EXCURSION "A"

Budapest - Szentendre - Visegrád - Esztergom - Tata - Vör tesszőlős

compiled by
M. Kázmér
Excursion A presents some aspects of the geology of the northeastern part of the Transdanubian Central Range (from Middle and Upper Triassic through Jurassic, Cretaceous, Eocene, Oligocene, Miocene to Pleistocene sedimentary and igneous rocks). The history of cultures can be studied from the Vértesszőlős man (350,000 years old) through Stone, Bronze and Iron age settlements, Roman cities, Middle Age castles and Baroque towns to modern Hungary. Three capitals of Hungary - ancient and present - can be found here. The region to be visited displays important industrial centres, farming lands and tourist recreation areas.

Good luck!
Buda Hills

Budapest lies on both sides of the Danube. Buda, on the right bank, is a hilly landscape with Jánoshegy (529 m a.s.l.) as its highest point. Pest, on the left bank is a large plain with an average height of 100 m above sea level, surrounded by gently sloping hills.

The oldest rocks of Buda Hills are Middle Triassic (Ladinian) dolomites with Diplopora annulata, overlain by Upper Triassic (Carnian) bituminous, cherty limestones and dolomites. They are followed by Upper Carnian - Norian Hauptdolomit and Dachstein Limestone containing one hundred species of the richest Norian fauna of the Alpine Triassic. After a considerable (Uppermost Triassic - Lower Eocene) hiatus some Middle Eocene mineable coal seams developed and were covered by transgressive sediments. Upper Eocene rocks are nummulitic limestones bryozoan marls and globigerina (Buda) marls. Oligocene is characterized by the laminitic Tard Clay deposited in euxinic environment, the littoral Hárshegy Sandstone and its shallow bathyal equivalent, the Kiscell Clay with rich foraminifera-fauna. The Upper Oligocene - Lower Miocene formations consist of sand and gravel with rich mollusc fauna. Middle Miocene (Badenian) Leithakalk, Sarmatian oolites, Pannonian clay and travertine close the Tertiary sequence. Pleistocene is represented by several gravel terraces of the Danube together with travertines deposited by thermal springs.

The present - day morphology of the Buda Hills has been controlled by differential block-faulting. All formations on the right side of the river have been hit by drilling under the Pest plain (the Triassic dolomite being downfaulted to a depth of 1200 m below the present-day surface).
The Gellért Hill (with the Citadel and Liberty Statue on top) is built up by Upper Triassic dolomites and Upper Eocene bryozoan marl and Buda Marl.

Castle Hill is a horst of Buda Marl. The Royal Palace itself and the whole castle quarter has been built on a 8 - 12 m thick lacustrine limestone bed of Pleistocene age. This bed contains several small natural caves which were connected by cellars and tunnels during the centuries forming a large cave system several kilometres long. The caves were used as shelters during the frequent sieges in the tormented history of the town.

Rózsadomb (Rose Hill) lies to the north of Castle Hill on the right bank of the Danube. It was named after the rose gardens of a Turkish holy man (Gül Baba) who lived here in the 16th century. His sepulchre ("türbe") still is standing on the hill and is eventually visited by Turkish pilgrims.

North of Margaret Bridge the hills on our left are made of Triassic limestones and dolomites, covered by Upper Eocene limestones and marls and Oligocene clays. The Middle Oligocene Kiscell Clay, world-famous for its rich foraminifera fauna first investigated by M. HANTKEN has been exploited by a number of brickyards along the foot of the hills since Roman times.

This hillside is the locus typicus of the recently introduced Kiscellian Stage (Lower and Middle Oligocene) of the Central Paratethys.

Along the right bank of the Danube at the foot of the hills there are thermal springs which supply with hot water the renowned medical baths of Budapest. Six baths (Gellért, Rudas, Rácz, Király, Lukács, Császár) queue up along this north-south fault line. Several others scattered in Budapest get water from artesian wells.

Between the hills and the river there is the wide Pleistocene gravel terrace of the Danube. Several large capacity wells exploiting drinking water for Budapest can be seen on the bank of the river. Several hundred similar wells border a sixty km long section of the Danube from Vác to the north to Szigetszentmiklós to the south.
These wells supply 80% of the 1.2 million cubic meters/day of drinking water needed by Budapest. This water doesn't require any cleaning. The missing 20% are pumped directly from the river and are cleaned mechanically and chemically.

Aquincum

The name was taken over and latinized from the Celtic name Ak-ink, meaning "abundant waters" and given on account of the numerous springs found there. A tablet dated 19 A.D. records that the 1st Hispanic cavalry cohort set up its camp within a stone rampart instead of the former earthworks.

About 120 A.D., under Emperor Hadrian, Aquincum became a municipium. Several decades later, under Antoninus Pius, two amphitheatres were constructed. Both of these have been uncovered in good condition. By the time of Septimius Severus, about 200 A.D., Aquincum had been made the capital of the province of Pannonia Inferior. The Emperor Commodus had watch-towers ("burgi") built along both sides of the Danube as a protection against the barbarians, particularly the Sarmatian tribes. A great wall, built during the reign of Aurelianus protected the province of Pannonia, too. As an outwork of this "limes", in 294 A.D., under Diocletian, a military outpost, Trans-Aquincum was built on the Pest bank. The ruins of this fortress lie near Elizabeth Bridge and part of them has been made into a museum.

Most of Aquincum has been excavated. A military amphitheatre to seat sixteen thousand, with a diameter of 130 metres, one of the largest in Europe, lay in the southern part of the town.

A little farther north are the remains of the Roman civilian town. Former streets, and in some cases even the layout of shops, can be traced. A gymnasion and hypocausts, or central heating flues of a large public bath have also been uncovered. The central heating of several private villas has been found, in one case ornamented with coloured tiles. Warm water was conducted from the natural springs nearby, from which the local name Római-fűrđő (Roman Baths) originates.
The ruins of two more baths were discovered here, together with a shrine of Mithras in which a relief and four votive altars were found.

On the grassy space which contains the ruins of the baths stands Aquincum Museum.

One of the altar stones was raised by Lucius Flavius Aper, the "perfect man", in honour of "the ancient protecting deities." This Aper was proconsul of a part of Pannonia and later a commander of the guards in Rome.

Another remarkable relic is a red marble sarcophagus in Greek style, with the figure of a hooded dwarf, Telesphorus, "he who brings the end."

The most interesting exhibit in the museum is a music instrument. It is the only Roman organ in the world which has actually been preserved; others are known to have existed, from mosaics and written accounts. The wooden parts have decayed, but the fifty-two bronze pipes have all been found. In the primitive water organ the bellows worked by hydraulic pressure, but the Aquincum organ represents a more modern type: in it, atmospheric pressure is regulated by weights. The instrument has been reconstructed and can actually be played.

Near the museum there is an amphitheatre for civilians, which seated six thousand people.

In Roman times the present-day Budapest - Esztergom highway was part of the great Roman military road leading to Vindobona (Vienna). Remnants of the Roman aqueduct pillars follow a part of this road.

Szentendre

The town of Szentendre with a population of about twelve thousands is the southern gate of the Danube bend. The first written record of the name of the town is a charter from 1146. The settlement seems to have been named after apostle St. Andrew (Endre in Hungarian), the patron saint of the Basilite monastery at Visegrád.
The main square of the little town is certainly of ancient design. The houses and churches create an atmosphere of Baroque time. Some houses are evidence of the culture of Serbian immigrants who fled from the Peć area in Turkish-occupied Serbia (in the 17th century) and were granted important privileges by the Hungarian kings.

Serb merchants were prominent in Danubian trade by ship for two centuries. Steadily increasing fortune allowed the prosperous and self-conscious community to build more than thirty richly ornamented Greek Orthodox churches in and near Szentendre.

The town has several museums exhibiting the life-work of the best Hungarian artists: sculptors and painters, who worked here. One of the most interesting is the collection of an outstanding present-day ceramist-sculptor, Margit Kovács.

Szentendre, skansen

This is the largest open-air ethnographical museum in Hungary. It will contain ten exhibitions from different parts of the country when finished. Two exhibitions are open now: one displays buildings from the Upper Tisza Region (Szatmár, NE-Hungary), the other from the Little Plain (Kisalföld, NW-Hungary). There are houses of rich and poor peasants, of noblemen, workshops of craftsmen, all fully fit up with furniture, linen, utensils, tools, etc. The backyards contain sheds for horses, cows, sheep, pigs and poultry, barn with wagons, shadoof, etc. There is also a wooden Protestant church with carved and painted ceiling and a mill. All buildings are typical of a small Hungarian village at the end of the last century.

After Szentendre we proceed north between the Danube to the right and the steep Dunazug Mts. to the left. Between Tahitótfalu and Dunabogdány we can observe the Csödi-hegy quarry on our left side. This separate hill is a Middle Miocene andesite laccolith famous for its zeolite minerals. The chabasite,
desmin and analcim crystals can reach a size of several centimeters. The rock is quarried for road construction purposes and for the Danube embankment.

Visegrád

The scenic hills of the Danube Bend are made up of andesite lava flows, agglomerates and tuffs. The volcanic activity took place in Middle Miocene (Early Badenian) time during a comparatively short span of time (0.5 - 0.7 m.y.) Stratovolcanic cones were produced. The considerable amount of volcanic ash fallen into water developed into andesite tuffite over much of the present-day area of the mountains. Later the original volcanic forms were eroded and most part of the mountain became a planated surface.

The shallow-water Badenian sea deposited, on the marginal denudation surfaces a thin blanket of lime-cemented sand and gravel. With the overall uplift of the Hungarian Central Range in Pliocene time the Pannonian sea retreated from the immediate neighbourhood. A fault line system developed separating the present-day Bőrzsöny and Dunazug Mountains. It is in this faulted "graben" system that the paleo-Danube found its channelway from the Little Plain into the Great Hungarian Plain. During the Quaternary the Danube carved out a valley gorge of 200 to 300 m depth, displaying 7 - 8 gravel terraces.

Along the Panorama road leading up to the ruins of Visegrád Castle, the Middle Miocene stratovolcanic sequence is well exposed. At the base of the roadcut there are pyroxene-hornblende andesite tuffs. These are overlain by andesite agglomerates at the upper end of the road. Most of the castle ruins lie on these rocks. Large red andesite bombs can be observed here, which are embedded in fine hypersthene-hornblende andesite tuffs. In some places, argillization can be recognized. The final member of the sequence is a hypersthene-hornblende andesite lava flow.

In the river and on the banks there is the construction site of the Nagymaros hydroelectric power station and shipping locks. This work is part of a joint
Czechoslovak - Hungarian engineering project to solve shipping difficulties on the Danube between Bratislava and Budapest. Three dams, two power stations and a new shipping canal are planned.

**Visegrád, medieval fortress**

The road runs along the narrow space between the hills and the river, and guarding it stands the old fortification named Solomon's Tower after King Solomon (1052-1087) of Hungary, who was supposed to have been a captive in this dungeon. Actually this is a part of the lower castle of Visegrád and was built, as its architecture indicates, later, in the second half of the thirteenth century. From Solomon's Tower a defensive wall runs up the hillside to the citadel on its summit, which was built by King Béla IV. (1235-1270) after the Mongol-Tartar invasion that inflicted terrible ravages on the country. Later, when the royal palace was built, the women and children were taken up to the castle during an attack, and, if necessary, the defending forces could also retreat there.

The remnants of the citadel built on the cliff suggest fourteenth- or fifteenth-century architecture. The castle building surrounding the upper courtyard was a two-storey edifice in the fifteenth century, with 16 rooms on the ground-floor, including a chapel, treasure chamber, a separate room for keeping the crown in and the Hall of the Knights. The second storey, with a total of 18 rooms, housed the suites of the King and Queen.

The Hungarian Royal Crown and the crown jewels were stored here. During the reign of King Louis the Great (1340-1380) the Polish Royal Crown, and during Sigismund (1387-1437) the diadem of the German-Roman Empire were guarded among these walls.

In 1335 Visegrád was the scene of a meeting of the rulers of Central Europe. The Kings of Hungary, Poland and Bohemia, the Marquis of Moravia and the Princes of Bavaria and Saxonia held "summit talks" here.
Visegrád, Renaissance royal palace

The palace of Visegrád was almost razed to the ground by the Turks in 1542. As it stood at the base of a steep hill, earth was washed down, gradually covering the ruins, so that the very existence of the palace was doubted until 1943, when some fragments of the wall were found by excavations. Since then, many treasures have been unearthed on the site, and where possible the ruins have carefully been restored.

The palace of Visegrád was first built by King Charles Robert Angevin (Anjou) (1308-1340) and given its final form by King Matthias (1458-1490). It had two wings, one of which contained the apartments of King Matthias and the other those of his Italian-born queen, Beatrice of Aragon. She was the daughter of the King of Naples; when coming to Hungary she brought in her train Italian artists and humanist scholars who had a great impact on the developing Renaissance culture of Hungary.

The court was surrounded by a graceful Gothic cloister, now restored. The ground-plan of the rest of the palace is clearly visible, with some steps and balustrades and the arches which enclosed the steam bath.

According to a description by Archbishop Miklós Oláh (1536) the palace contained 350 rooms, and two fountains, one of red marble and one of white, which flowed with wine on occasions of royal celebration. The red marble fountain has been found and restored.

Visegrád - Lepence, Zsigmondy Museum

Vilmos Zsigmondy (1821-1888) was the founder of drilling industry in Hungary. He studied mining engineering and metallurgy at Selmecbánya (Schemnitz, today: Banská Štiavnica, in Slovakia). He worked as mine inspector at several iron and coal mines. His firm drilled the first artesian well in Hungary in 1878: the 970 m deep Budapest-Városliget well is still in work supplying the Széchenyi Bath.
with thermal water from the karstified Triassic basement. (Up to now about forty thousand artesian wells have been drilled in Hungary and 24,000 of them are still in function.) Zsigmondy became a Member of Parliament, member of the Hungarian Academy of Sciences and knight of the Légion d'Honneur.

The collection presents the life history of Vilmos Zsigmondy, a model of his drilling equipment and the history of the Hungarian water exploration and drilling industry.

The museum is sponsored by the Water Exploration and Drilling Co. (VIKUV).

Esztergom

Esztergom lies on the right bank of the Danube higher upstream, just before it enters the hills. This ancient town was the eastern border fortress of Charlemagne’s Frank Empire. At that time it was called Oster Ringum, or Eastern Fort, a name which became in medieval Latin Strigonium, and was in turn magyarized to Esztergom. When the seven Magyar tribes settled definitely in Hungary at the end of the ninth century, this town became the seat of the first Hungarian royal dynasty, the Árpáds.

In 1001 King (St.) Stephen I, son of Prince Géza, was crowned here with a crown sent by Pope Sylvester II. Under his rule the bulk of the Hungarian people was converted to Roman Christianity. He had a cathedral built on Castle Hill. In the 12th century King Béla III. erected a palace on the hilltop which served as a royal residence until 1249. During the Tartar-Mongol invasion the region was depopulated. The royal court, returning from emigration, took seat in Buda.

From 1468 on, Johannes Vitéz, King Matthias’ humanist chancellor, promoted Esztergom to the centre of the Hungarian Renaissance.

The town, which preserved for centuries its ecclesiastic character, has been the seat of the Archbishop of Esztergom, the Primate of Hungary, for one thousand years.
Esztergom lies on the northern flanks of the Dunazug Mts. Opposite the Cathedral, on Szent Tamás Hill, well-bedded Middle Oligocene Hárshegy Sandstone layers are exposed overlying the Triassic dolomite horst of Castle Hill.

Esztergom was one of the first towns in Hungary to inaugurate an engineering geological mapping programme, about fifteen years ago. The steep, unstable slopes of the surrounding hills, the many forgotten cellars dating as back as medieval times made this work unavoidable.

Esztergom has been a town of schools for centuries. After World War II, industrial growth set in (machine-tools, electrotechnical and optical industry, etc.)

**Esztergom, Royal palace**

The royal palace of the Árpád kings stood on the southern rock of Castle Hill for centuries. In Turkish times it was ruined and filled up with earth. Excavations have been being made here since 1934, bringing to light rich stone relics from the 11th - 12th centuries. One of the most interesting parts of the palace, in quite good condition, is the one-time chapel, showing a Burgundian influence of the 12th century. On the walls and ceilings of some of the rooms several coats of medieval and Renaissance fresco-fragments are to be seen. A stone staircase leads down to the lowest and oldest part of the palace; the original steps, worn down through the centuries, are still in place. The few square yards of space below form the oldest room in Hungary, and the Romanesque capitals of the columns show them to be almost a thousand years old.

In the throne room the brick flues used for heating can still be seen and there are fragments of a fresco showing an imposing triumphal procession and of the frescoes depicting the four cardinal virtues (Prudence, Temperance, Fortitude and Justice).
In the museum a model of the main portal (Porta Speciosa) of the medieval St. Adalbert cathedral of Esztergom is on display. It has been reconstructed from fragments. Its interior was decorated with inlaid marble in Byzantine style (the builder, King Béla III. was brought up at the imperial court of Byzantium).

**Esztergom, Cathedral**

North of the excavations stands the Cathedral, the biggest church of Hungary, built in classicist style, with a dome. Its height is 100 m, length 107 m, diameter of the dome is 33 m.

The southern side chapel is an incorporated earlier construction built between 1506 and 1511 as a sepulchral chapel for Archbishop Tamás Bakócz. It was built in Early Toscanian Renaissance style by an Italian master and is the only intact relic of Renaissance in Hungary. The cathedral in its present form was built from 1822 till 1869, mainly according to the plans of the great classicist architect József Hild. It was consecrated in 1856, with Ferenc Liszt conducting his Missa Strigoniensis.

From beside the Sanctum we can get to the Church Treasury, a very rich collection of goldsmith's works and sacerdotal clothes. Probably the finest piece of the collection is the "Calvary of King Matthias", made in the 15th century of pure gold, decorated with pearls and enamel.

**Esztergom, Museum of Christian Art**

At the foot of Castle Hill we find the palace of the Cardinal Archbishop, Primate of Hungary. It also houses the Museum of Christian Art. Its collection in ecclesiastic art is second to the Vatican Museum only.

The first room gives a foretaste of the very rich medieval Hungarian panel-painting. Among triptychs and panels from the 15th century stands a valuable piece
of North-Hungarian wood-sculpture: the "Lord's Coffin" from Garamszentbenedek (now Hronský Beňadík in Slovakia). It's the only relic of its kind in the world. The following rooms display a rich collection of Italian paintings of the 13th - 15th centuries: Duccio, Lorenzetti, Giovanni di Paolo, Lorenzo di Credi, etc. In further rooms there are works of Renaissance and Baroque painters: Memling, Hemessen, Cranach, Ribera; icons, etc. Beside them there is a rich material of handicrafts (delft-ware, Flemish gobelins, Gothic pieces of stained glass, etc.)

A unique exhibition was opened in the museum last year: copies of famous statues are on display for blind visitors to touch them.

Tata

The small town of Tata is known for its Baroque monuments, its numerous springs and lakes. The castle of Tata was built by King Sigismund (1420) and made a royal resort by King Matthias (1463). Its destruction coincides with the Turkish occupation. The 18th century witnessed a romantic revival of the town, as shown by a number of masterpieces by Jakab Fellner, a great master of the Huguenot Baroque style in Hungary. Now the castle houses a regional museum.

Tata, Kálláriadomb (Geological Nature Conservation Area)

The geological section of the Mesozoic basement cropping out from below Pannonian and Pleistocene sediments in the western forelands of the Gerecse Mts. can be readily studied in the quarry here.

The lowermost member of the sequence is Upper Triassic Dachstein Limestone. The presence of oolites and calcareous nodules, the local occurrence of intraformational breccia indicate deposition in shallow, agitated water. The microfauna contains few species but many individuals. The characteristic fossil is Triasina hantkeni MAJZON, associated with some other foraminifers. The macrofauna consists of Megalodontidae.
The **Lower Liassic** pink limestones overlying the Dachstein Limestone with a hiatus are represented by fissure and cavity fillings within the Dachstein Limestone beds. In normal position it contains brachiopods and Arietites. The **Middle Liassic** is represented by crinoidal limestones. The **Upper Liassic** is developed in a red, clayey facies with calcareous nodules and cephalopods (ammonitico rosso). The **Aalenian** and **Bajocian** are thin-bedded layers with Palaeotryx. The **Bathonian-Callovian** is represented by radiolarites (cherts). The **Oxfordian** is a greyish-white nodular and brecciated limestone. The **Kimmeridgian** is a nodular limestone with abundant cephalopods. The **Tithonian** is represented by purplish-red compact limestones grading with continuous sedimentation into **Lower Cretaceous** cephalopod limestones of similar lithofacies. The final member, of different litho- and biofacies is the grey crinoidean limestone of the **Aptian** separated from the underlying rocks by a considerable gap. The Kálváriadomb is an excellent locality to study the typical fault elements characteristic of the Transdanubian Central Range.

The Bathonian-Callovian cherts were used for tool-making as early as Neolithic time, as proven by the chert-pits, artifacts and hearth remains unearthed during the geological investigations. A Paleolithic campsite with Mousterian remains has been excavated in the freshwater limestones beneath the building of the secondary school on the shore of Lake Öreg.

The Tata - Kálváriadomb Geological Nature Conservation Area was established in 1958 and it is being developed by the Hungarian Central Office of Geology, under the personal care of President J. Fülop.

**Vértesszőlős**, campsite of prehistoric man

Along the large fault forming the western border of the Gerecse Mountains, a number of hot springs have been active since Late Pliocene time. Travertines produced by **Pleistocene** hot springs are quarried near Vértesszőlős village.
The investigation of the deposit has led L. Vértès to the discovery of the earliest remains of prehistoric man ever found in Hungary:

\textit{Homo(erectus seu sapiens) palaeohungaricus} (THOMA, 1966);

Vértesszőlős man, popularly nicknamed "Samuel".

The lowest occupation level (Level I) was 5 cm thick and contains the human remains (an occipital bone, teeth of a child along with animal and human footprints). Numerous artefacts were found, "pebble-tools" and "chopper-tools" as well as numerous flakes many of which were of small size (Buda Industry). Perhaps a "microlithic variant of the industrial traditions of Afro-asia" (M. Kretzoi and L. Vértes, 1965).

The bones of fossil mammals that were recovered at the site included those of a beaver (\textit{Trogontherium schmerlingi}), an etruscan rhinoceros (\textit{Didermoceros etruscus}), a wild dog (\textit{Canis etruscus}), a large sabre-toothed cat (\textit{Epimachairodus sp.}) as well as rich micro-mammalian fauna.

The deposits underlie the Mindel loess and are within the fourth, or Mindelian terrace of the river Danube (Biharian Stage: Mindel \(_1\)-2 interstadial and Mindel \(_2\)).

The lower two occupation layers are said to correspond to a mild climate whereas the upper two layers correspond to a period of colder conditions. The presence of imprints of beech leaves from the lower layers suggests that the remains should be dated to a warm phase within the second (Mindel or Elster) glaciation. On the basis of a thorium/uranium estimation the date of the remains is approximately 350,000 years B.P. Traces of the use of fire were identified at the living site: thus Vértesszőlős man may rival Peking man of the Chowkowtian cave (Sinanthropus) as the earliest known fire-user.

Returning to Budapest we pass along Tatabánya, the centre of an important Eocene brown coal basin. After more than 100 years of continuous mining the coal fields are almost worked out. Within a few years the last shaft of the coal mine will be closed. The mining activity is moving to the eastern part of Gerecse Mts.,
about 15–30 km to the east from the town, where brown coal seams partly overly bauxite deposits interbedded in fanglomeratic, reworked debris of Triassic dolomites.
EXCURSION "B"

Transdanubian Midmountains (Vértes - Bakony)

compiled by
M. Kázmér
Excursion B presents an overall view of the geology of the Transdanubian Midmountains, from Carboniferous granite through Permian, Triassic, Jurassic, Cretaceous, Eocene and Miocene carbonate and clastic sediments to Pliocene basaltic volcanism. This region owes its economic importance to various natural resources: Cretaceous, Eocene and Miocene brown coal, Cretaceous and Eocene bauxite, Jurassic manganese ore; the Badacsony vineyards on volcanic soil; thermal and mineral waters used for medical purposes; and a beautiful landscape attracting several million tourists every year. Middle Age churches, monasteries and fortresses, Baroque castles and towns, beautiful villages and modern industrial centres are scattered among the forests of the Midmountains.

Have a good journey!

Good luck!
I. Tectonic setting

The Transdanubian Midmountains represent a tectono-facial unit situated east of the Alps and south of the Carpathians. Its southeastern boundary is defined by a probably transcurrent fault line extending parallel with Lake Balaton.

For the most part, the Midmountains represent Mesozoic elements of "Mittelgebirge" type. They rise a few hundred metres above the flat (100 - 200 m relief) surface of the Transdanubian basins, filled with 1000 - 4000 m of Neogene sediments, and are separated by intramontane basins. They form an asymmetrical synclinorium affected by both tensional and compressional stresses, with some subordinate manifestations of flexing.

In the southeastern limb of the synclinorium Palaeozoic and Triassic rocks occur, generally in a monoclinal position. Along its axis there are Jurassic and Cretaceous formations. The narrow outcropping band of the opposing limb consists of Triassic rocks. In addition to synclinorium forming, compression is manifested in the piling up of blocks, thrust-sheets (imbrications) and horizontal faults. Their effect is also reflected in the distribution of the sedimentary facies zones. The disjunctive tendencies that gradually became predominant in the Tertiary fostered andesitic-dacitic and basaltic volcanism.

II. Geological formations

The oldest formations occur on the southeastern border of the NE-SW trending mountains, on a line between Lake Balaton and the Velence Hills.

Silurian. The oldest formation is an anchimetamorphic shale series exposed on the northern coast of Lake Balaton. It contains intercalations of quartz porphyry.
Black chert lenses contain a Monograptidae fauna which, associated with Hystrichosphaeridae, dates the whole series as Silurian.

**Devonian.** There is an isolated exposure of crystalline limestone which can be considered marine Devonian.

**Carboniferous.** Similarly isolated are the Lower Carboniferous dark calcareous and marly shales with corals, brachiopods and foraminifers. South of Lake Balaton, deep drilling reached Upper Carboniferous, Schubertella- and Clima cammina-bearing, yellowish-white limestones. The Velence granite pluton is also considered to be of Carboniferous age (Variscan). Its essential minerals are orthoclase, oligoclase, quartz, and biotite; the accessories are apatite, zircon, magnetite, and orthite. Associated with the pluton are numerous dikes of granite porphyry, aplite and kersantite on the one hand, and pegmatitic, pneumatolytic, and hydrothermal veins (with fluorite- and Pb, Zn mineralization), on the other.

**Permian.** It is represented by an Upper Permian continental red sandstone sequence which becomes more complete and thicker (from 200 to 700 m) from southwest to northeast. At the base of the Permian sequence there is a conglomerate (50 to 150 m) of shale, quartz, quartzite, quartz porphyry and sandstone pebbles. It is followed by red sandstones with graded bedding. The final member of the Permian is a fine-grained, grey sandstone with variegated intercalations. The cement of the sandstones is silica in the south, silica and carbonate in the north, (at some places, ankerite-dolomite). Kaolinite also is a characteristic constituent of the cement. The red sandstone is very poor in fossils. Silicified and carbonized plant detritus, tracks of mud-eaters and the footprints of a terrestrial reptile (Chirotherium) have been found so far. The sequence is the product of continental, fluvialite sedimentation during which the role of flood-plain and lacustrine sediments gradually increased. In the upper part of the Permian of the southern foreland of the Vértes Mountains there is a lagoonal anhydrite- and gypsum-bearing series overlain by marine limestones, dolomites and marls.
Triassic. The bulk of the exposed Transdanubian Midmountains is made up of Triassic formations. The most complete Triassic sections can be found in the Balaton Highland and the Bakony Mountains. They can be readily correlated with the occurrences in the Southern and Eastern Alps, but they are tectonically less disturbed and rich in fossils.

In the south the Lower Triassic rests on the Upper Permian with a hiatus; farther north, sedimentation was continuous. The Werfenian sediments, more than 1000 m thick, were deposited in the shallow water of the coastal plain of a continuously subsiding sedimentary basin. The Seisian consists of grey and micaceous sandstones, laminated shales, sandy marls, and thin dolomites. The ripple marks observable on the bedding planes and the eurythermal and euryhaline fauna suggest near-shore, shallow-water sedimentation.

The appearance of thin bedded oolites in the Campilian, the subsequent disappearance of coarser detritus, and the simultaneous appearance of an ammonite fauna indicate deepening of the sea and stabilization of salinity (Tirolites marl). The cellular-porous dolomites - which owe their texture to the removal of gypsum and anhydrite that once filled the cavities of the dolomite - and the stunted, dwarf fauna of the thin-bedded limestones overlying them are indicative of a hypersaline environment.

The basal member of the Anisian is the Megyehegy dolomite, poor in fossils. On the basis of their brachiopod fauna the overlying limestones can be correlated with the Recoaro horizon of the Southern Alps. Upwards, it grades into the Paraceratites trinodosus horizon of marls and limestones with an abundant fauna, which can be correlated with the Reifling limestone.

In the Ladinian the Protrachyceras reitzi horizon, composed of alternating siliceous limestones, tuffaceous marls, and diabase tuffs, can be correlated with the Buchenstein beds of the Southern Alps, while the red cherty Tridentinus limestone horizon can be correlated with the Wengenian beds. The deeper-sea limestone facies of the Balaton Highland, characterized by tuff intercalations bearing thin-shelled pelecypods and ammonites, is replaced by Diplopora dolomites.
in the eastern parts of the Bakony Mountains. This very thick (900 m) neritic succession of biogenic sediments represents the Ladinian in the area of the Vértes, Gerecse, and Buda Mountains as well.

The Carnian exhibits the marked heterogeneity that is typical of the area of Triassic sedimentation of the Transdanubian Midmountains. In the Balaton Highland the Füred limestone was deposited first, overlain by a very thick marl sequence. The final member is a thin limestone group.

The Norian is represented in the Balaton Highland and in the Bakony Mountains by the widespread Hauptdolomit of enormous thickness, containing a Megalodontidae fauna typical of the Norian stage. Proceeding from south west to north east across the northern Bakony, Vértes, Gerecse and Buda Mountains, the Hauptdolomit is replaced by the Dachstein limestone.

In the Balaton Highland and in the southern Bakony a Rhaetian sequence of cherty dolomites and dolomitic marls of Kössen facies occurs. Towards the northeast it pinches out. Elsewhere the Rhaetian is represented by continuation of Dachsteinkalk of the Norian Stage.

Jurassic. In the Bakony Mountains the Hettangian develops from the Triassic with no break in sedimentation. Its lithological features correspond to those of the Rhaetian Dachstein limestone. In the Vértes and Gerecse Mountains there is a gap between the Triassic and the Jurassic. The absence of Jurassic formations on the southeastern border of the Midmountains and the lithologic features of the Jurassic of the central areas suggest a break in sedimentation from the end of the Triassic period to the end of the Jurassic. In the Jurassic sedimentary basin crinoid- and brachiopod-bearing limestones were deposited in the shallower parts, and red clayey limestones with ammonites and planktonic microfauna, cherty-nodular limestones and radiolarites in the deeper sea. A locally developed manganiferous formation, comprising workable accumulations of manganese carbonates and manganese oxide, was discovered here. The Jurassic deposits suggest that the basin gradually deepened from the Liassic to the end of the Dogger, and then became shallower again during the Malm. The near-shore formations indicate discontinuous sedimentation. The locally abundant ammonite fauna present in the
continuous sedimentary sequences in the central part of the basin permits recognition of all stages of the Jurassic system. The majority of ammonite species are of Mediterranean type, but Central European forms are also represented.

The Jurassic member of the geological section is only 50 to 60 m thick in the Gerecse and Vértes Mountains and does not exceed 200 m in the Bakony Mountains. In the lagoonal marginal facies it may locally be only a few metres thick.

Cretaceous. The Cretaceous is represented by various members of different facies, deposited in isolated basins and separated from one another by stratigraphic gaps.

In the Gerecse Mountains a 200 to 300 m thick Neocomian (Berriasian - Barremian) sequence which can be correlated with formations in the Northern Alps and Carpathians, shows a normal cycle of sedimentation: basal breccia - marls - sandstones - regressive conglomerates. In the Bakony Mountains it is less clastic, represented rather by cherty-nodular limestones (Biancone facies) and by marls and crinoidal limestones. Relationships with the Southern Alps are suggested. In the central basin areas the Berriasian, Valanginian and Hauterivian stages consist of cherty-nodular limestones with tintinnids and nannoplankton, and the Barremian is represented by sandy limestones. In the marginal areas rocks of this age are represented by crinoid- and brachiopod-bearing limestones. Simultaneously with the marine sedimentation bauxite bodies were deposited on the land, on a limestone and dolomite surface of rough topography (coastal cone karst) in a zone along the strike of the Midmountains.

In the Aptian grey crinoidal limestones were formed along the whole length of the Midmountains. These are overlain - transgressively and with an erosional unconformity - by the following sequence: Upper Aptian mottled clays with a mostly brackish fauna, Albian limestones with Pachyodonta, Orbitolina and other microfossils, molluscs and echinoids, Albian glauconitic marls and Cenomanian Turrilites marls.
Upper Cretaceous (Senonian) occurs in the southern Bakony Mountains. The Midmountains were uplifted by Late Cenomanian movements and block-faulted in the Turonian. In the south, sedimentation started with Early Senonian submergence and ended with Late Maastrichtian emergence due to Laramian movements. The basal Senonian is a bauxite and variegated clay member containing pebbles of Mesozoic limestones, cherts, dolomites and bauxites. It is overlain by freshwater limestones, calcareous marls and clayey marls with a freshwater gastropod fauna and a rich assemblage of sporomorphs dated as Santonian. This member underlies a coal-bearing formation which shows limnic features in the lower and paralic in the upper part, of Upper Santonian - Lower Campanian age. The continental freshwater sequence is covered by marine sediments: Campanian clayey marls and limestones of reef facies containing a characteristic assemblage of corals, rudists, foraminifers and sporomorphs. The Maastrichtian is represented by a sequence of calcareous marls, limestones and clayey marls with a characteristic Inoceramus and Globotruncana fauna.

No marine Palaeocene formations are known in the Transdanubian Midmountains. Some bauxites are considered being of Paleocene - Early Eocene age.

Eocene. Although incomplete, the Lower, Middle and Upper Eocene (Cuisian, Lutetian and Priabonian) members are all represented in the Midmountains. Near-shore (calcareous-detrital "Nummulitenkalk") archipelagic and pelagic(silty and marly) facies can be distinguished. Rough bedrock topography and variable conditions of sedimentation gave rise to a remarkable variety. Stratigraphic subdivision is based on the larger foraminifers, planktonic foraminifers and nannoplankton. The geologic evolution was controlled by differential subsidence and uplift. In the Upper Lutetian - Upper Eocene a general transgression set in. The Eocene sedimentation was associated with andesitic and dacitic - rhyolitic volcanism of predominantly explosive nature. At the base of the Eocene cycles brown coal seams of economic value were deposited.
Oligocene. At the end of the Eocene the area was uplifted and became the scene of very intensive erosion. Renewed sedimentation produced conglomerates, variegated clays and sandstones with lignite seams deposited in former embayments. At Bodajk a vertebrate fauna has been discovered in the 400 m thick continental sequence. During Rupelian time the sea invaded the Midmountains from the northeast. Its sediments, containing Cyrena, Melanopsis, Potamides and agglutinated foraminifers occur in the area between Budapest and Esztergom. In the Gerecse and Vértess Mountains only brackish-water deposits and in the Bakony only continental freshwater deposits can be found. The marine Kiscell Clay of the Buda Hills is of more limited geographic range. The Upper Oligocene (Egerian) is represented by a regressive sandstone member.

The Lower Miocene sedimentary cycle is represented by a sequence of continental-fluvial conglomerates, sandstones and variegated siltstones. Many of the pebbles in the conglomerate are derived from older members of the stratigraphic column. This sequence is overlain by lacustrine sediments with allochthonous lignite deposits.

The Carpathian stage is represented by marine sediments, such as fine-sandy clay and clayey marl of Schlier type, deposited in the central part of the basin and by brackish and lagoonal clayey marls formed in the nearshore zone. The volcanism that furnished the andesitic masses of the Dunazug Mountains and the northeastern part of the Midmountains began in this time.

Badenian - Sarmatian. The sea advanced considerably during the Badenian. In the nearshore shallow water zone coarse conglomerates, Pecten- and Corallinacea-limestones (Leithakalk), Heterostegina-limestones and sandstones were formed. Near Várpalota the littoral molluscan sands are overlain by an autochthonous lignite formation. Farther offshore molluscan clayey marls were deposited. The Sarmatian deposits constitute the final member of the sedimentary cycle. In the Midmountains the Sarmatian is represented by coarse-grained molluscan limestones and clayey marls, and freshwater limestones. The presence of thin dacite tuff intercalations is evidence of continued volcanism.
Pannonian (Pliocene) formations have been developed on the border of the Midmountains as well as in the inner basins. These are coastal and nearshore clastic sediments. Their lithologic and palaeontologic patterns well reflect the break-up of the Pannonian inland sea, its subsequent filling up and the establishment of a completely freshwater regime. At the end of the Pannonian significant basaltic volcanism took place in the southern parts of the Midmountains, the Balaton Highland and the Little Plain. Completely emergent by the end of the Pliocene, the landscape was subjected to extensive erosion with fluviatile-lacustrine accumulations.

Quaternary. It is represented by continental, lacustrine, fluviatile and eolian (loess) sediments of periglacial type. The slopes of the more and more deeply dissected inner sections of the mountains were covered with talus and extensive alluvial fans developed at the foot of the mountains. Glacial climatic changes and tectonic movements produced terraces along rivers and brooks. Some areas became covered with eolian sands. Loess formations containing fossil soil horizons and intercalations of rubble are common. Their sand content is considerable. Of special importance are relics of early Paleolithic and Neolithic man's campsites and chert pits.

III. Mineral deposits

The most important raw materials of the Transdanubian Midmountains are bauxite, lignite and manganese ore. In addition, quartz sands for metallurgic and glass industries, refractory clay, bentonite, ceramic materials and building stones are mined. Less important are some deposits of base metal ores, fluorite, baryte and quartzite.

The bauxite and manganese ore deposits and some lignite deposits occur in the Mesozoic. Most of the lignites and all of the refractory clays are in Lower Tertiary sediments. Quartz sands, bentonite and building stones are largely associated with the Upper Tertiary formations.
Bauxite is one of Hungary's most important mineral resources. The ore bodies, constituting lenses and sinkhole fillings of various sizes, were deposited under the tropical climate of Cretaceous to Early Eocene time on a karstic coastal plain made up of Upper Triassic dolomites and limestones. They are sometimes overlain by Middle and Upper Cretaceous formations and more frequently by Eocene deposits. The bauxites are mainly of gibbsitic - boehmitic type. The deposits of highest economic value have been discovered at Halimba, Nyirád, Fenyőtő, Iskaszentgyőrgy, Iharkut and Nagyegyháza - Mány. The deposit near Gánt is nearly exhausted.

The manganese ore in the region of Urkut and Eplény is a marine deposit at the base of the Upper Liassic. Both manganese oxide and manganese carbonate ore bodies are mined.

The brown coal resources of the Midmountains are of different age. Near Ajka Upper Cretaceous (Senonian) coal is mined. This deposit is overlain by Senonian marine sediments. The Middle Eocene deposits are of greatest economic value. They were developed in the depressions of the Mesozoic basement during the subsidence that introduced Eocene transgression. The Balinka, Dudar, Oroszlány, Pusztavám, Tatabánya, Dorog, Nagyegyháza - Csordakut-Mány, Solymár coal basins are of this type. The Oligocene coals are less important. Near Szápár, seams of liptobiolithic nature suggesting a forest bog origin have been found. Miocene lignite deposits occur at Várpalota and Herend.

Other mineral deposits worth of mention are: refractory clays (Bajna, Pilisvörösvár, Csákberény, Városlőd); bentonites (Tétény plateau, Bánd - Herend - Márkó, Nyirád); glass sands and foundry sands (Sárisáp, Bicske, etc). Scores of basalt, andesite, marl and limestone quarries supply building stone, road materials and facing stones as well as raw materials for the lime and cement industries. In the Velence Hills aplite, hydrothermal quartzite, fluorite and baryte are known.

Oil shale (alginit) has been discovered recently in the one-time crater lakes of Pliocene basaltic tuffite cones.
Finally, mention should be made of the ground waters which also play an important role, either negative or positive in the national economy. On the one hand, large amounts of karst water endanger mining operations; on the other hand, various thermal, medicinal and mineral waters are being utilized on a large scale.
Leaving Budapest on the Vienna road we pass along the southern slopes of Buda Hills composed of Middle Triassic Diplopora dolomites partly overlain by Upper Eocene-Oligocene sediments. The Tétény plateau is made up by Middle and Upper Miocene limestones. The low, hilly landscape till Bicske hides Middle Eocene coals seams still to be explored.

At Bicske we turn to the SW and pass along the SE side of Vértes Mountains. This range, built up mainly of Triassic carbonates, has a great economic importance. It is surrounded by Middle Eocene coal basins and it contains bauxite in karstic traps on its SE side.

Gánt: bauxite pit and Museum of Bauxite Mining

In the vicinity of Gánt village is one of the largest bauxite deposits of Europe mined continuously since 1925. It is exploited in a huge open work, at the bottom of which the karstic Upper Triassic dolomite surface is coated secondarily by a dark red iron crust.

The bauxite bodies are 5 to 25 m thick, forming the following sequence: clayey bauxite, usually light coloured, poor in iron; clayey bauxite, red to rusty, pisolitic; commercial ore, yellow to brick-red, slightly siliceous, usually pisolitic; clayey bauxite, yellow to light brown, locally with pisolite concretions. The bauxites are overlain by a Middle Eocene sequence of variegated clays, Melania clays, brackish-water clays, argillaceous coal (rich mollusc fauna), Miliolina limestones and Pleistocene-Holocene sediments.
There is a small underground Museum of Bauxite Mining at the edge of the Bagolyhegy pit. It displays, beside information on the history of mining in general, precious documents on the history of bauxite exploration and exploitation in Hungary.

Our route crosses Székesfehérvár, a large industrial city with a beautiful Old Town. We shall return here on the second day of the excursion.

Várpalota is an important industrial centre. Its nitrogen-fertilizer plant has been built in the 1930s. In the 1950s a large electric power station was added to burn Middle Miocene lignite mined near the town. The shaft-towers of the mines can be seen on the left side of the road and there is a cableway overhead transporting lignite to the power plant. The high cooling towers on the right operate by the Heller – Forgó system, which is a Hungarian world patent. An important aluminium foundry lies on the right side of the road.

In the old inner town there is a 15th-century castle which was one of the most important border fortresses during the time of the Turkish occupation. Now it houses the Museum of Chemistry.

Várpalota, Szabó sand pit: protected Middle Miocene Mollusc locality

Here the Lower Badenian shallow marine sublittoral sand is exposed with a very rich and well-preserved mollusc fauna (about 400 species). The lowermost part of the complex is homogenous, yellow in colour and contains a rare fauna. The upper part is grey and cross bedded due to wave action. Some characteristic forms are: Phacoides columbella, Cardium paucicostatum, Pitaria raulini, Solenocurtus candidus, Angulus planatus, Corbula carinata, Nerita plutonia, Turritella aquitaniensis, T. partschi, Terebralia lignitarum margaritifera, Pirenella gamlitzensis, P. picta mitralis, Cerithium europeum, Calyptraea
Natica millepunctata, Ocinebrina crassilabiata, Bullia nodosocostata, Galeodes cornuta, Tuditica rusticula, Terebra halavátsi, etc.

The maximum thickness of the complex attains 100 m with a transition to the clayey pelitic inner deposits of the basin.

At the entry to the sand pit silicified tree trunks recovered from Upper Badenian lignite deposits are on display.

**Veszprém**

With its 40,000 inhabitants, Veszprém is an unofficial 'capital of the Bakony. After Roman, Avar and Slavic settlements the first episcopate (diocese) of the conquering Hungarians was established here by Prince Géza in the 10th century. Through several centuries Veszprém was the residential town of the Queens. The first Hungarian College was established in Veszprém in the 13th century. The Turks held the town for 130 years in the 16th - 17th centuries. In the early 18th century the town was one of the centres of the Independence War led by Prince F. Rákóczi against the Hapsburgs.

The oldest part of the town is built on a steep Triassic dolomite cliff. Throughout its history it has been an important fortress. On the left side of the only little street running through the Old Town we see the Firewatch Tower.

On a small square we face the Episcopal Palace. Close to the palace stands the Gizella Chapel, one of the oldest buildings in Hungary. Queen Gizella, wife of King St. Stephen sponsored the building of the cathedral about the year 1000.

The main square is dominated by the Cathedral. The original, Romanesque church was rebuilt several times in Gothic and Baroque styles, while the last restoration re-established the first style again.

Beside the cathedral lies the small St. George Chapel built in the 10th century.
At the end of the street at the outlook-point stand the statues of St. Stephen and his wife, Gizella, the first King and Queen of Hungary (1000-1038).

Veszprém is an industrial and cultural centre. Besides its precision instrument factories, a Chemical University, two industrial research centres and a branch of the Hungarian Academy of Sciences are seated here.

Zirc

This small town lies in the middle of the Bakony forest in a broad valley. The two towers of the monastery of Zirc are visible from afar. It was a Cistercian foundation made in the twelfth century. King Béla III. invited French monks to Hungary. In keeping with the tradition of their order the monks chose a remote spot surrounded by forests, similar to that of the mother cloister at Clairvaux. They named it Nova Claravallis, or New Clairvaux, when they founded it in 1182. Only one pillar of the original triple-naved church now remains, standing by the monastery wall. The present church is an ornate Baroque building, with an altar-piece by the Austrian Anton Maulpertsch, whose work is found in so many Transdanubian churches. The fifty-seven acres of the former monastery grounds are now an arboretum where many exotic and beautiful trees are grown. On the ground large foraminifers (Nummulites) can be found, called "coins of King St. Ladislas".

The former Cistercian abbey adjoining the church now houses the local branch of the Bakony Museum and a trade school. The museum displays folk art and scientific material from the Bakony region. The abbey's library has a valuable collection of scientific books decoratively arranged in a Neo-Classical hall.

On the outer wall of the building is the "Bakony Pantheon" displaying memorials of persons of excellence connected with this region. There are reliefs of three geologists.

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Lajos Lóczy, Sen. (1849-1920) geologist and geographer, Professor of Geology at the Technical University in Budapest, Professor of Geography at the University of Sciences in Budapest, Director of the Hungarian Royal Geological Institute, Member of the Hungarian Academy of Sciences. As a young scientist he participated in the 3-year Asia-expedition of Count Béla Széchenyi in 1877-80. Based on his personal experiences and the existing literature he published the first comprehensive geographical review of the Chinese Empire. As president of the Hungarian Geographical Society he promoted and organized the most detailed scientific investigations ever made on a region of the world: the investigation of Lake Balaton. The voluminous monograph "Wissenschaftliche Resultaten der Erforschung des Balatonsees" (Scientific Results of the Investigation of Lake Balaton) published in German and Hungarian simultaneously contains the results of the two-decade-work of the best scientists of Hungary and Europe. This opus consists of 20 volumes: 1 on geology, 4 on palaeontology, 1 on petrography and mineralogy and several other volumes on geophysics, geography, hydrography, lacustrine and land fauna and flora, climatology, ethnography, anthropology, archaeology and history of the Balaton Region (the lake + Balaton Highlands). Lóczy himself wrote the 600-odd quarto pages of the geological description and plotted a geological map on a scale of 1:75,000.

Károly Telegdi-Roth (1886-1955) geologist, Professor of Mineralogy and Geology at the University in Debrecen, Head of the Mining Department of the Ministry for Industry, Professor of Palaeontology at the University of Budapest. He explored the Cretaceous bauxite deposits at Perepuszta in the Bakony Mountains and at Nagyharsány in Southern Transdanubia. He promoted the first oil exploration work in Hungary in the 1930s. He published the first geological synthesis of the Carpathian Basin in 1929, and a voluminous university textbook on Palaeozoology in 1953.
István VITÁLIS (1871-1947) geologist, Professor at the Mineralogical-Geological Department of the Mining Academy at Selmecbánya (Schemnitz, today: Banská Štiavnica in Slovakia) and after World War I in Sopron. Member of the Hungarian Academy of Sciences, President of the Hungarian Geological Society. He was the most successful coal geologist in Hungary. After 1920, he explored 200 (two hundred) million tons of brown coal in different coal basins of the post-war country.

Pannonhalma

The monastery, which stands on a 280 m high (a.s.l.) hill is the seat of the Chief Abbey of the Benedictine Order in Hungary. Founded by Prince Géza in 996, its construction was finished by his son King St. Stephen. The Chapel of St. Martin was built in its initial form in the 11th century; the second church was finished in 1137. The late Romanesque building, which constitutes the foundation of the present church (reconstructed and enlarged over and again through the centuries) was consecrated in 1224. The oldest section of the church is the crypts consisting of three naves, which shows a transition from the Romanesque to the Gothic style. The building complex was restored at the end of the 19th century. The 55 m high Neo-Classical tower was built in the first half of the 19th century. An appreciable section of the monastery adjoining the church is medieval (13th century), its final form having evolved during the Baroque period. A secondary school and dormitory finished in the early 1940s are also parts of the impressive group of buildings, which are divided by a number of courtyards.

The various collections at Pannonhalma are of great value. Rare documents and records from the earliest centuries of the Hungarian Kingdom are preserved in the archives of the main abbey. Among them is the earliest written record of the Hungarian language, the Latin deed of foundation of the Benedictine Abbey at Tihany dating from 1055, in which a considerable number of Hungarian words (about 100 words consisting of place-names and proper names) occur for the first time. The
library founded by King St. Ladislas possesses more than 70 codices from the 11th century. A number of valuable codices and incunabula as well as rich materials from more recent periods are preserved in ornamented cherry-wood cupboards. Consisting of over 300,000 volumes, the library presently houses the fifth largest collection of books in the country. The art gallery contains valuable, mostly 16th to 18th century works, among them a few genuine masterpieces (mainly Italian, German and Dutch paintings). There are also archaeological and stone collections, collections of medal signets and woodcuts, as well as a natural science exhibition.

On the way from Pannonhalma to Sümeg we pass Pápa, Devecser and cross the Bakony Mountains. Pápa is a small Baroque town at the northern foot of the Bakony. The most remarkable buildings are the 18th century Esterházy Palace and a large Baroque Catholic Parish Church built by Jakab Fellner. The town is well-known for its excellent secondary schools.

Sümeg

Situated below a medieval castle which crowns a horst of grey crinoidal Aptian limestone, the town has a rich historical past. Neolithic chert pits have been discovered in the Berriasian limestone at Mogyorósdomb; the tops of the steep Cretaceous and Eocene limestone cliffs rising above the town were prehistoric campsites. Artifacts of Copper, Bronze and Early Iron Age have also been found. There are records of Illyrian, Scythian and Celtic residents and of Roman occupation from the early years of the first to the end of the fourth century. After the Roman legions withdrew, Huns, Eastern Goths and Longobards replaced each other, and then there were invasions by Avars, Franks and Slavs. The Hungarians built a castle here after the Mongol invasion of Hungary, which became an important stronghold in the fights with the Turks (never conquered by them) and during Pálkóczí’s insurrection. In 1713 it burned down and was abandoned. Worth of mention are the Baroque and Neoclassic buildings and the frescoes of the parish church painted by Anton Maulpertsch.
Sümeg, Mogyorósdomb: Geological Field Station and Nature Conservation Area

Over a relatively small area the following formations can be studied here:
Rhaetian Dachsteinkalk underlying (with erosional unconformity) remnants of incomplete Lower, Middle and Upper Liassic in tectonic contact with chert-nodule-bearing Radiolaria marls (Dogger) grading into cephalopod limestones (Malm) and then into Biancone limestones with white chert nodules (Berriasian to Hauterivian). On the edge of Kővesdomb hill this sequence is in tectonic contact with the Senonian Hippurites limestone below which Aptian grey crinoidal limestones crop out on the northwestern flank of the hill. A few hundred metres beyond the Sp. No. 2 borehole has penetrated Upper Cretaceous of pelagic facies.

The Geological Field Station at Sümeg has been established by the Hungarian Geological Institute. It consists of fifteen wooden houses, a central building with working-rooms and laboratories, a canteen - lecture room, a sitting room and a kitchen. Scientific meetings, post-graduate training courses and the four-week summer field seminar of the geology and geophysics students of the Budapest and Miskolc Universities are held here. Near the Station there is a small museum displaying chert quarries and tools of Neolithic man.
Nagytárány, Darvastó: protected bauxite pit

This one-time lenticular body lies in the SW part of the Nagytárkány bauxite area. In the o-encast pit we can see the karstic paleorelief of Upper Triassic dolomite which is intensively weathered and pulverulent at the contact with the bauxite. Ferruginous crusts are common.

Lithologically, the bauxite is essentially a light or dark brick-red body, variegated in the upper and lower levels. Sporadically, near the hanging wall, the bauxite is grey, containing many pyrite-marcasite (partly haematitic) concretions and fragments of plant roots.

The principal mineral of the bauxite is gibbsite; boehmite is subordinate. In the red-coloured bauxite types haematite is dominant and the quantity of goethite is 4-5%. Silica is present in kaolinite.

This bauxite body is immediately overlain by an Eocene series made up of lignite, carbonaceous clay, Miliolina-Alveolina limestone and Assilina- and Nummulites-bearing limestones.

Not only the higher Eocene members were affected by post-Eocene erosion, but sometimes the bauxite as well. In the area of the bauxite body the erosion reached, in some places, down to the upper level of the bauxite formation. In such a way, the ore body remained in situ, without degradation.

The faults are abrupt, either controlled by pre-existent faults, or developed simultaneously with the bauxite, or post-Eocene ones.
Tapolca, Szentgyörgyhegy

The trip across the Tapolca Basin offers magnificent scenic views of a typical basalt cone landscape that was the scene of Latest Pliocene volcanism. The upper, steep slopes of the cones covered by forests are made of basalts; the lower, gentler slopes are built up of Pliocene sandy-clayey sediments and bear famous vineyards.

The most beautiful basalt volcano in the Tapolca Basin, preserving its natural state and studied in detail, is Szentgyörgyhegy.

In chronological order of formation, the following rock types occur. The eroded surface of clay and sand series of the Congeria ungula caprae horizon of the Upper Pannonian (Pliocene) is overlain by the basaltic sequence: the lower basalt tuff and agglomerate, lower basalt flow, upper basalt flow, upper basalt tuff and agglomerate and finally the scoriaceous basalt in the vicinity of the cone. Petrographically the two basalt tuff layers are essentially identical, with a preponderance of unaltered glassy lapilli. There are many olivine phenocrysts in the lapilli, and highly corroded, fragmental olivine lapilli are also common. The cement of the pyroclastics is fine-grained tuff. Secondary carbonate is also to be found as cement, in the upper tuff level.

The lower basalt flow is a dark, coarse-grained olivine basalt with diabasic texture. The rock shows columnar jointing; The columns are thick and show platy parting perpendicular to the columns. In addition to olivine, augite, plagioclase (An 45-55), ilmenite-platy magnetite appear as phenocrysts. The groundmass consists mainly of plagioclase and augite, some of which is acicular; apatite appears in the form of very thin, long needles. The rock is nearly holocrystalline.

The upper lava flow is fine-grained olivine basalt, light grey in colour, with thin columnar jointing. Only olivine appears as phenocrysts; plagioclase, augite and magnetite (ilmenite) occur in the fine-grained groundmass. There is some acicular augite and apatite. The cracks and cavities in the groundmass are often
filled with calcite. A basalt dike, intersecting the lower basalt tuff, was found in one of the old quarries. There are many beautiful basalt bombs in the upper basalt tuff at the top of the hill. Zeolites occur in the cavities and vesicles of the two basalt flows, as small epigenetic crystals of phillipsite and water clear idiomorphic chabazite associated with aragonite needles several centimetres long.

There is no substantial chemical difference in composition of the upper and the lower flows. These basalt flows display cooling effects in form of spectacular columnar and platy jointing.

Lake Balaton

Lake Balaton lies almost exactly in the centre of Transdanubia. It is the largest lake in Central Europe (595 sq km) - a long, narrow sheet of water, almost divided into two unequal basins by the Peninsula of Tihany.

Lake Balaton is shallow - not deeper than eleven or fourteen feet in most places - the southern shore having an exceptionally gentle slope and being carpeted with fine sands so that it is possible to wade for several hundred yards into the lake without the water reaching higher than one's waist. The shallow water, its high oxygen content, as well as other factors give it its distinctive colour - kind of milky turquoise.

The scenery of the Balaton has attracted many landscape painters with its serene charm.

Naturally, more visitors go to Lake Balaton in summer than any other time of the year, though every season has its own beauty. The shallow water warms up quickly, so the bathing season lasts from early spring to late autumn. In summer the water is often warmer than the air, particularly in the mornings and evenings. The hot and dry Hungarian summer is tempered by the great sheet of water. There is plenty of sunshine - an average of 2000 hours is recorded yearly.
In winter the lake usually freezes over. When it is possible to move about safely on the ice, the surface becomes alive with activity; this is when winter fishing and ice-sailing begins. By the way, it was on the ice of Lake Balaton that L. EÖTVÖS made the first gravity measurements with his torsion balance in 1903.

There are about forty species of fish in Lake Balaton, of which the most sought-after is the pike-perch (fogas).

At the beginning of the century Lajos LÓCZY, Sen. published the worldwide known monograph on the scientific investigations of Lake Balaton and its surroundings ("Wissenschaftliche Resultaten der Erforschung des Balatonsees") in twenty volumes. At that time this lake was the best-known one in the world. Owing to the work of the Hydrobiological Research Station of the Hungarian Academy of Sciences at Tihany it is still among the most investigated three lakes in the world, together with Lake Constance (Bodensee) and Lake Baikal.

Travelling along the northern coast of Balaton we pass numerous resorts and small villages among vineyards. One of the best Hungarian wines: Badacsonyi szürkebarát (The Grey Friar of Badacsony) is cultivated here.

Tihany (Nature Conservation Area)

The Tihany Benedictine Abbey was founded in 1055 by King Andrew I. Its charter contains the first written record of Hungarian language. The founder is buried in the Romanesque crypt of the church. Above the crypt a Baroque church crowning the hilltop was built between 1719 and 1754. The building of the Benedictine monastery is now a regional museum.

In 1954 a Geophysical Observatory for geomagnetic, gravimetric and telluric measurements was built on the Tihany Peninsula. It is run by the staff of the L. Eötvös Hungarian Geophysical Institute. At the shore there is the Hydrobiological Research Station of the Academy built in the 1920s, engaged now in ecological investigations of the lake.
The people of Tihany are farmers and fishermen. In ancient times the fishermen kept a look-out for shoals of fish from the hilltop and when they were sighted, signalled to the boats below; now the signal is sometimes given from airplanes circling over the lake. The village is now under protection.

Concerning landscape and geology, this is one of the most interesting and beautiful areas of Hungary. As shown by drilling and by xenoliths in basalt tuffs, the basement of the Tihany Peninsula consists of Paleozoic anchimetamorphic rocks and of Permian red sandstones. They are overlain by a Pannonian sequence. Tectonic disturbances at the end of the Pannonian opened up channels for basaltic volcanism. The volcanic went was in what is now the Outer Lake, a hypothesis supported by prominent positive magnetic anomalies.

This was the crater that furnished the basalt tuffs, rich in xenoliths. After the crater collapsed and the caldera had developed, coarse-grained lapilli and bombs were ejected in the northern part of the caldera, giving rise to independent cones of basaltic tuff. The development of numerous geyserite cones was contemporaneous with the second phase of volcanism. Younger formations are Pleistocene loess and Holocene deposits. - In the basalt tuffs there are cells of a "cave monastery" hewn by orthodox monks settled here by Queen Anastasia, wife of King Andrew I., daughter of the Great Prince of Kiev.

**Balatonsfűred**

It is an internationally known spa, famous chiefly for its natural carbonic acid waters. Since more than two centuries its spring-waters have been used for curing heart and circulation diseases. The spa was developed in the 19th century. During the Reform Period (1825-48) it became a symbol of the Nation's efforts. The first Hungarian stone-theatre was built here in 1831. Monuments, memorial tablets and self-planted linden-trees keep the memory of the Bengali poet Rabindranath Tagore, the Italian Nobel-Prize-winner poet Quasimodo, and others.
Balatonárács

In the cemetery of the village there is the grave of Lajos LÓCZY (1849-1920). The tombstone was carved of Permian red sandstone. Covered by a glass plate there was a small bouquet of edelweiss sent to LÓCZY’s funeral from the Himalayas by Sir Aurel Stein, the famous Hungarian indologist and Asia-explorer in British service.

Exposure of the Permian - Triassic boundary on the N side of the lakeside road between Balatonfűred and Csopak. The red Upper Permian sandstone is overlain - conformably, but with a sharp contact - by Seisian porous dolomites.

Tác - Gorsium, ruins of a Roman town

The settlement had 7000 - 8000 inhabitants and was given the rank of a city by Emperor Hadrian. It was destroyed many times in successive wars, and completely ruined after the Romans had left. Most of the stones were used in the Middle Ages for building the town of Székesfehérvár. Scientific and methodical excavation began as recently as 1958 and is still being carried on. Archaeologists say that continuing the excavations in this pace they have to work for about a century to uncover the whole city. An outdoor display and a small museum show remains that have been uncovered so far (an early Christian crypt, a capitoll, part of a street, villas, columns and ornamented wells, etc.). Each spring a Floralia celebration lasting several days is held here, and in the summer dramas of classical authors are staged.
The city had been inhabited by numerous prehistoric populations. The first lasting and important settlement established here was that of the Celts, a community replaced later by the town of Herculia in Roman times. Alba Regia (the "Royal White Town") was the Latin name given the Hungarian town of the Middle Ages.

In this region was the first campsite of Chieftain Árpád, leader of the Hungarian tribes at the time of the Conquest (9th century). The city later became the centre of the new unified Hungarian Kingdom. Under King St. Stephen (1000–1038) the settlement was surrounded by walls and given particular royal privileges. In ruins through, still imposing are the remnants of the first cathedral and royal palace built at the time of King St. Stephen. During half a thousand of years, till 1527 the cathedral was the scene of coronations of 37 Hungarian kings, 17 of whom were buried in the crypt of the church.

Under Turkish rule (16th–17th centuries) the city, like many others in this country, was almost completely destroyed.

Large scale architectural development took place in Baroque times and the present day townscape of the city is the legacy of that and of the subsequent Classicist periods.

In the decades around the turn of the century the development of the city was rather contradictory.

The developing major railway lines, the relative proximity of mineral resources and other economic circumstances were urging for large-scale industrial development; nevertheless, because of the strong feudal influence (Fejér country was one of the most typical areas of feudal latifundia in Hungary) the economic pattern of the city was stabilized in the function of an agricultural centre.

At the end of World War II the city suffered considerable damages, but since the liberation it has undergone a dynamic economic development and the structure of its economy has changed, promoting Székesfehérvár to one of the most important provincial industrial foci of the country (TV factory, etc.)
Elemér VADÁSZ (1885-1970), Professor of Geology at the Eötvös University in Budapest, member of the Hungarian and several foreign Academies of Sciences, promoter and organizer of the training of professional research geologists at the Budapest University of Sciences, author of five textbooks, was born at Székesfehérvár. His bust stands on the place of the house where he was born.

Velence Hills

On our way back to Budapest the highway crosses Velence Hills. They represent a low peneplain massif of small extent, the truncated remnant of a batholith that had soared rather high in the southern foreland of the Transdanubian Midmountains by the Middle of the Tertiary. The hills are constituted by Upper Carboniferous granite surrounded by Lower Paleozoic shale and pierced by Upper Eocene andesite dikes.

In the southern foreland is situated the shallow-water Lake Velence. Because of its proximity to the capital and good communication facilities it has become a favourite weekend resort. Terrain correction and drafting of housing and engineering development projects for this region are now being undertaken. The water level of the lake has been liable to considerable fluctuations. Presently efforts are being made to stabilize it. To this end the storage basins of Zámoly and Pátka have been constructed on the northern side of Velence Hills.

The average depth of the lake is 1.6 m, the greatest depth measured in the Agárd subbasin being 2.8 m. The bottom of the aging lake was covered by some 30 to 80 cm of decaying vegetal mass and mud up to latest times. Dredging and removal of these unwanted materials have been conducted for several years.

Passing by Pakozd, on the hilltop between the highway and the lake there is a monument, which commemorates the first victorious battle of the 1848-49 War of Independence, the Battle of Pakozd (September 29, 1848, considered the birthday of the Hungarian Defence Army).
Fig. 1. Situation of the Transdanubian Central Mountains (Dunántúli-Középhegység)
Fig. 2. Geological section of the bauxite pit of Cast.
Fig. 3. Geological section of the bauxite pit No. VI at Darvastó

1. Bauxite, 2. limestone and dolomite detritus, 3. clay with coal and huminite, a—b. lowermost marine silty calcareous marl, c₁. brackishwater clay, d—g. silty limestone and calcareous marl, c₂. brackishwater clay, h—l. limestone with Nummulites laevigatus, 4. Pleistocene gravel, detritus
Fig. 4. Geological sketch map and section of the Tihany peninsula
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