 mm of layer with sample No. 10 during 7 ka of Jaramillo).

Magnetostratigraphic investigations obtained from two profiles in the Divaška Jama-Trhlovca Cave system allow the mutual correlation. According to Pliocene-Pleistocene geomagnetic polarity time scale of Mankinen and Dalrymple (1979) in Butler (1991), narrow normal magnetozone most probably correlates with the Jaramillo polarity event (0.90 to 0.97 Ma) of the reverse Matuyama epoch. Such datum evidences for a substantial age of the cave system of Divaška jama-Trhlovca, when the older phases of cave filling by sediments is about 1 Ma old and the rest fall into the reverse Matuyama epoch, i.e. sediments are older than 0.73 Ma (Brunhes/Matuyama boundary). This datum correlates with earlier datum from the Divaška Jama indicating that the age of sediments below flowstone layer is older than 350 ka.

CONCLUSIONS

Three profiles of caves sediments were studied for their magnetic properties and mineralogical composition in the area of the SW part of Slovenia.

Mineralogical study proved relatively uniform mineral composition of the light fraction indicating the main source from Eocene flysch sediments which were weathered into different degree. Some minerals are derived from weathering profiles and crusts. The surprising find of gibbsite-bearing clay clasts in the Trhlovca Cave indicate the destruction of red soils or bauxite on the surface in the time of deposition of cave sediments.

Magnetostratigraphic investigations obtained for three cross-sections defined normal and reverse polarity magnetozones (Fig. 10) and shows the correlation between the profiles in the Divaška Jama and Trhlovca Cave. According to Pliocene-Pleistocene geomagnetic polarity time scale of Mankinen and Dalrymple (1979) in Butler (1991) the narrow normal magnetozones probably correlates with the Jaramillo polarity event (0.90 to 0.97 Ma) of the Matuyama epoch. Magnetostratigraphic data of the Divača profile detected, two narrow normal and one reverse magnetozones in the long reverse polarity zone. Two narrow normal magnetozones probably correlates with Olduvai and Reunion polarity events (about 1.67 to 1.87 Ma) of reverse Matuyama epoch or with two of four normal magnetozones (about 3.8 to 5.0 Ma) within reverse Gilbert epoch.

Magnetostratigraphic data in the Divača profile indicate the possibility that the cave itself was originated during the Messinian period characteristic by extreme sea-level fall accompanied by the evolution of deep karst in the Mediterranean Basin and its surroundings. Data from the Divaška Jama-Trhlovca Cave system indicate also substantial age of cave fill which started to be deposited below 0.97 Ma and finished before the Brunhes/Matuyama boundary, i.e. around 0.73 Ma.

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PALEOMAGNETNE RAZISKAVE JAMSKIH SEDIMENTOV V JZ SLOVENIJI

Povzetek

Paleomagnetne raziskave jamskih sedimentov so bile narejene v izbranih profilih v fosilni jami blizu Divače, v Divaški jami v Trhlovci na Krasu blizu Divače.

Mineraloška analiza jamskih sedimentov izpričuje relativno enotno sestavo lahke frakcije in kaže na njihov glavni izvor v preperelih ostankih eocenskega fliša. Nekaj mineralov je produkt preperevanja in skorij kot na primer prisotnost gibbsita v plasti z glinenimi klasti v Trhlovci. Glineni klasti z gibbsitom kažejo na razpad rdečih tal ali boksita na površju v času usedanja jamskih sedimentov.

Podrobna magnetostratigrafska raziskava treh profilov kaže na normalno in reverzno polarnost magnetocon in kaže na korelacijo med profiloma v Divaški jami in Trhlovci. Glede na Pliocen-Pleistocensko geomagnetno časovno skalo po Mankinen & Dalrymple (1979) in Butler (1991) ozke normalne magnetocone verjetno sovpadajo z Jaramillo polarnim dogodkom (0.90 do 0.97 Ma) v Matuyama epohi. Dobljeni podatki iz Divaške jame in Trhlovce kažejo na močno obdobje zapolnjevanja jame, ki je nastopilo pred 0,97 Ma in se končalo pred Brunhes/Matuyama mejo to je pred približno 0.73 Ma.

Magnetostratigrafski podatki profila iz fosilne jame pri Divači so zabeležili dve ozki normalni magnetoconi v dolgi reverzni polarni coni, kar verjetno sovpada z Olduvai oz. Reunion (okrog 1.67 do 1.87 Ma) reverzne Matuyama epohe ali pa z normalnimi magnetoconami (okrog 3.8 d0 5.0 Ma) v reverzni Gilbert epohi. Podatki nakazujejo možnost, da je jama nastala v messinski stopnji, za katero je značilen drastičen padec morske gladine in razvoj globokega krasa v Mediteranskem bazenu in njegovi okolici.