1869

125 years Hungarian Geological Survey

Studies

1994

125 YEARS
HUNGARIAN GEOLOGICAL SURVEY

BUDAPEST 1994

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FOREWORD

The 18th of June, 1869 is of outstanding importance in the history of the Hungarian geology in as well as in the whole world. The King of Hungary Francis Joseph I signed the Deed of Foundation of the Royal Hungarian Geological Institute on this day. By this royal act the Hungarian Geological Survey began its activities – as being the first scientific research institute of the Hungarian state and as one of the earliest foundations of this kind also all over the world (Böckh&Szontagh 1900, Nelson 1994).

The fundamental tasks of the Survey were specified by the Deed of Foundation along the following lines:

(a) detailed geological survey of the Lands of the Hungarian Crown is to be carried out, along with the publication of the results obtained corresponding to the demands of the science, agriculture and industry;

(b) geological maps of the territory of the Hungarian state, both of general and detailed character have to be compiled and published;

(c) petrographical and paleontological collections have to be established in order to demonstrate the formations and their features taking part in the makeup of the territory of the Hungarian state;

(d) chemical analyses of soils, minerals and rocks are to be performed for agricultural, mining and other industrial purposes.

Since the 12^{th} of October 1899 the Survey is housed in the present headquarters. This building being an excellent representative of the characteristically Hungarian "secessionist" style has art historical importance and as such it is held in high esteem all over Europe. It is one of the most important works of Ö. Lechner, a renowned architect of the Hungarian "fin de siécle". The building was erected in 1898–1899 by S. Hausmann on the site donated by the city magistrate of Budapest. The financial basis was provided by the Hungarian state and by Mr. A. Semsey a rich landowner who generously offered a considerable part of the enormous sum of money needed.

During its history the Survey has always been acting in the spirit of the aims formulated in the Deed of Foundation, although in the time elapsed since its foundation many of changes took place as the tasks were modified according to the current demands of the society and the national economy. By serving the science the Survey has made every effort, however, to meet the requirements of everyday life as well.

During the 125 years of its existence there were times of success and those of crisis. The past few years were of the latter. We are living in a period of constrained restructuring and reform times, of fundamental changes in the scope of our activities, and we are looking for new directions. Doing our work in the framework of the new organization set up in 1992 we have to reformulate our tasks and to achieve success bearing the burden of the radical cutback of our staff and of the restrictions in our budget since 1993. Accordingly, we commemorate the 125th anniversary of the foundation amid considerable difficulties.

It is essential, even in difficult times, to commemorate, and to recall the successes but also failures. We owe this not only to ourselves but to the posterity as well. And it is essential to have days of celebration, because we are proud of our 125 years old Survey, which has achieved outstanding results in the enrichment of the geological knowledge at home and abroad. We do need the historical retrospection for learning the lesson of the past and for our successful advancement; but we do need also the celebration, in order to strengthen our belief in the importance of our vocation.

We intend to celebrate the 125th anniversary of the foundation of our Survey by organizing an International Conference and a Hungarian Day. The International Conference will be organized in co-operation with ICOGS – the International Consortium of Geological Surveys – under the auspices of the UNESCO and the International Union of Geological Sciences. The aim of this Conference is to investigate and to discuss the role of geological sciences in a changing society.

A general introduction by E. Dudich, who will briefly outline the history of the Hungarian Geological Survey, will be followed by talks given by the Directors of national geological surveys on the following topics;

– Geological sciences in a changing society (by A. E. Babcock, Director of the Geological Survey of Canada);

– East-west co-operation in the geological sciences (by G. Gaál, Director of the Geological Institute of Hungary, Hungarian Geological Survey);

– North-south co-operation in the geological sciences (by C. Frick, Director of the Geological Survey of South-Africa);

– Co-operation between geological surveys in Europe (by Ch. Staudt, Director of the Geological Survey of The Netherlands);

– Role of geological surveys in the 21st century (by P. Cook, Director of the Geological Survey of Great Britain);

– International geological science co-operation – the role of the IUGS (by M. Schmidt-Thomé, IUGS, Treasurer, Bundesanstalt für Geowissenschaften und Rohstoffe, Germany);

– The task and organization of geological sciences in the USSR and in Russia – a comparison (by V. P. Orlov, President of the GEOLCOM – Russia);

– Highlights of Chinese geology – in view of the preparation of the 30th International Geological Congress (by Zhao Xun, Vice-president of the Chinese Academy of Geological Sciences, China)

The plenary session will be followed by a business meeting of ICOGS, providing the framework for discussing the following two important topics:

– global co-operation in the geological sciences;

– geological sciences and education.

Prior to the Conference – and as an introduction to it – on the occasion of the field trips to Tokaj and Eger (17 and 18 of September) the participants will have an opportunity to familiarize themselves with the geology and the wines of two famous historical winedistricts of Hungary.

The patronage over the Hungarian Day has been kindly accepted by His Excellency Árpád Göncz, the President of the Hungarian Republic. This day is dedicated to the presentation of the past 25 years of the Hungarian Geological Survey to the Hungarian audience. The programme includes the presentation of the following topics:

An overview of the 125 years of the Hungarian Geological Survey (by G. Gaál, Director);

Geological mapping in the past 25 years (by G. Chikán, Head of Division);

Geological basic research in the past 25 years (by Z. Balla, Head of Division);

Stratigraphical results of the past 25 years (by G. Császár, Project-leader);

Mineral exploration in the past 25 years (by J. Knauer, Head of Division);

Environmental geological research in the past 25 years (by Gy. Tóth, Head of Division).

On the occasion of the Hungarian Day our guests will have the opportunity to get acquainted with our Survey. The results of the past 25 years will be visualized by posters and maps, while the history of the Hungarian geology and the earth's history in our country will be presented in a new permanent exhibition which will be opened on this occasion.

The present publication has been compiled on the occasion of the anniversary. In previous publications the first three decades of the Survey's history had been reviewed by I. Böckh and T. Szontagh in 1900; while the studies dealing with the first hundred years have been published in a special volume edited by J. Fülöp and A. Tasnádi Kubacska in 1969. In our present situation we can not afford to publish a decorative volume like the mentioned ones, which might contain also a detailed historical overview. Nevertheless, we present this collection of studies, which gives a brief review of the past 125 years.

In the first part of the volume four papers summarize the most important events of the 125 years of the Survey's history. The studies of the second part are focused on the activities of the recent 25 years, on the results of the important tasks of the Survey. This part contains also the short biographies of the Survey's directors who were in office in the period under consideration. At the end of the volume there is a detailed list of references in which the published papers and unpublished manuscripts referred to by the authors have been compiled. In this bibliography the emphasis has been on the publications reporting on the most important achievements of the past 25 years.

I have the honour to recommend our present publication to readers of the present time and of the future in Hungary and abroad, both to our colleagues and to all those who are interested in the activity of our Survey. We hope that we might do our work under more calm and more orderly conditions in the coming times serving the interests of the society and the economy of Hungary, and the development of geological sciences both at home and on the international scene. If our hopes come true, the authors will report on more success and less problems in the volume to be edited on the occasion of the next anniversary.

Gábor Gaál
Director

PART I

1869—1994

HISTORY OF THE HUNGARIAN GEOLOGICAL SURVEY FROM 1869 TO 1919

by KÁLMÁN BALOGH

According to its Deed of Foundation, signed by the king, the Institute is expected to perform the following main tasks: (1) Small-scale and large-scale geological mapping of the national territory extending to 325 000 square kilometres with the inclusion of Croatia and Slavonia. (2) The issuing of publications on the survey results for the scientific, agricultural and industrial life. (3) The establishment of a map depository, a technical library and a geological museum containing collections of minerals, rocks and fossils suitable for comparison. The above were expected to secure a continually high standard of geological work to awaken the interest in geology of the general public, making thereby the geological sciences popular, and making the Survey better known and more respected both in the country and abroad.

At the time of foundation (1869), director Miksa Hantken could count upon the assistance of only three geologists graduated in Vienna and/or at Selmecbánya (J. Böckh, K. Hofmann and B. Winkler), in company of two assistant geologists trained at the Budapest University under the professorship of József Szabó (L. Telegdi Roth and D. Gaál), with two more geologists contracted from Erdély (Transylvania), namely F. Herbich and E. Pávay. The number of experts remained unchanged till 1882, but thenceforth it rose at first slowly then somewhat more rapidly, with many personal variations, attaining a peak of 26 ordinary staff members plus 12 contracted ones as late as in 1913 only (Fig. 1).

In view of the deficient and rapidly obolescent knowledge gained during the previous decades, the Survey was obliged to perform two basically different activities: generalizing scien-

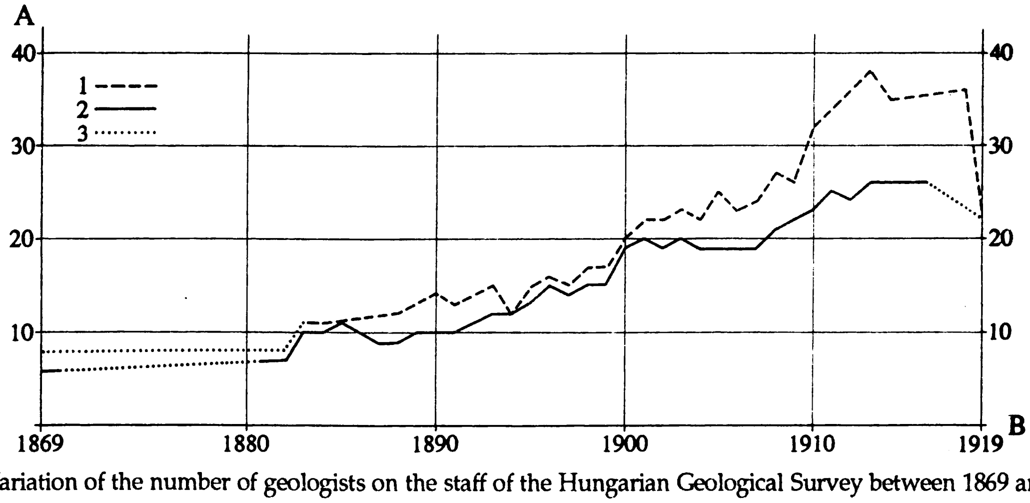


Fig. 1. Variation of the number of geologists on the staff of the Hungarian Geological Survey between 1869 and 1919
Continuous line marks the number of permanent staff members, broken line shows the number of permanent members plus outside contributors. Dotted line indicates lacking data

tific research and practical expertises locally required by the everyday life. The quickly developing economy brought about an increasing number of practical tasks hindering thereby the progress in country-wide geological mapping and material testing. Both Hantken and his successor, J. Böckh made unsuccessful attempts to increase the number of geologists and to differentiate the fields of work. All in all, 14 and 22 years, respectively, after the Survey's foundation, it needed a good deal of manage for J. Böckh to set up the following separate departments: (a) a Mining-Geological Department to study of regions of ore mineralization in Upper Hungary and in Erdély (Transylvania), (b) a Chemical Laboratory attending internal and external claims of the sort and (c) an Agrogeological Department to deal with the soils of the Great Hungarian Plain.

The economic life required the assisstance of the Survey in accomplishing the following tasks: marking of the tracts of the road and railway system; exploration of coal and metallic mineral resources; search for occurrences of construction materials and ornamental stones; exploration of water for drinking and industrial use; medicinal water supply; problems of river regulation; examination of ground slumping and landslides, and questions relating the protection against the phylloxera plague and solodization. This manysided work was done official or private expert reports according to the kind of claimant (governmental institutions, private individuals or private venturers). The sphere of activities was further widened by the Water Law coming into force in 1885 which vested the Survey with the power to issue official expert opinions, which had to be applied for prior to commencing any action in the concerned field. In 1894–1895, at the request of the Minister of Finance, J. Böckh investigated the hydrocarbon problems of Iza-Valley and Sósmező in Szekler Land, T. Posewitz did the same in Körösmező (Jaszinya) and L. Telegdi Roth dealt with ozocerite of Zsibó (Jibou). The asphalt-bearing lignite deposits at Derna and Tataros (Brustura) in the Réz Mountains were also studied (Telegdi Roth 1923).

In 1908, plans of prospecting for potassium salt and natural gas resources in Transylvania demanded the setting up of a Department of Applied Geology in the Survey. In 1910, however, upon a proposal made by L. Lóczy Sr. the task of hydrocarbon exploration was transferred to the Geological Department created inside the Ministry of Finance. Thereafter the exploratory work performed by the Survey was marked mainly by the study of M. Pálfy (1911), on the mines of the Transylvanian Ore Mountains (Erdélyi-érchegység, Mtii Metalliferi), the work of K. Papp (1915) entitled "The iron ore and coal resources of the Hungarian Empire", the discovery of manganese ore of Úrkút in Transdanubia and the study of the bauxite of Királyerdő (Padurea Craiului) in Transylvania are also mentionable (Rozlozsnik 1917, 1918).

Anyhow, on account of the practical tasks assigned to be accomplished by the Hungarian geologists, the results of geological mapping executed simultaneously have been left behind in concise reports only. Only a few authors of the more voluminous publications (Hantken 1878, Hofmann 1871, 1873, 1875, Böckh 1872, 1875 a, b, and 1877, Telegdi Roth 1883, Schafarzik 1892) were staff members of the Survey participating in the first major scientific venture, the geological mapping of Transdanubia. The authors of the majority of major publications were associate members, foreign scientists and specialists dealing with late Tertiary faunas (Pávay 1875, Herbich 1878, 1886, Staub 1882, 1883, 1887, 1891, Heer 1877, Halaváts 1890a, b, 1892, 1894, 1895, 1896, 1904, 1912, 1914, Felix 1884, 1890), and even some mineral prospectors (Schafarzik 1904, Kalecsinszky 1893, 1901, 1905).

The publishing process was also kept back by the fact that no author's royalties were paid. Since their salaries were low, geologists became more interested in producing well-paid expert's reports than in the compilation of monographs and explanatory notes to maps. Furthermore, most of them preferred the quick megascopic methods in petrological and palaeontological determinations to the onerous tasks using more sophisticated methods. Despite its great practical usefulness, the microscopic method practised by Hantken was adopted only by an associate member, Á. Franzenau (1881), though Hantken was a pioneer of stratigraphic micropalaeontology who recognised the dimorphism (A and B generations) of the nummulites. The petrological microscope was disregarded by J. Böckh and even by the mining geologist S. Gesell, and was introduced as an indispensable tool of the study of igneous and metamorphic rocks only by K. Hofmann (1879, 1886), F. Schafarzik (1892), B. Inkey (1883) and Gy. Primics (1883, 1889).

The main strength of the geologists in the first 38 years lay in their profound knowledge of macropalaeontology and in the stratigraphy developed under the influence of the German school (A. G. Werner, L. v. Buch, E. A. v. Schlotheim, F. Au. Quenstedt, H. G. Bronn, W. Haidinger), based upon good observation ability.* Due to this, the sedimentary deposits of Hungary ranging from the Devonian up to the Quaternary were dated correctly in the main. Because of the poor knowledge relating to metamorphism at that time, the genuine nature of these rocks remained unclear for long, however, the personal obstinacy of J. Böckh also played a role in the coming about of this setback.

After its foundation, the Geological Survey set out to survey Transdanubia, a region which had been neglected geologically. The mapping, in general, was aimed at the plotting of sheets joining the maps completed by Viennese geologists in 1869 to depict the Carpathian region to the Visegrád–Bükk Mts line. Geological maps were plotted on scales of 1:28 000 and 1:144 000, respectively. Only the "General Map of Transylvania" of F. Herbich had to be prepared as a more generalizing one. The 1:25 000-scale and 1:75 000-scale, hachured military maps were printed only in the late 1870's. All the former geological observations had to be re-visualized, of course, by the geologists, on these new ordinary topographic maps. Despite this, the map representation of Transdanubia was almost entirely completed by 1883, so the 1:144 000-scale geological map of this region of Hungary could be displayed at the National Exhibition of 1885.

Difficulties appeared when the surveying of the regions of the western boundary mountains of Transylvania and of the NE Carpathians was started in 1877. Hardships presented by the very nature of high mountains such as the great differences in altitude, the severe climate, the loneliness of the mountain woodland as well as the inaccuracy of the topographic map bases required extraordinary efforts of the geologists working for months under such conditions. Some of them drew back from the work, and left the Survey. Others, for example Gy. Pethő and K. Hofmann who was unsurpassable in precise mapping, were taken ill and died too soon, whereas the very talented Gy. Primics met his death during fieldwork. The progress of work was slowed down by the resulting changes in personnel. Other kinds of inconvenience also emerged. Resulting in a spiritless work, it was required, that the surveyor should fulfil the norm prescribed for the completion of fielfdwork in a map-sheet area, irrespective of whether it is possible with regard to the areal extent of the geological units and to the problems involved. Sometimes the willingness of the mappers was lacking to fit together the individual map sheets. These problems had already been encountered when mapping Transdanubia, however, they became accentuated in the high mountains. Geologists had a minimum chance to specialize in any topic, since between two periods of field work, in wintertime, they were unable to process even their own rock samples and fossils collected during the mapping. Accordingly, only brief survey reports were written, and the publication of the expectable summarizing studies was retarded. L. Lóczy Sr. (1909) complained that the Survey was bound to publish 3 to 4 dozens of 1:75 000-scale map sheets with appropriate explanatory notes and only 19 volumes of the Annals appeared in forty years.

The geological museum, starting from scratch, was gradually enriched by the findings of mappers, private persons and companies, and also from the donations of the great Maecenas, Andor Semsey. Educational purposes were served by providing schools with didactic collections of minerals, rocks and fossils for. The stock of the library was developed through an international exchange of publications, besides purchase and donation.

The results of mapping and material testing were first published exclusively in the Bulletin of the Hungarian Geological Society (Földtani Közlöny). As late as in 1871 the Survey commenced to issue the Annals, and in 1881 the Annual Reports. To the geological maps printed on a scale of 1:75 000, explanatory notes were also attached. Information on applied-geological activities, moreover museum and library news were published in the form of Occasional Papers. These publications and the participation in international congresses and exhibitions made a name for the Hungarian Geological Survey.

Although the fundamental merits of the first 38 years have to be acknowledged, the wrong research strategy leaves its mark on the whole period. The serial production of map sheets according to a chessboard-like system, in itself a tool only, was taken for the principal aim in-

* The results in stratigraphy of the Hungarian geologists are dealt with in K. Balogh's paper (1993) in detail

stead of a systematic study of geological problems. The geological knowledge of the areas once mapped was not consecutively improved, and their summarizing description was not fostered. No serious step was taken to start a geological reconnaissance of the NW Carpathians and Croatia-Slavonia.

In 1908 J. Böckh was followed in the directorship by L. Lóczy Sr., who had already made a name by his investigations carried out in Middle Asia and in the Balaton Highland. Lóczy Sr. intended to improve the above-described situation by setting the preparation of geological syntheses as a principal goal. Although he chose himself to bring the project to a successful conclusion, nonetheless he allowed his colleagues to co-operate by describing monographically, in a manysided manner, each natural geological unit, and arranged for proper royalties to be paid after the job had been done. An up-to-date research approach was required, with stratigraphical analysis followed by the reconstruction of paleogeography, tectonics and evolution-historical events, including the outlines of geomorphological evolution. Lóczy directed and stimulated this work by making frequent visits in the field and by the unselfish transfer of his long experience to fellow researchers. Ensuring a long-term financial background, he doubled the number of the members of the permanent staff, and increased the number of the outside contributors even higher than shown in Fig. 1. Some prominent foreign scientists and Hungarian secondary school teachers were also drawn into the work.

At his nomination, in 1908, Lóczy Sr. was already fifty-nine, when he boldly undertook to implement his plans. First of all, he envisaged the completion of the works launched by Böckh in the Southern Carpathians, Bihar Group, Transylvanian Ore Mts and in the NE Carpathians, by a modern approach. However, researchers were sent simultaneously to the following regions, too: Bán Mts, Villány Mts, Mecsek Mts, the Alps where extending as far as into Hungary, the basalt buttes of Kisalföld (the Little Hungarian Plain), parts of the Transdanubian Central Range, Cserhát, Salgótarján Basin, Mátra Mts, Borsod–Bükk Mts, the principal parts of the Eastern Carpathians and the

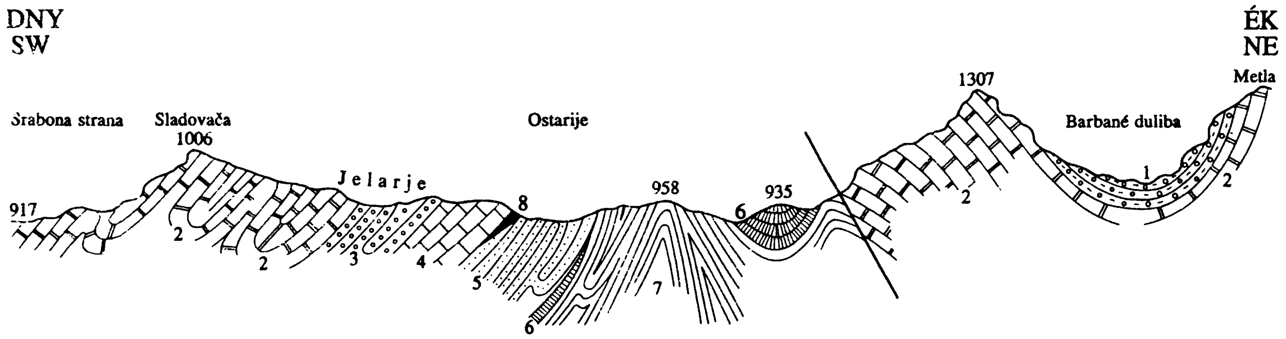


Fig. 2. Geological section across the Oštarije area with the upthrow of Carboniferous rocks, according to Koch, F. (1914)
1. Upper Liassic mottled limestone, 2. Middle and Upper Liassic, 3. Hauptdolomit, 4. Diplopora limestone, 5. Seisian strata, 6. Permo-Carboniferous, 7. Upper Carboniferous, 8. Porphyrite

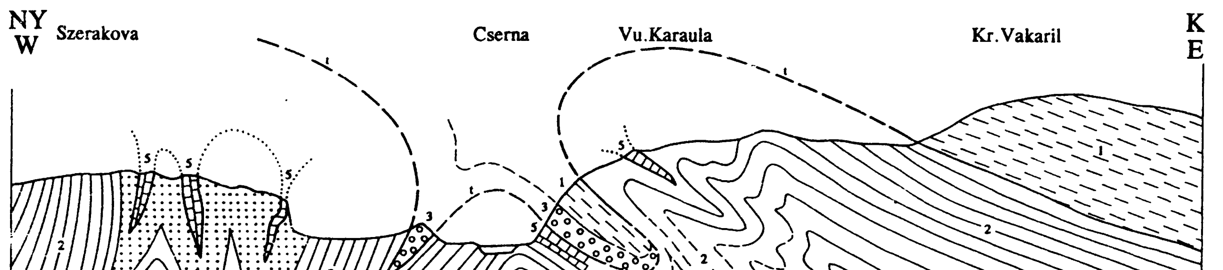


Fig. 3. Geological section set to the south of Csernahévíz, according to Schafarzik, F. (1914)
Autochton: 2. Garnetiferous gneiss, biotite gneiss, micaceous phyllite, 4. Liassic quartzsandstone, 5. Malm limestone. Units of the nappe: 1. Micaceous gneiss, mica schist and pegmatite, 3. Verrucano (Permian)

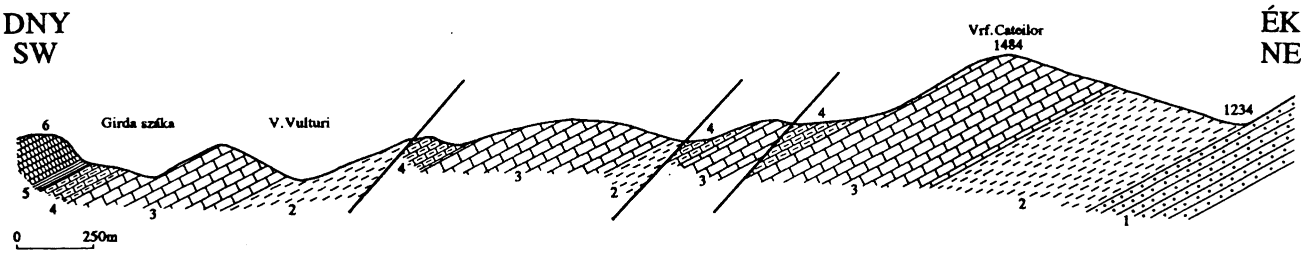


Fig. 4. Geological section set from Girda-száka towards the north-east, according to Pálfy, M. (1914)
1. Permian limestone, 2. Triassic dolomite, 3. Triassic limestone, 4. Rhaetian-Liassic sandstone with overlying Upper Liassic arenaceous limestone, 5. Dogger, 6. Malm

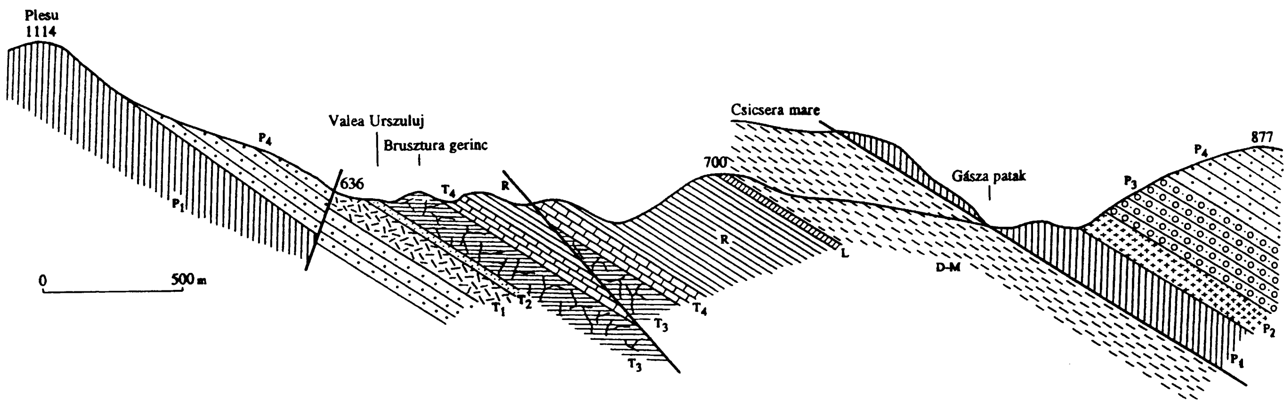


Fig. 5. Geological section of the eastern side of the Bél Mts (Béli-hegység) according to Pálfy, M. (1913)
Lower Permian, P_1: Quartz porphyry, P_2: diabase and keratophyre, in the III. Permian range with intercalated violet and grey slate, sandstone, diabase tuff, at places strongly pressed quartz porphyry. Upper Permian, P_3: Quartz porphyry tuff and conglomerate, arkosic sandstone, passing upwards into quartzite sandstone; P_4: quartzite sandstone. Middle Triassic, T_1: Lower dolomite (Anisian), T_2: dark grey limestone with grey and yellow slate; Wengenian strata (Ladinian stage), T_3: upper "saccharoidal" dolomite (Carnian stage). Upper Trassic, T_4: Light and dark grey limestone with red veinlets (Norian stage), R: sandstone, marl, dark grey coralline and brachiopod-bearing limestone (Rhaetian stage). I: Light grey or red crinoidal and compact limestone (Lower and Middle Liassic), D-M: grey marl and sandstone (?Upper Liassic, Dogger-Malm), Kv: gravel (Diluvium)

Transylvanian Basin. With seven Croatian and Hungarian geologists involved, the geological survey of Croatia-Slavonia, concerning mainly the Karst Mountains was started in 1911. The remapping of the Northern Carpathians was launched in 1913, as a work planned for ten years with the participation of nine mappers. In 1916, taking along twelve men, Lóczy Sr. himself undertook the small-scale geological surveying of West Serbia, Bosnia and East Montenegro.

As a matter of fact, this ambitious programme turned out to be exaggerated in the historical situation of those times. The execution of the plans met with difficulties of different nature. The internal troubles of the Austro-Hungarian Monarchy, the outbreak of the First World War, the call-up of numerous geologists, the drawbacks of the work to be performed inside and outside the Survey, the revolutions in 1918 and 1919, the undeserved personal attacks launched on Lóczy Sr., the downfall of the state consequent upon the military defeat and the foreign occupation of the country – all these handicapped the researchers and the progress of geological research. On account of his frustrations and getting more and more exhausted in a desperate race against time, Lóczy Sr. resigned from directorship on 03. 09. 1919, and half a year later he died. With him, Hungary lost one of her geologists with the widest intellectual horizon.

Yet the first half a century of the Institute can display significant achievements. J. Böckh (1883, 1887), F. Schafarzik (1895, 1914), F. Nopcsa (1905a), B. Inkey (1884, 1885, 1891), Gy. Primics (1883) and A. Vendl (1932) established very well the geological knowledge of the region situated between the Lower Danube and Királykő in the Southern Carpathians. For instance, it was Schafarzik who distinguished the Lower Carboniferous of Kornareva in a group of phyllites, stating that the concerned unit is unconformably overlain by Upper Carboniferous beds containing coal seams. Upon microscopic examination he rectified numerous former views (Fig. 3). Scha-

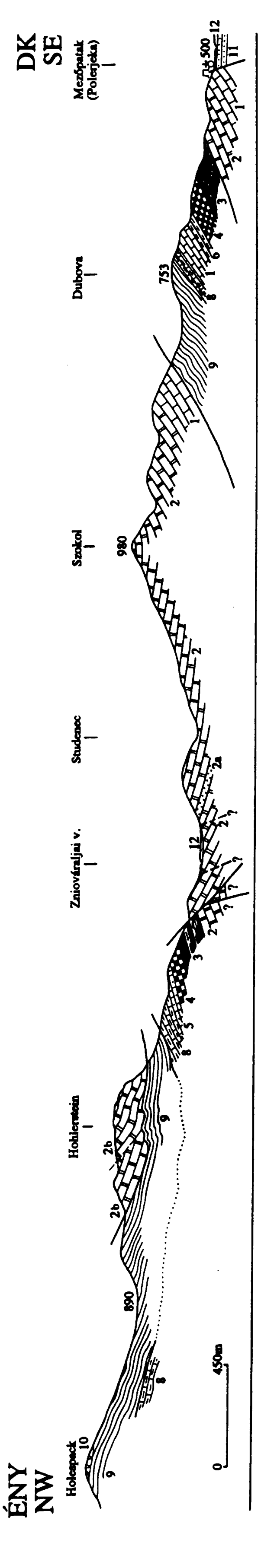


Fig. 6. Geological section across Zniováralja Valley between the Turóc basin and the watershed of the Klak group of mounts, according to Vigh, Gy. (1919)
1. Middle Triassic limestone, 2. Triassic dolomite, 2a. Lunz limestone, 2b. Triassic limestone and dolomite, 3. Variegated Keuper, 4. Kössen Beds, 5. Gresten strata, 6. Liassic mottled calcareous marl, 7. Jurassic laminated limestone, 8. Red and yellow cherty limestone (Tithonian), 9. Neocomian marl, 10. Neocomian foraminiferal limestone, 11. Neogene, 12. Alluvium

farzik evidenced also the Jurassic age of the Schelea Formation. His statements were considerably relied upon when the nappe theory relating to the Southern Carpathians was elaborated (Murgoçi, 1905).

P. Rozlozsnik (1906 a, b, 1908, 1913), moreover M. Pálfy (1911–1916; Figs. 4 and 5) described the structure of the Bihar Group (Mtii Apuseni) as a truncated set of nappes. In this, the study of occurrences of continental Carboniferous rocks around Nagybihar (Cucurbeta) was instrumental, together with that of the distribution of different Mesozoic facies. The distinction of the Vepor and Szepesség nappes is also linked with the name of P. Rozlozsnik (1914–1915). Fossils collected by E. Vadász (1909) indicated the presence of marine Carboniferous deposits in the Bükk Mountains. The age of calcareous algae described by J. Jablonszky (1919), after a due revision, proved the presence of marine Upper Permian deposits – then the only such occurrence in the entire Carpathian Basin. At that time, rocks of the continental Permian were already widely known in the Balaton Highland, Mecsek and Kodru (Böckh 1872, 1876a, b, Lóczy 1913, Vadász 1912, 1914, 1915, 1917, Pethő 1892, 1896, 1897). The existence of the above-mentioned algae was also reported from the Karst Mountains and, what is more, V. Vogl (1913) succeeded in finding Middle Carboniferous cephalopods at Mrzla Vodica.

Upon the distribution of the carbonatic and detrital features, J. Böckh (1872, 1876a, b, 1880-1881), K. Hofmann (1871, 1873), L. Lóczy Sr. (1913) and E. Vadász (1910) distinguished two different facies in the Transdanubian Triassic–Jurassic sequences. Accordingly, they identified a Gersten-type near-shore deposition in the Mecsek Mts region and an East-Alpine-type neritic sedimentation to have existed in the Transdanubian Central Range (mainly in Jurassic time).

In the Southern Carpathian region, the Triassic deposits were found to be missing almost entirely due to erosion (Böckh 1888), and the Jurassic was described as representing a transgressive deposition initiated by Gresten facies. These statements corresponded to the hypothesis put forward by E. Mojsisovics (1880) assuming that an Eastern Continent must have existed in Liassic time.

In response to the pertinent criticism of M. Lugeon (1903), V. Uhlig (1907) worked out the first nappe synthesis for the structural inter-

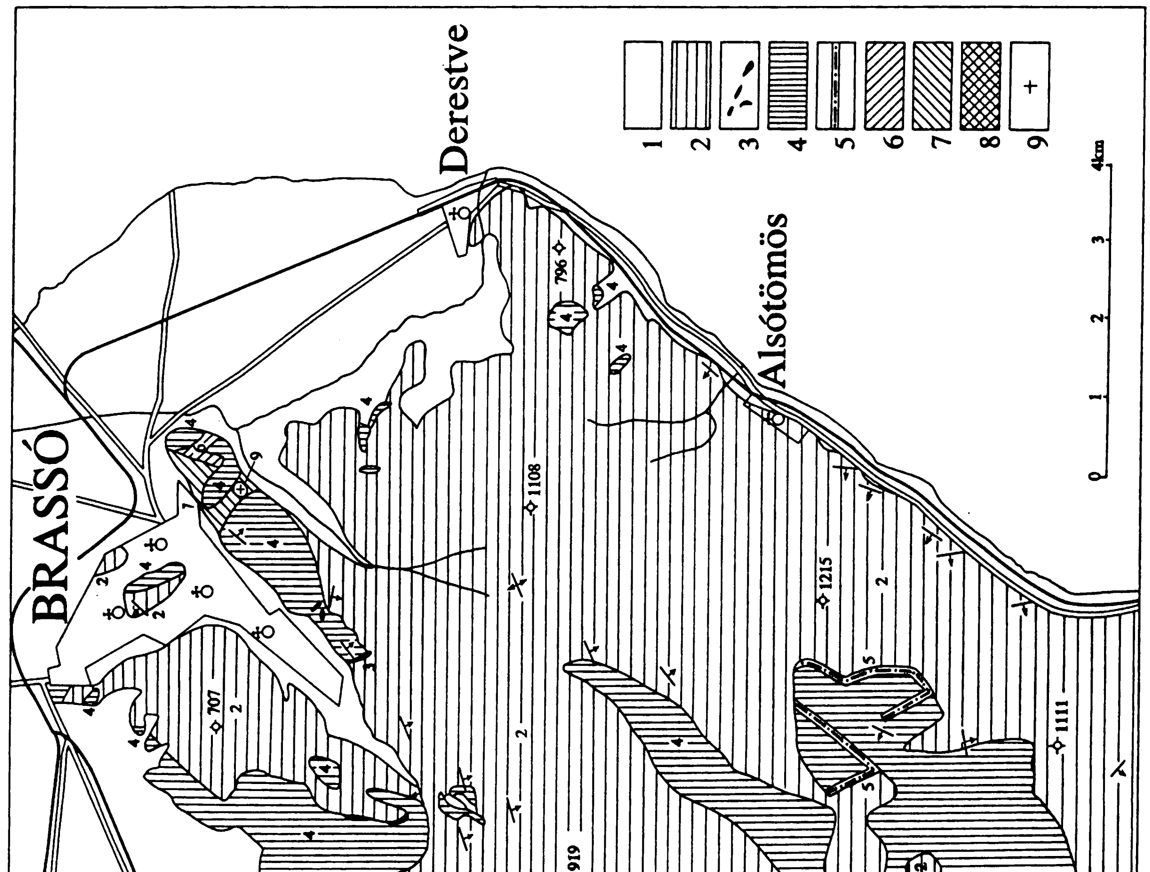
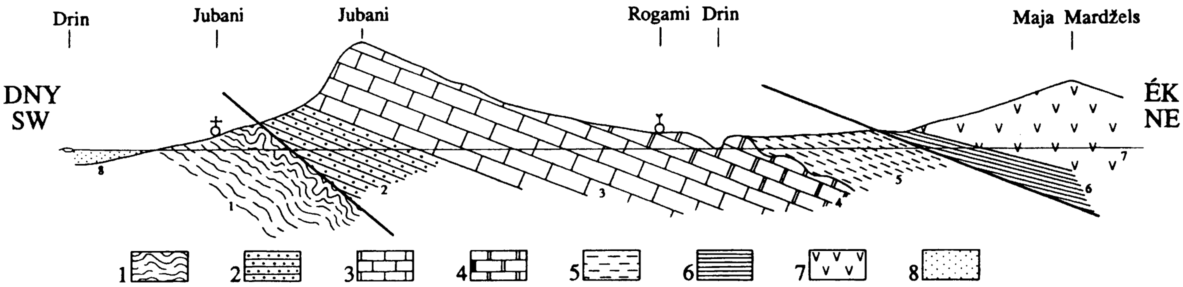


Fig. 7. Small-scale geological map of Keresztényhavas, according to Jekelius, E. (1914)

1. Holocene-Pleistocene, 2. Cenomanian + Gaultian, 3. Neocomian, 4. Tithonian-Oxfordian, 5. Callovian, 6. Lower Dogger, 7. Liassic, 8. Triassic, 9. Trachyte



8. The geological section of Jubani, Albania, according to Nopcsa, F. (1916a)
1. Eocene of Zadrima, 2. Middle Triassic of Cukali, 3. Upper Triassic of Cukali, 4. Rhaetian of Cukali, 5. Eocene of Cukali, 6. Middle Triassic of Merdita, 7. Serpentine of Merdita, 8. Alluvium

pretation of the NW Carpathians, as based upon the presence of Permian to Mesozoic sequences of more explicitly neritic origin deposited in the foot region of the Tatra Mts, somewhat farther from the immediate but discontinuous sedimentary mantle of the granitic nuclei. However, the fact that the Choc dolomite and limestone masses that overlie the Neocomian marls of the sub-Tatric facies mentioned above, are Triassic in age and belong to a tectonic nappe detectable from the Little Carpathians up to Mincov, was recognized by B. Dornyai (1913, 1917), Gy. Vigh (1915; Fig. 6), K. Kulcsár (1916, 1917) and L. Lóczy Jr. (1915a–1916).

It was K. Hofmann (1884) who first observed that the Lower Cretaceous beds of Lábatlan (Gerecse Mts) overlie the lower Tithonian limestone with a hiatus and a Berriasian breccia. The presence of Aptian, Albian and Cenomanian deposits was established in the Bakony Mts, too. The faunal assemblage collected from the "augite porphyry" tuffs of the eastern Mecsek Mts by Hofmann, indicated that the related volcanic activity must have taken place in the Early Cretaceous. The facies and the extension in time of the Cretaceous deposits in the western and eastern ranges of the Krassó-Szörény Mts, were also determined. The Lower Cretaceous flysch of the Transylvanian Ore Mts was described as strongly folded and incorporating limestone cliffs. The flysch was found as thrusted over the Upper Cretaceous unit of undisturbed position of the marginal zone. The concerned structure was interpreted as being indicative of post-Gosau tectonic movements. Gosau strata starting to develop with coal-bearing beds were detected in the southern Bakony Mts (Ajka, Sümeg). Dinosaurs of Danian age found in the Hátszeg basin in Transylvania were determined by F. Nopcsa (1915). Gy. Pethő (1910) wrote a study on the hyper-Senonian fauna of Fruška Gora. Mesozoic faunae of Brassó were studied by E. Jekelius (1915, 1916–1917, 1917) and the Dogger ammonites of Villány by L. Lóczy Jr. (1915b) (Fig. 7).

Many valuable data recorded by the Hungarian Expedition in Serbia (Exploration of the Balkans, 1918) were represented on a 1:200 000-scale map of L. Lóczy Sr. (1924) exhibiting 29 geological units. The Mesozoic and the Palaeogene of North Albania were described by F. Nopcsa (1905b–1906, 1908, 1911, 1916a, b, 1929) according to tectonic units (Fig. 8).

The study of Tertiary rocks in Transdanubia and Transylvania allowed the setting up of comparative stratigraphic columns for the Carpathian Basin on the whole. M. Hantken (1871, 1873 and 1875) played a pioneering role when establishing the stratigraphic subdivision of the Palaeogene sequence developed between Budapest and Esztergom on the basis of foraminifers. The Palaeogene succession in the Transylvanian Basin embraces four full sedimentary cycles with notable changes according to depth inside the Upper Oligocene – the related study was done by K. Hofmann (1887) and A. Koch (1894). In addition to the Upper Cretaceous, the presence of Palaeogene deposits in the flysch belt of the Carpathians was recorded by J. Böckh (1894) and T. Posewitz (1910, 1913, 1916). The stratigraphic subdivision of the sequences deposited in early and late Tertiary times in the Vértes Mts; Liptó basin; the left-bank area of the Danube; Cserhát, Nógrád and Bükk regions was outlined correctly by E. Vadász (1910), H. Taeger (1909), V. Vogl (1910, 1917, 1923), J. Noszky Sr. (1909–1917) and Z. Schréter (1913–1917). The description of the Wind brickyard section at Eger according to faunal horizons (Telegdi Roth 1912, 1914) represented a tool in the hand of stratigraphers to mark out the Oligocene/Miocene boundary. The disclosure of three main rhyolite tuff horizons played an important part in the division of the

Miocene of Transylvania and of other regions in the country. Especially the Miocene strata around Budapest were subdivided in much detail. In areas such as Sopron, the Transdanubian Central Range, the Mecsek Mts, Bihar and Krassó-Szörény counties, Lower and Upper Mediterranean units and Sarmatian strata (detrital, calcareous, marine and of brackish-water origin, at places coal-bearing or volcano-sedimentary deposits) were distinguished. No Lower Mediterranean sediments have been found in the Bakony Mts, in the area situated north of the Fruška Gora Mts and on the Vinga ridge.

L. Telegdi Roth (1879) proposed that the thick sedimentary sequence occurring between the Sarmatian of brackish-water origin and the fluvial, lacustrine or aeolian Quaternary sediments should be assigned to the Pannonian stage. Since the Sarmatian of the Carpathian Basin represents only the lower one-third of the East European one, the lower argillaceous part of the Pannonian was ranged into the "missing" part of the Upper Miocene. In turn, the more arenaceous upper part of the Pannonian stage occupied its place invariably in the Pliocene (Gaál 1909, 1910, 1912, Schréter 1912).

More exhaustive Quaternary studies were launched only after the setting up of the of Agrogeological Department (1891), but even then almost exclusively in the lowland areas, with the exception of the Lake Balaton region. In mountainous areas these were restricted to the study of vertebrate remains found in cave sediments. After the I. International Agrogeological Conference held in Budapest in 1909, discussions conducted at the Department resulted in the preparation of a small-scale soil map by P. Treitz (1918), which was, however, published as late as 1927.

Lóczy, L. Sr. levelled up the general standard of the publications, and accelerated the editorial work of the Annals. Geologica Hungarica was put into circulation in 1914. The planned big monographs, however, failed to appear or were published with considerable delay and have remained incomplete. Lóczy's map, the "Geological Map of Hungary" scale 1:900 000, overlooking the entire Carpathian Basin region, was published in 1922, after having been revised by K. Papp (edited by the Hungarian Geographical Society). In the life of Lóczy Sr. only a study of his was printed in 1918, which dealt with the essentials of the Tisia-theory backing up the idea of Hungary being from the megatectonic point of view a "median mass". The discovery of the natural gas resources of Transylvania is also linked with the directorship of L. Lóczy Sr. (Papp 1909, 1910).

As a consequence of the Trianon peace-treaty, the Hungarian Royal Geological Institute lost the two-third of its former survey areas and the financial possibilities for any further works had also diminished. Despite some lacks the upper summary probably makes clear, that during the first 50 years of its existence, the Survey carried out a modern geological survey in the Carpathians and in the surrounded basins, which could have been developed later with success both in Hungary and in the successor countries of the Monarch.

HISTORY OF THE HUNGARIAN GEOLOGICAL SURVEY FROM 1920 TO 1949

by SÁNDOR JASKÓ

Lajos Lóczy Sr. retired in November 1919 and died in May 1920. This was the beginning of a new era for the Geological Survey.

Initially Tamás Szontagh and later Móricz Pálfy were appointed as temporary directors of the Survey in the 1920–24 period. In this period the research goals of the Survey were fundamentally changed by the pressure of external circumstances. One of these changes was a big reduction in the area for geological mapping. The Carpathian and Dinarid mountain ranges, and the Transylvanian Basin became parts of the neighbouring countries by the terms of the Trianon peace treaty. Surveys being done in these regions by Hungarian geologists were interrupted. The publication of results from these areas was made difficult not only by the political changes but by a reduction in funds available to pay for publication.

The other change in direction was motivated by the goal of reconstructing the economy. A detailed investigation of the country's iron-ore and coalfields was begun. As a result of this work, with the financial support of interested mining companies, several papers were published. Worth mention among these are studies of the Rudabánya iron-ore deposit and coal geology maps of the Esztergom, Tatabánya and Borsod coalfields (Pálfy 1924, Rozlozsnik 1924, Rozlozsnik et al. 1922, Schréter 1929).

Ferenc Nopcsa was director from May 1925 till the spring of 1928. From an early age he had the opportunity to visit all the major university departments, museums and geological surveys of Europe for the study of vertebrate fossils. His outstanding knowledge of palaeontology won him general acclaim and he is considered to be one of the greatest palaeontologists ever. Several foreign scientific societies elected him to be an honorary member. He was also a member of the Hungarian Academy of Sciences. He is remembered both for his comprehensive studies of dinosaurs and as the founder of the discipline of palaeo-physiology.

Nopcsa recognised that the mining geology publications of the Survey, devoted to practical problems, were mainly read by Hungarian professionals and therefore he favoured the continued publication of these in Hungarian. On the other hand he deemed it a most important task to let the scientific results of the Survey be widely known abroad. Accordingly, he decided that the longer reports, distilling the results of several years of scientific investigations, should be published in major European languages in the Annals of the Survey. He also encouraged staff to publish in foreign periodicals. When there was a need for it he made it possible for members of the Survey to study stratigraphy and palaeontological collections abroad. By his invitation, the Palontologische Gesellschaft held its 1928 meeting in Budapest. A large number of internationally known specialists gathered for the meeting. They visited the Survey, where Nopcsa, already a sick man, gave the welcoming plenary paper in the museum hall. The meeting was followed by field trips. The guide book for the trips was published in German as an occasional publication of the Survey (Rozlozsnik et al. 1928).

F. Nopcsa was followed in the post of director by Hugo Böckh. The two had very different styles. Nopcsa was attracted by the fundamental theoretical questions of pure science. His rapidly deteriorating health however prevented him from devoting the necessary energy to practical management of the Survey. By contrast, H. Böckh was a born leader. During his varied career he worked as university professor, headed a section in a government department, and was the chief geologist of a multinational oil company. His wide-ranging experience made it possible for him to reorganise the Survey and once again direct its activities towards practical problem solving. To achieve these aims he started two new projects. He proposed applied geological surveys aimed at mineral resource exploration for which he sought the financial support of the Treasury (the department which was responsible for mining revenues). The agrogeological surveys he planned were to be financed by the Ministry of Agriculture as before. Exploration for hydrocarbons and salt deposits was, he considered, to be of prime importance. He introduced new techniques to enhance field surveys and laboratory analysis. The 1:25 000 scale maps with hatched relief in use at the time were inadequate for accurate positioning. For this reason Böckh made it a rule for field surveys of the mountains to measure every exposure with tape, bubble level and oil compasses. More important was his other innovation of introducing the Eötvös torsion balance for hydrocarbon exploration in Hungary. In 1929 he formed a laboratory for the processing of borehole samples as there was a need to systematically investigate and describe the samples from an ever increasing number of boreholes drilled. Except for chemical analysis, this laboratory could handle every investigation that needed laboratory instrumentation. In addition to the determination of sand and carbonate content the range of investigations included micropalaeontology and coal petrology.

Lajos Lóczy Jr. was the director of the Survey for 15 years from 1932 to 1947. He was the son of the director who died in 1920. In his career he spent a long time abroad in geological exploration. Despite this he was familiar with both the geology of Hungary and the state of exploration in Hungary. He had clear ideas about the duties and aims of the Survey and he was ready for the task when he entered office. His directorship of the Survey can be divided into three stages each with a different character, mainly due to influences of world events and the war.

(1) The years from 1932 to 1938. When Lajos Lóczy Jr. entered office he planned to continue in the footsteps of H. Böckh and develop the range of practical applications but he also tried to restore the balance by promoting basic scientific research. His guiding principle was that the secret of practical science e.g. exploration successes is in the expert technical knowledge and its correct application. Stratigraphic and hydrocarbon genetic considerations led Lóczy to the assumption that the most important source rock of hydrocarbons in Hungary was the Middle Oligocene Kiscell Clay, more particularly its evaporite-clay facies (Annual Report of 1933–1935, Lóczy 1939 p.25). Therefore he decided to concentrate petroleum exploration on the northern margin of the Great Hungarian Plain where these beds are outcropping or are near the surface. He organised several survey teams from the staff geologists of the Survey and university personnel for the study of particular regions. In the first phase the Cserhát, Mátra, Bükk, and Tokaj ranges were surveyed. On completing this phase the teams surveyed the hilly terrain north of these ranges which consist mainly of Oligocene formations. Lóczy's wish was to locate petroleum traps by investigating structural geology conditions. Surface weathering of the Oligocene clay and silt formations constituted a formidable problem because the bedding could only be recognised at 3-4 m depth. Thus the survey required the digging of hundreds of deep pits in each area to expose the beds for structural analysis. Nevertheless, the great financial and intellectual effort resulted in success. Several horsts were identified as structural traps where subsequent drilling resulted in oil discoveries (Bükkszék, Demjén, Mezőkeresztes).

The Geological Survey assisted oil exploration in other areas as well. By agreement, the Survey let the European Gas & Electric Co. (Eurogasco) use its manuscript maps and drilling log reports when exploration started in the Transdanubian region. The contract also provided the oil company with laboratory tests and draughting services. Agricultural soil surveys were also reorganised in the 1934–35 period. The Ministry of Agriculture commissioned a group of soil scientists from various departments to define new standards for soil surveys and produce a pilot sheet of the new style maps (Kreybig 1937). These new guidelines were used to start the work in the Survey under Lajos Kreybig. A separate soil laboratory was formed and several soil chemists were employed. Significant funding was obtained for field surveys and for the printing of publications. In the years 1936–38 the Survey published nearly two dozen colour printed sheets of the 25 000 scale soil survey maps together with explanatory booklets. The publication of "solid" geological maps with stratigraphic and structural data regrettably received much less funding. With the accumulated backlog of several decades L. Lóczy Jr. had to find a compromise solution. He started publication of a new series for regional geology (Magyar Tájak Földtani Leírása). Each issue was a concise monograph of a particular regional unit of Hungary with a coloured geological map and text. The geology of the Mecsek by E. Vadász and that of the Cserhát by J. Noszky Sr. are both among the works that appeared in this series (Vadász 1935, Noszky 1940).

(2) The period 1939 to 1943. World events changed the borders of Hungary. The Munich Agreement of September 1938 awarded Hungary the Hungarian populated southern regions of Slovakia. In March 1939 Carpatho-Ukraine, in August 1940 Northern Transylvania was returned to Hungary. These mountain regions are rich in good exposures and with their varied geological make-up offered excellent work opportunities for field geologists. Understandably, the surveying activities of the Survey were concentrating in these regions. For a period of five years this work was carried on uninterrupted until in the spring of 1944 the war front reached the Carpathians. During this time, in addition to general geological surveying work, the Hungarian geologists studied the palaeontology, petrology and other details of a number of localities, describing the results both in the Annual Reports (Évi Jelentés) and scientific periodicals. Several of the monograph studies of the Carpathian range are worth mentioning. Tibor Szalai's essay on structural geology appeared in vol. 38 of the Annals of the Survey. Lajos Lóczy Jr. described the economic geology and mining conditions of Ruthenia (Carpatho-Ukraine) in vol.I of the Annual Report for 1939. Boleslaw Bem, a Polish refugee geologist, wrote a long paper on the petroleum geology of the north-eastern Carpathians (Szalay 1947, Lóczy 1943, Bem 1941).

The Ministry of Industry commissioned the structural geological survey of the Transylvanian Basin. This was co-ordinated by Horst Bandat, introducing the use of photo-geology which was a novel technique in Hungary in those days. The geological surveys used 1:10 000 scale aerial photographs supplied by the Hungarian Military Cartographic Institute. The character of the geological make-up in this area made aerial photos particularly useful. The Transylvanian Basin is not covered by loess and it is easy to trace the volcanic ash marker beds outcropping on hillsides with sparse vegetation. The ash beds form 1 to 2 m thick intercalations in the Tertiary clays and with their contrasting white colour they appear as stripes on the photos. Formation strike and dip can be determined from the elevated or depressed position of these marker beds. This enables the outlines of the shallow gas-bearing anticlines to be drawn (Bandat 1942). The activities of the Soil Department continued in 1939–1943 under the leadership of Lajos Kreybig. Generous financing made it possible to employ many external workers to speed up the field surveys. The external workers surveyed the country in teams with a staff member as team leader. As a result of the quick work the whole area east of Tisza was completed by the end of 1943 and the teams started surveying the rest of the country between the Danube and the Tisza and in south Transdanubia.

"Proceedings of the Meetings" (Beszámoló a Magyar Királyi Földtani Intézet vitaüléseinek munkálatairól), another series of publications was started in 1941 to increase the awareness of the results obtained in the areas of "solid" geology. The meetings discussed new ideas, problems and the potential application of new techniques. Staff of the Survey, and also colleagues from universities and mining companies took part in these discussions. One of these memorable meetings was the occasion for a heated debate between Ferenc Pávai-Vajna and the geologists of MAORT (i.e. Hungarian American Oil Company) on the tectonics of Transdanubia (Pávai-Vajna 1943).

Sándor Jaskó also read a paper on the evolution of the Bay of Bicske thereby demonstrating the technique he developed for constructing cross sections using a combination of borehole log and surface outcrop data. Such sections present a highly visual and reliable picture of the structure of subsurface formations (Jaskó 1943).

(3) The period 1944 to 1947. The last stage of Lajos Lóczy's directorship was marked by the effects of the war. Field and laboratory work became much reduced in 1944, because of air raids and the front reaching Hungary. When the

Evacuation Commission ordered the removal of the Survey to a country location some workers moved with their equipment to Balatonarács. This section found temporarily offices in the buildings of the Vintners and Vine Growers School. Meanwhile, part of the library was moved to Somogyvár and Aklipuszta.

When the front reached the suburbs of Budapest those remaining in the capital were employed in securing the safety of museum specimens and laboratory instruments in the basement of the Survey. Platinum crucibles from the laboratory were buried in the grounds.

When the Hungarian Arrow Cross party came to power, the director, Lajos Lóczy went into hiding, leaving the leadership of the Balatonarács section in the hands of deputy director Gyula Vigh. The siege of Budapest caused substantial damage to the Survey building. It took over a year to restore the damaged building, clear away the war debris and again start geological research. In the early days there was no electricity, water or heating. There remained no glass in the windows and floor of every room was covered by a thick layer of bits of bricks, mortar and broken glass.

When fighting in Budapest was over, Lajos Lóczy resumed the directorship, continuing till 1947 when he left the country never to return. Already in January 1945 Lóczy requested the Ministry of Agriculture to appoint Tibor Szalai as a new deputy. Upon the approval of this request Tibor Szalai took over the tasks of directing the restoration work, supervision of the return of staff and material from country locations and, in general terms, ensuring the right working conditions for the resumption of professional work. The survey of the Oligocene terrain in the hills north of the Bükk and Mátra in NE Hungary was continued. The Soil Department was employed in exploring the Kis-Balaton peat area by shallow bores. Exploration for trass cement material was carried out in the Tokaj Range.

When Lajos Lóczy left Hungary, the deputy directors Tibor Szalai and Gyula Vigh took turns in leading the Survey till 1949. There was no possibility of formulating a long term plan in this period. Instead, several smaller projects of mining geology were realised in various parts of the country following the occasional directives issued by the changing authorities. The survey explored for iron-ore at Rudabánya, for fire-clay at Bánk, base metals at Velence, and for rock salt in Sóshartyán. By government decree, the Soil Department was detached from the Survey in April 1948 and became a separate research Survey. Thus the role of the Survey in agricultural and soil research has came to an end. Later decades of lowland surveys concentrated mainly on Quaternary geology, hydrogeology and engineering geology.

The geochemical laboratory was formed as a new analytical section after the removal of the soil chemistry laboratory. New instruments and an increase of staff were needed to provide for faster and more accurate mineral and rock analysis. DTA, spectro-photometry and ion exchange techniques were introduced in this period.

To conclude, let us look at the staffing figures. Lists of officers published in the annual reports give a summary of staffing levels. In the first half of this century the Survey had about 50 staff. Only in the years 1945 to 1947 immediately following the war was there a small temporary reduction in this number.

The fifties saw the beginning of a conspicuous increase in staff. The establishment grew from 83 in 1949, through 176 in 1950 to 230 in 1953. The reasons for this change are explained in the next paper.

A summary classification of the staff of the Survey by qualifications and job function in the first half would result in three groups. Group one (35%) consists of survey geologists. The second group represents 15% of the staff: chemists, petrographers and palaeontologists working in the laboratories. The third group is 49% of the total. These are the ancillary staff: accountants, secretaries, draughtsmen, laboratory assistants, porters and others. So the establishment of ancillary staff was about equal to the number of graduates.

These figures refer to the permanent staff of the Survey. In addition to the establishment other "external" workers were employed for occasional/seasonal work. The number of these changed from year to year. Most of them were recruited from the academic staff of universities, working only in the summer season in field surveys for the Survey. The enclosed diagram continues the figure given in the previous paper by K. Balogh. As shown by the graph, there was an abundance of external workers in the years 1940 to 1943. This was required by the suddenly intensified rate of agrogeology and soil surveys. The former employees of the Survey deserve some comment. After the war there was a drastic shortage of food and fuel in Budapest. Runa-

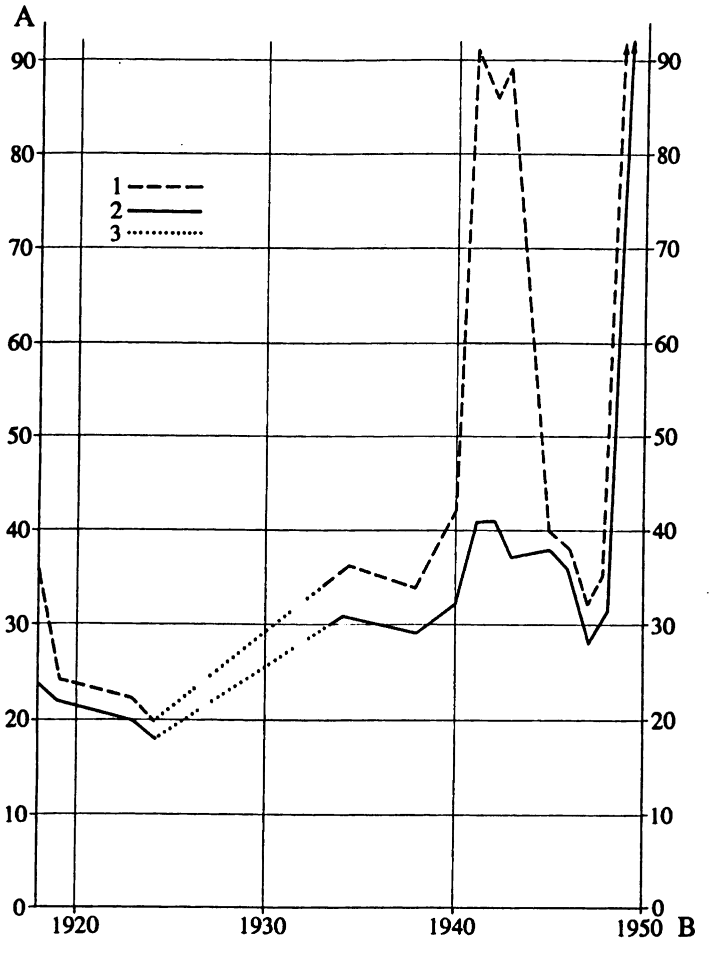


Fig. 1. The number of the researchers of the Geological Survey between 1920 and 1950
1. Total number of the staff, 2. Number of the permanent collaborators, 3. Lack of data, A: Number of the staff, B: Year

way inflation made wages and salaries practically worthless within a couple days of pay day. In such trying circumstances survey employees still reported for work each day, helping in the clearing of war debris and the restoration of the building. Only this way was it possible to create the necessary working conditions for the resumption of professional work. The loyal workers of our Survey deserve every praise for their steadfast and unselfish devotion in such difficult times. The difficulties lasted, on the whole, till about 1948–49. Then, at last, professional work could again be pursued effectively. This closes a chapter in the history of the Survey and the next period, the fifties, saw the realisation of new aims under more favourable conditions.

TASKS, ACTIVITY AND RESULTS OF THE HUNGARIAN GEOLOGICAL SURVEY BETWEEN 1949 AND 1991

by **GÉZA HÁMOR**

The history of the Geological Survey can be divided into four periods: until 1957 it is characterized by the development of new constructions of the Hungarian geological life after the 2nd World War, and social re-organization; between 1958 and 1969 by renewal and development; between 1970 and 1978 partly by intensified work and partly by extensive development; and between 1979 and 1991 by the evaluation of the results, their publication and multifaceted modernization.

We try to introduce these periods in the framework of the external effects, the development and success of the concepts, the appearance of new principles, and, primarily, the results.

PERIOD OF NEW CONSTRUCTIONS (1949–1958)

The first part of this period (until 1954) was characterized by unadvised raw-material prospecting, in which territories and aims were changing from time to time, and which didn't have suitable professional and financial foundations. The reason was the serious lack of raw-materials after the 2nd World War, the change in raw-material sites due to the new borders of the country, and the forced change in heavy industry, energy-production and centralized economic life. The heavy-industry and mining-oriented work of the Geological Survey, which lasted until the mid seventies, with its all advantages and disadvantages, dates back to this time.

The main task of the Geological Survey was intensified raw-material prospecting. The urgent problems of the reconstruction required practical research in the Survey, as stated by Szalai, T. (1952a). The dual administration (the geological and mining branches belonged to the Ministry of Industry, whereas the agrogeological branches belonged to the Ministry of Agriculture), then the change in the levels of direction (Geological and Mining Center of the Ministry of Industry, Geological Department of the Ministry of Mining and Energy, Geological Management of the Ministry of Heavy Industry, Hungarian Geological Authority), and the frequent changes of directors (Tibor Szalai, Gyula Vigh, Sándor Vitális, László Majzon, Jenő Noszky, Kálmán Balogh, Jenő Noszky, Miklós Kretzoi) made it impossible to spell out the basic tasks of the Survey or to do effective work, even though many talented geologists worked in the Geological Survey at that time. Geological mapping touched the bottom; local geological mapping, based on individual ideas, was performed during raw-material prospecting on 5 sites in 1949 and on 121 sites in 1952. At the same time, more than 30 different raw-material sites (9 in 1949 and 65 in 1953) had to be cadastrally surveyed and evaluated. This work was done by 18 and 70 geologists, respectively, so the survey was frittered away; it was unsuitable for publications and had only *pro forma* results.

The difficulties increased with the frequent internal and external re-organizations. In 1949 the Survey parted with the Soil Science Department. Between 1950 and 1953 it had to give scientists to the OFKFV (i.e. Mining Research and Deep Drilling National Company), to the coal, iron and ore-mineral mining geological branches, to MASZOBAL (i.e. Hungarian-Soviet Bauxite and Aluminium Company), MASZOLAJ (i.e. Hungarian–Soviet Oil Company), FTV (i.e. Geodesical and Soil Mechanical Company), and sometimes to the highest authorities (21 geologists and 21 technicians). This brain drain, and the 30 year-long interruption of agrogeological research wasn't compensated by the "Peat Researching Group", transplanted from the Ministry of Agriculture, nor by the employment of freshly graduated young geologists from Eötvös Loránd University, where Prof. Elemér Vadász started geologic courses.

However, despite these serious difficulties, some conceptual and organizational decisions of this period still influence the present life of the Survey, directly or indirectly.

Besides the obligatory organization of local and industrial Geological Services, Vitális, S. (1950) regarded the nation-wide, centralized geological research and systematic geologic mapping, as the 3rd most important task of the Survey, which took into account all the requirements of industry and agriculture. The (nameless) Report of the Director in 1951 [see as I(gazgatói) 1953 among the References] emphasizes that Hungary needs a nation-wide multidimensional survey, based on industrial and agricultural requirements, and not experts' opinions. He had the same ideas about raw-material prospecting; he considered consulting and data recording as the main task of the Survey.

The geological mapping of the low-land areas started, supported by shallow drilling and cadastral survey of groundwaters. This work continued at a changing rate, but after 30 years finally had excellent results. There were some attempts at the hydrogeological establishment of water supply for big organizations and regions, for the multifaceted investigation of karst-water (1950), rather than just minor hydrological consulting and permits for well drilling. The results of this period are the beginning of radioactive raw-material prospecting (1948–1949) and the establishment of engineering geology (1948). Later the Survey joined the work of the Budapest underground railway network (1952), made the hydrogeological assessment of the power stations along the Danube (1953), established the Geological Database (based mainly on the data of the mining and other surveys that came out during nationalization), and compiled the first review of the geological technical literature (1949). Some new departments were also established: Department of Engineering Geology (1948), Department of Petrology (1948), Laboratory of Sedimentary Rocks (1950), DTA Laboratory (1951), Department of Inventory (1950). The latter worked out the first cadastral raw-material statement of the country (according to the situation of 1st January 1953). Joining the geological survey on the low-land areas (1951), palynological research started (1950). The Department of Laboratory Investigations (not the Department of Paleontology) began the determination of forams and ostracods.

The worst year was 1953. After the libel action and arrest of Sándor Vitális, the establishment of the Hungarian Geological Authority (1953), and the previously mentioned growth of projects, the (nameless) Report of the Director in 1953 [see as I(gazgatósági) 1954 among the References] is satisfied with the "suppressed" and "decreased" work of the groundwater and artesian well network all over the country, geological mapping, and Quaternary research on the Great Hungarian Plain, and organization of collections, in the interest of practical, every-day surveying. During the drastic re-organizations, there was only one department of geological mapping, a paleontologic laboratory, the museum and two other laboratories, in addition to the six departments of raw-material prospecting.

The forthcoming more pleasant periods are reflected in that Report of the Director, in which he desires that the Survey could "do its own tasks". The encouraging development of hydrogeological work started [short-lived Department of Karst Hydrogeology, orders of OVF-VITUKI (i.e. National Water Management Authority and Water Resources Research Centre, respectively) for national cadastral survey of soil-groundwater], which was soon followed by its separation from the Survey. Cooperation with the University started during geological mapping in the Gerecse Mts, possibly because of the lack of specialists. Geological mapping in the Mecsek and Buda Mts also started at that time. A four-month long course was organized for technicians, and the first appointments, based on scientific qualifications were made (2 Academy Doctors, 11 "Candidates"), which improved the education of the staff.

The flurried and confused work, focused on raw-material prospecting, finally showed the lack of scientific basics. Compilation of all the former data on geological maps at a uniform

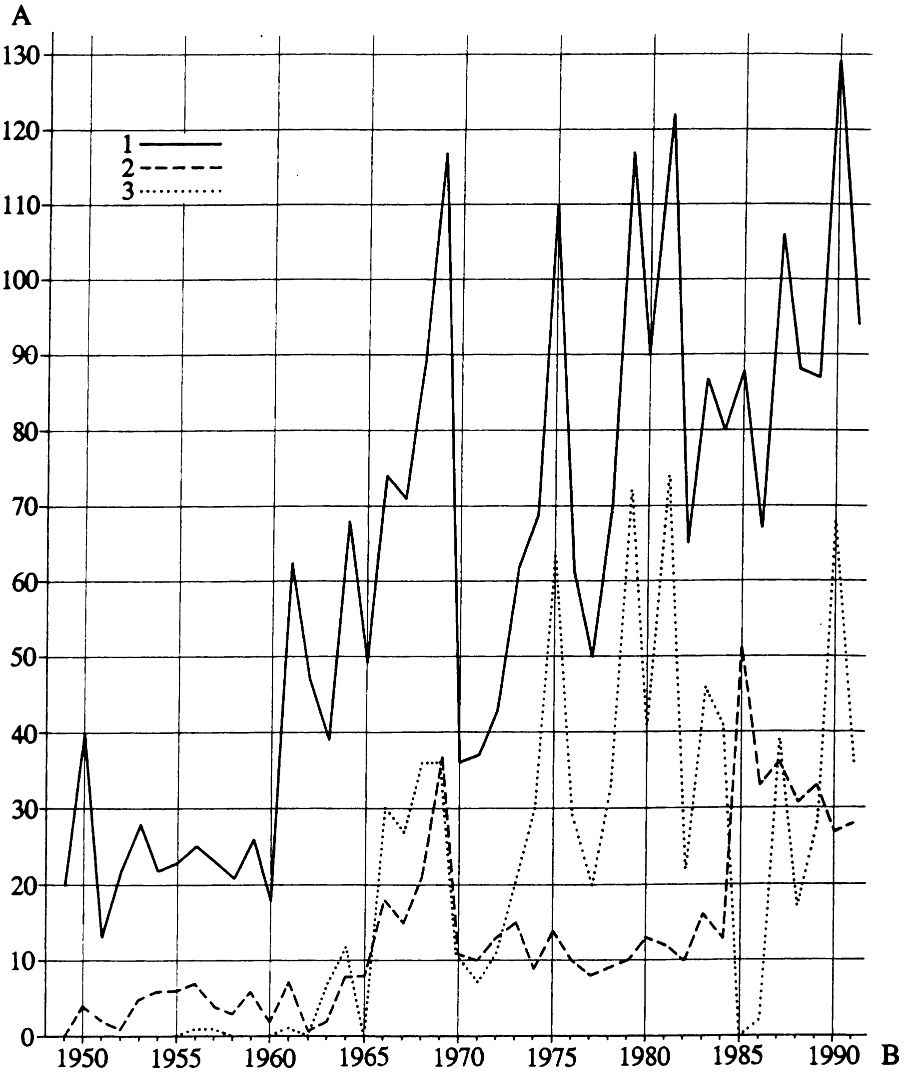


Fig. 1. Publishing activity of the Hungarian Geological Survey (1949–1991)
1. Total number of publications (maps, explanation volumes for the maps, monographs, publications, reports), 2. Separate volumes, booklets, 3. Maps
A: Number of pieces, B: Year

1:25 000 scale was a good initiative. Some of these maps are still used today by some institutions for those areas where no new mapping was carried out or no other data were published. These maps were also profitable, when the national geological map of Hungary at 1:300 000 scale, and some other maps at 1:200 000 scale were edited. A positive change was the establishment of the Palaeontological and Chemical Departments, which were only groups before, and the declaration of the Hungarian Geological Database.

The few publications of the Survey are shown in diagrams of Figs. 1, 2. The number of reports about geological mapping, stratigraphy and even raw-material prospecting decreased. A slight increase can be observed in the number of paleontologic reports, because of the above mentioned principles. The total number of publications in the Survey between 1949 and 1958 is shown in Fig. 1, too; where the line of achievements stagnates at a very low level. An outstanding result of this period was the editing of a covered geological map of the Bakony Mts at 1:25 000 scale, which was compiled from earlier documents (the so called "bauxite map"), and the geological map of Hungary at 1:300 000 scale, which reflected the knowledge about the geology of the country at that time. An important result was the recognition of the genesis of the manganese deposits in the Bakony Mts (1954), and the beginning of palynological research (Quaternary in 1952, other sediments in 1954).

The contradictions of this period, which was unsuitable for creative work, are reflected in the rate of publications compared to the number of researchers and technicians: in 1945 31 geologists and 42 technicians worked in the Survey, while in 1953 this rate was 104:181.

At the end of this period, the revolution in 1956 made geologic research impossible. Some specialists emigrated, and the staff was restocked with young geologists who got their degrees in 1955–56. The unfinished research projects all became fruitless work.

PERIOD OF RENEWAL (1958–1969)

This period was very important in the latest history of the Survey. Despite the financial, organizational and personnel problems, a grandiose conception developed, which possessed sufficient tasks, methods, organization and staff. It resulted in systematic and intensified basic research, alignment with European standards, geological mapping, methodological research, and the beginning of syntheses of the results and their publication.

The historical antecedent of this development was the realization by the Hungarian Geological Authority of the importance of long-term planning for geological research and the significance of expertise. It established the Geological Council, clarified the principles of geological research together with the best experts, and graded the prospecting areas from an economic perspective (1955). The development of this process was delayed by the events of the 1956 revolution, but the programs were prepared in 1957. Professional discussions were mainly about the research methods for the investigated areas, about the rate of laboratory investigations and questions of organization.

The most important external event that influenced the Survey was the re-organization of OFF (i.e. Hungarian Geological Authority) in 1962, which belonged further to the Council of Ministers and was called the Central Office of Geology. The "Credit for Prospective Research", which was controlled by the Survey since 1966, and the short-lived "New Economic Mechanism" in the sixties had a brightening effect, which increased demand and released the restriction on the number of staff.

The aims of the new director of the Survey (József Fülöp) were: concentrated research on certain localities, the fortification of laboratory investigations, and the modernization of documentation in the framework of equal units of analysis-synthesis and publication. As a basic scientific method, he advanced long-term, organized research and publication of comprehensive monographs about certain areas. The structure of the Survey was built up of departments, according to research areas and specialists, who had a close relationship with the field-work geologists. The large-scale research projects all over the country (hydrogeology, map editing, database, library, museum) had their own departments. Development of the organization was marked by the establishment of major departments in 1965 (geological mapping, laboratory investigations, documentation). The Geochemical Department (1963) developed from some groups in the Geophysical Institute and from some researchers in the Geological Survey. The laboratory of OFKVF (i.e. Mining Research and Deep Drilling National Company) at Várpalota has belonged to the Geological Survey since 1964. Because of the crowded central building in Budapest, further settlements and laboratories were constituted in the country, too (sedimentology at Szolnok, rock physics at Pécs–Vasas, soil mechanics at Balatonfüred, stores of rock samples and cores at Rákóczitelep, Szolnok, Pécs–Vasas and Szépvízér, and local research bases at Nagyirtás-puszta and Sárospatak).

Extensive research has been done on some outstandingly important areas, concerning geological mapping and raw-material prospecting in the eastern Mecsek Mts (coal, lignite, uranium), in the northern Bakony Mts (bauxite, manganese, brown coal), in the Dorog basin (brown coal), in the Mátra Mts (ore minerals), in the Tokaj Mts (different mineral resources) and on the Great Hungarian Plain (hydrogeology, agriculture, construction raw-materials). Field-work geologists, as well as specialists of mineralogy, petrology and paleontology focused their research on certain geological times and locations, and this comprehensive work, after the preparation in 1957, emerged in 1958.

The novelty and international uniqueness of this grandiose work is represented by the following:

– profound preparation (evaluation of all the previous data of mapping and literature);

– geologic mapping, according to continuous sections in a regular network at a detailed scale (1:10 000 and 1:25 000 in the mountain areas, 1:100 000 in the low-land areas);

– detailed field-work and data recording, supported by artificial outcrops, shallow and deep drilling, later by geophysical methods (1963), systematic evaluation of satellite and aerial photographs (1968), and finally by agricultural, engineering-geological, hydrogeological, raw-material prospecting, and environmental-geological data;

– wide-ranging laboratory investigations of numerous samples, which could support suitable stratigraphic, structural, magmatic, genetic and applied geological models as well as facies distribution;

– separation of objective field-work data, which can be documented, and subjective elements during the editorial work in 2–21 versions of the same scale and publication;

– preservation of rock samples and cores for possible reproduction of the whole research, and for further special investigations.

The simultaneous success of these criteria was a real novelty in geological mapping at that time. Besides geological mapping, 25 pages of Comecon "Unified Geological Map System" at 1:200 000 scale were prepared (1963), which (partly) covered the territory of Hungary, and had uniform sections and keys. The disadvantage of the compiled work was, that the new results were reflected only on the maps of the low-land areas. However, the authors enclosed volumes of explanations, which discussed the whole geological literature of the area, and also contained hydrogeological and economic geological data.

The first series of these new maps of the Mátra and Tokaj Mts came out in 1964 (their continuous publication lasted until 1982). The monographs of the Bakony Mts were published between 1961 and 1991. It was an outstanding result, that in the year of the Centennial of the Survey, we could publish proof maps at various scales, partly with an explanation in English, on which all data had been strictly secret before (Veszprém: 1:200 000, Szolnok: 1:100 000, Mád: 1:25 000, Hasznos, Komló and Kesztölc: 1: 10 000 scales).

In addition to all these efforts, the Survey was even able to improve its activity. Instead of the partly useless hydrogeological research of the past, and the hydrogeological experts' opinion, which were later delivered to the competent hydrological institutions, two respectable works were published: the Soil Groundwater Atlas of Hungary (1961) and the Hydrogeological Atlas of Hungary (1962). Besides the research of soil groundwater in the Great Hungarian Plain, the investigation of deep-origin and thermal waters became conspicuous. Thermal-water research concluded with the successful establishment of 19 wells. Investigation of the first group of wells of deep-origin waters at Jászladány (1964) proved the fruitful character of this work. A three-decade-lasting monitoring of 74 wells yielded many useful data for recognition of the hydrogeology of Hungary.

Research on the Great Hungarian Plain also resumed at that time. A turning point was the consideration of engineering geological requirements (1963), and the publication in atlases of deep structures (based on different geophysical measurements) during the common directorship of the Geological Survey and Eötvös Loránd Geophysical Institute of Hungary.

Conceptions of geological mapping and publishing changed in some aspects after 1965:

– new areas were included in geological mapping efforts (Buda Mts), and preparation started on some other areas (Cserhát- and Börzsöny Mts);

– a 4th generation of thematic geological mapping started in the surroundings of Balaton (1967) with engineering geological aims, and in Budapest (1968) (development of methodology, geological mapping at 1:10 000 scale together with cross-sections, soil mechanics, petrophysical and other laboratory investigations). The first published map was the Tihany Atlas at 1:10 000 scale;

– geological mapping continued until the stage of raw-material prospecting. During this survey, some economically outstanding results arose: exploration of the Liassic coal in the Mecsek Mts, brown coal in the Bakony Mts and in the Lencse Hill at Dorog, ore minerals at Gyöngyösoroszi, and the preparation of mining at Recsk.

A decisive change resulted from all these works: the idea of regional raw-material prognosis (forecasting) arose even in 1963. Its first result was the three-version geological map of the Lower Miocene coal in Borsod at 1:100 000 scale (1966, 1967), and the prognostic map of the Liassic coal in the Mecsek Mountains at 1:50 000 scale (1968), with a volume of explanation.

The first, unfortunately unsuccessful, attempt at geochemical prognostic research was the cadastral survey of rare earth elements.

The Survey made enormous efforts in publishing its results. The Annual Report was renewed with the publication of many scientific

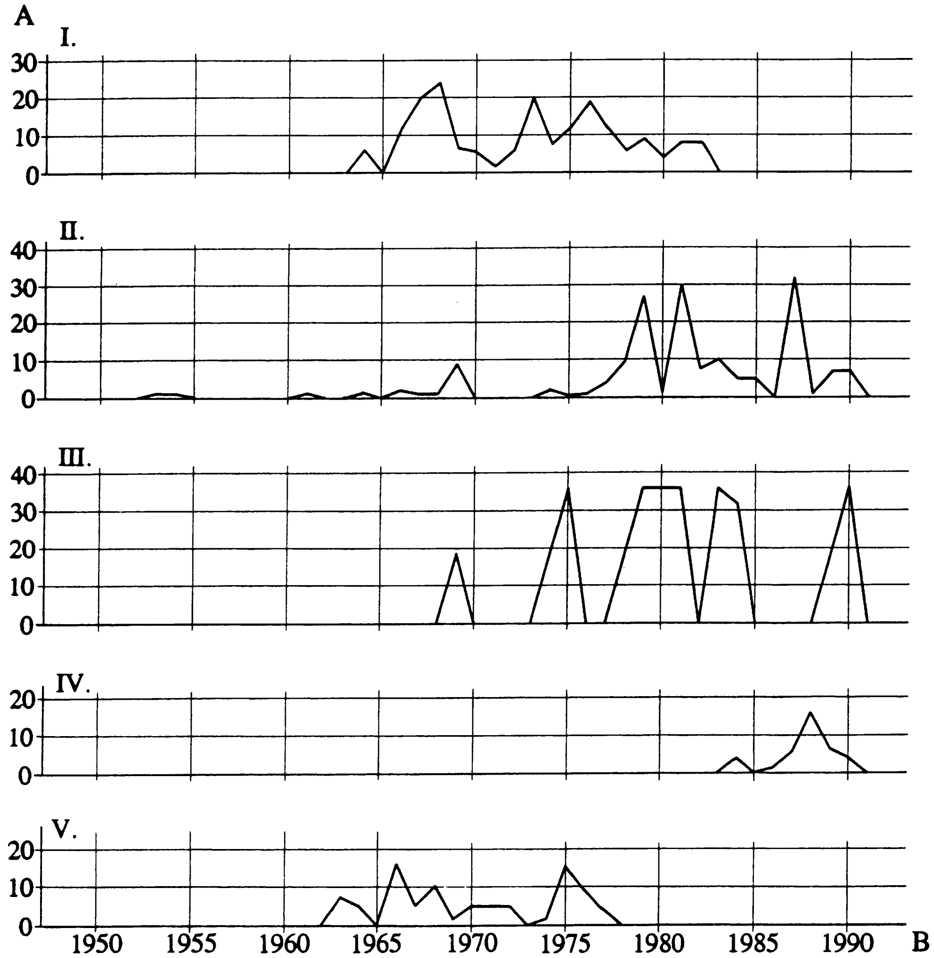


Fig. 2. Maps, published by the Hungarian Geological Survey (1949–1991)
I. Detailed maps at 1:10 000 and 1:25 000 scales, II. Prognostic and wall-maps at 1:25 000 and 1:100 000 scales, III. Maps at 1:100 000 and 1:200 000 scales (Great Hungarian Plain, Little Hungarian Plain), IV. Maps at 1:500 000 and less scales, V. Maps at 1:200 000 scale, A: Number of pieces, B: Year

reports and papers (1960), and the postponed volumes of the previous five years were retrieved. Later the Annals and the series of Geologica Hungarica were also renewed. The volumes came out regularly, and contained the outstanding results of other researchers, too. The development of publication of maps is shown in Fig. 2.

After 1961 regular reports of meetings (after 1965 even in the regional centers in the country, too), from 1963 the volumes of "Long-Term Geological Research", which contained bore-hole data, from 1968 the Group of Information, and from 1967 a self-controlled printing-office, all made the work of the Survey more open and easily accessible for external institutions.

The scientific problems, research methods and results of the Survey were presented on an international platform at the International Mesozoic Conference in 1959. At the centennial celebrations, both the formal relations of development (reconstruction of the building, improvement of the laboratories, collections and library), and of effective research (geological mapping, basic research, raw-material prospecting, publications) were demonstrated. All these results were due to the reliable staff: there were 116 researchers, 180 technicians and 120 economic and administrative employees in the Survey at that time. The number of scientific qualifications increased by 21.

During the centenary celebrations, 629 participants from abroad, and 249 from Hungary attended the following meetings:

International Jurassic Colloquium, 19 countries, 118 participants;

International Bauxite Conference, 13 countries, 83 participants;

International Neogene Colloquium, 22 countries, 155 participants;
International Eocene Colloquium, 14 countries, 90 participants;
Day of the Geological Institutes, 39 countries, 293 participants;
9th Congress of CBGA i.e. Carpathian-Balkan Geological Association, 6 countries, 386 participants.

The published results between 1958 and 1969 indicated an enormous development, which is shown in Figs. 1, 2.

RESEARCH IN THE SURVEY BETWEEN 1970 AND 1978

External effects were favorable for the Survey during the first part of this period. After the death of György Kertai, former president of the Central Office of Geology, József Fülöp became his successor between 1968 and 1984. As he bound himself to geology, he tried to guarantee optimal conditions for research in the Survey. The number of geologists significantly increased, the organization of the Survey developed (Regional Geological Services), and national and international partnerships improved. The acceptance of the program "Exploration and Research of Natural Sources of Energy in Hungary", and its affirmation by the government also helped the work of the Survey.

It was a regrettable contradiction of this prosperous period that the Survey paid more and more attention to the requirements of mining and heavy industries and to the every-day economic tasks. These activities were extensively developed, which resulted in an increase of the staff by 30% (which exceeded 700 people at that time). The Survey engaged itself in gigantic works that surpassed its capacity, and in oversized laboratory investigations. However, the latter was necessary for the examination of 360–380,000 meters of cores per year.

The new director, József Konda (1969–1978) thought, that solid-raw-material prospecting and complex prognosis were the most important tasks of the Survey. After 1975 the research focused on hydrogeology and engineering geology; most attention was paid to the investigation of aquifer storage and prospecting construction raw-materials. This concept influenced the seven projects of the program "Exploration and Research of Natural Sources of Energy in Hungary", however it could have provided a unique opportunity to have basic research acknowledged as the main profile of the Survey. Instead of the financial support of the Central Office of Geology for specific activities, artificial stages of exploration (initial, exploring, preliminary, detailed) were forced, and they tried to link the Survey together with the everyday life. Its deadlocks are marked by the engineering geological maps of the cities, the map of surface movements in Hungary, preliminary plans for engineering geological projects, geological plans for settlements, regional tasks, etc.

Raw-material prospecting focused mainly on ore minerals (Börzsöny Mts, Darnó Zone, western Mátra Mts, Velence Hills), geochemical inquiries (Recsk–Rudabánya) and on the cadastral survey of rare earth elements. The Survey took part in eight programs of coal exploration ("Liassic" program: S-Máza, "Eocene" program: Várpalota, Senonian coals), and some alginite research. Unfortunately, despite the enormous efforts, the geological maps of the Börzsöny-Dunazug Mts, Velence Hills and the southern forelands of the Gerecse–Vértes Mts didn't come out.

Lignite exploration developed slightly in the forelands of the Mátra and Bükk Mts as did perlite prognosis in the Tokaj Mts. A report about the hydrocarbon-geology survey in the Transdanubian Central Range was also issued, and a similar one had been finished about SW Transdanubia.

Basic geological mapping continued at a decreased rate in the Nógrád–Cserhát, Balaton and Budapest areas, and started in the western Mecsek Mts (1978). Engineering-geological mapping at 1:10 000 scale started in Eger, Pécs, Veszprém, Miskolc and Salgótarján.

New map issues included the publication of detailed geological maps that had been edited in the past, two further pages of the atlas of the Great Hungarian Plain and geological maps of the Mátra (1974), Bükk (1977, fig. 2) and Nógrád–Cserhát Mts (1974). The publication of the map-series at 1:200 000 scale and their explanatory volumes concluded in 1977. An outstanding result was the issue of the bauxite geological map of the Transdanubian Central Range at 1:100 000 scale (1978).

The different complex research projects all over the country decreased at that time, only hydrogeology had sufficient importance. Despite good conceptions and the efforts to establish suitable scientific foundations, the two main programs (exact data of dynamic storage in aquifers, and water movement problems of the non-karstic mountain areas) could not be carried out, and the research was frittered away. Only the well-registration system on the Great Hungarian Plain moved forward; the number of the wells increased to 51. The "Hydrogeological Atlas of Borsod and its Surroundings" was also a product of this period, though it was compiled by other authors.

The development of the Survey also can be followed in some re-organizations. Between 1970 and 1975 Regional Geological Services were established (Salgótarján, Pécs, Veszprém, Sopron, Szeged, Debrecen, Budapest), which had authority over 2–3 counties. Besides research, their authority functions were also outlined. The Department of Economic Geology, which handled the inventories of mineral resources, their annual statements, and later worked out their computer database, also was founded. The initiation of computer programs to handle coal and bauxite statements was an important result (1972). The Information Group, which prepared forecasts about geology and raw-material prospecting in Hungary, was strengthened and gave information about scientific literature, too. The Survey followed the Czechoslovakian GEOINDEX (1970), then the French BGRM (1974). Preparation of the GEOINFORM system (1978) also started.

The organization of the major departments was completed with that of Prognosis, which was charged with the preparation of prognostic methods and with the prognosis of solid raw-materials. A few hydrogeological and environmental-geological reports were also published about pollution. The opening to the public of the representative building and open pit at Tata-Kálváriadomb and Sümeg-Mogyorósdomb was an outstanding result of geological nature conservation. Sümeg-Mogyorósdomb also served as an educational center, and had an important role in the improving relationship between the Survey and the universities.

The staff of the Major Department of Geological Mapping was rounded out by geologists and technicians, who took part in expeditions to Mongolia (1970) and Cuba (1972), where they mostly conducted geological mapping and raw-material prospecting. Their work significantly contributed to the scientific development of the Survey, and to the international reputation of Hungarian geology. The knowledge about the geological make up and raw-material properties of eastern Mongolia and Cuba-Oriente were significantly expanded during these expeditions.

All these changes in the organization had multifaceted effects: the achievement in Hungary decreased, because the best specialists were working mainly abroad, and the staff of the Survey became more diverse at the same time. Coordination of the work became more and more difficult with the employment of about 50 people, who had only industrial experience before.

During this period (partly prospering from the favorable economic situation, partly based on its own sources of power) the directorship of the Survey started some important methodological developments in laboratory investigations and analyses. In cooperation with the Geophysical Institute, a computer registration of raw-material properties was started. Together with ATOMKI (i.e. Institute for Nuclear Research of the Hungarian Academy of Sciences) in Debrecen, K/Ar geochronologic investigations began in 1975. Further development occurred in remote sensing, in the Hungarian–Canadian partnership, in paleomagnetic research, in the improvement of the database and in the establishment of the microfilm laboratory.

The contradictory change of publication policy is marked by the significant decrease in the number of volumes of the Annual Reports, the Annals and Geologica Hungarica, as well as the changing achievement of map issues, which is shown in Figs. 1 and 2. A new series called "Methodological Papers" (3 booklets) started, while "Special Papers" (3 booklets) published, in English, the papers that might be of international interest.

The international partnerships of the Survey were favorably affected by the bilateral cooperations contracted by the Central Office of Geology and the geological institutions of Czechoslovakia, East Germany and the Soviet Union.

The International Engineering Geological Training Courses in 1975 and 1979, the International Hydrogeological Conference (1976), supported by IAH–IAHS–UNESCO, and their publications were outstanding events in the Hungarian geological life.

Despite the intense disputes about the profile of the Survey and the increasing pressure from the Ministry of Industry, three main programs started to be outlined between 1976 and 1978, which already showed the further directions of development. This was due to the efforts of some excellent researchers and consideration of the experience of the past. These were the program of key-sections all over the country, and studies about the possible environmental and agrogeological research.

MODERNIZATION OF RESEARCH IN THE SURVEY (1979–1991)

This period was characterized by the synthesis and publication of the results of the previous two decades, by observance of international standards, by the renewal of research methods and by a general modernization.

The possibilities were assured by the improving attention of the government, which was forced out by concentrated scientific politics and efforts, and by the support of the Central Office of Geology, directed by József Fülöp, then by Viktor Dank. The experts of the Survey also did their best to achieve good results. The development of financial support for the different projects was favorable at that time, because the Survey had the opportunity to undertake external works. Support through OTKA (i.e. National Scientific Research Fund) competitions also increased. During the 2nd part of this period the financial consequences of the general economic recession and the frequent unadvised changes of the economic conceptions were disadvantageous. First, it had harmful effects in raw-material prospecting and exploration. The neglected environmental-geologic aspects in certain works (development of regions, state investments) also had serious consequences.

The new director of the Survey (Géza Hámor, 1979–1991) based his new concepts, with his colleagues, on the results and lessons of the previous period, and on some basic relationships:

- the raw-material supply of the country (about 50% from Hungary) is adequate for decades of exploitation; the detailed research, which prepares the exploitation itself, is an industrial task;

- the results of the huge research projects that were already finished must be published in suitable forms, both for economists and scientists;

- the huge amount of new data requires its feedback to basic research, but this process doesn't have suitable foundations in the Survey;

- besides basic research, two programs guarantee the further development of the Survey:

(a) new regional geological mapping on basin areas;

(b) the decrease of raw-material focused research, and development of hydrogeology, engineering geology, environmental geology and agrogeology;

- certain possibilities for improvement have finished (areal expansion, number of the staff); further development can only happen in the case of well-organized cooperation between certain institutions (possibly with the leading role of the Geological Survey). Management of the survey is also important.

At the conclusion of these deliberations, the basic tasks of the Survey were drafted as the following: basic and regional geological and applied geological research, scientific publications, provisions (laboratory investigations, library, database, collections).

The basic methods were geological mapping, according to a network system, the expansion of prognostic research to basin areas and certain regions (including hydrogeological, engineering geological, environmental and agrogeological survey). The success of the work must be reflected in publications. The strength of basic research was assured by the program of key-sections, and by the regional and national syntheses (monographs, maps). The development of the different provisions is shown by the well-equipped laboratories, by the database, which was completed with industrial data on microfilms, by the information about scientific literature, by the establishment of core-stores, which belong to the collections, and by the activity of publication (text-editing programs, printing office for maps).

The renewal of the Survey was marked by a decrease in the number of projects (19 instead of 95), and of course by the structural re-organization.

The basic principles of organization at the beginning of the period, and at the re-organization in 1986, were decentralization and dual superstructure (the administrative organization, required by law, and the thematic structure, required by the research itself). The spheres of authority and jurisdiction gradually came to the intersection of execution. Two deputy directors assured the balance between the major departments of geological mapping, prognosis and regional survey, and that of laboratory investigations and documentation. The heads of the major departments had the authority of the deputy directors (from 1987 independent from the departments, which change was forced by the major authorities), and they organized the work of the departments. The organization of the major departments of geological mapping (later survey), and regional research (previously Regional Geological Services) was based on areas (Mecsek, Bakony, Mátra and Tokaj Mts, Great Hungarian Plain, Budapest, Balaton), later on consolidated regions (Transdanubian Central Range, northern Hungary, southern Transdanubia, Little Hungarian Plain, International Expeditions). The other major departments had a thematic organization. The major department of Prognosis had departments of hydrocarbons, bauxite, and solid raw-material prospecting, and later was completed with the departments of hydrogeology, engineering geology, environmental geology and agrogeology, as the importance of the applied geological profile of the Survey gradually increased. The major department of laboratory investigations supervised regional laboratories of paleontology, geochemistry, mineralogy and petrology, as well as sedimentology. The major department of documentation had divisions of publishing and editorial office, stores of cores together with the department of collections. It also supervised the scientific library and the database. The work of the major department of survey was helped by the independent department of remote sensing, prognosis by the department of methodology, laboratory investigations by the OTKA (i.e. National Scientific Research Fund) instrument center, documentation by a collection of the history of science and by the printing office, the work of the directorship by the raw-material evaluating, computer and international departments. The economic directorship, whose leader had the authority of a deputy director, had an important role in the financial results of the Survey.

Financial support of the research was provided according to projects, so a system of themes, which was "independent" from the organization also existed. Despite its many disadvantages of planning, administration and accountancy, it could concentrate the scientific powers of the Survey well. It re-established the common interest of the scientists, who had worked on the same theme, and the rank of the leaders. It also promoted the vertical organization system of the laboratories–specialists–field-work geologists–scientists–editors–publisher, and flexibility of the previously rigid structure. Its advantages are shown by the high number of publications at that time; the disadvantages by the increased number of themes, which was a result of individual ambitions. This increase was significant in the number of the methodological themes, which were independent from the major projects.

During the accomplishment of the basic tasks, we had these further results:

Results of *basic geological research* were documented in the "Catalogue of key-sections and boreholes between 1985 and 1990", which contained comparative data, complex geological laboratory investigations and evaluations of 140 key-sections and 236 bore-holes. In accordance with this program, the "Lithostratigraphic formations of Hungary" was published (Császár & Haas 1983), which was compiled by experts from all over the country. It contained the nomenclature of 410 rock bodies, which took part in the geological build-up of the country, their short description, areal and chronostratigraphic distribution, facies and sometimes their K/Ar ages. The second part of this volume has come down only in manuscript. The results of geological research in certain areas and regions were published in 18 volumes of the *Annals*, in 14 volumes of *Geologica Hungarica ser. Palaeontologica* and *ser. Geologica*, and in other paleontologic, petrologic-mineralogic and geologic monographs. Partly as their appendices, comprehensive maps were also published at 1:25 000 and 1:50 000 scales: Dorog Basin (1981), Oligocene-Lower Miocene formations of the Transdanubian Central Range (1981), eastern Mecsek Mts (1982), western Mecsek Mts (1984), covered geological map of the Bakony Mts (1984), uncovered geological map of the Bakony Mts (1990), Aggtelek–Rudabánya Mts (1988), Veszprém (1979), Salgótarján (1981), Budapest (1984), areas surrounding Balaton (1985), Szeged (1987), and manuscripts of the Börzsöny-Dunazug Mts, Velence Hills, Balaton Highland, suburban areas of Balaton, and Pécs.

A summary of the basic research in the Survey was published in a series of handbooks, entitled "Geology of Hungary". The volumes were written and compiled by József Fülöp, but significant scientific support was given by the Survey. These are the "History of raw-materials in Hungary" (1984), "An introduction to the geology of Hungary" (1989), and "Geology of Hungary, Palaeozoicum I." (1990). The latter one was issued in the Survey. The volume "Palaeozoicum II." also was ready in manuscript.

The summary of basic research in the form of maps started with the program "Geological Atlas of Hungary" (1980). The first pages were issued in 1984. During the period under consideration, 19 pages came out (two in plastic relief printing), from these 7 are geological maps (surface), Pannonian (4), mountain basements and structural versions), 5 are raw-material prognostic maps (2 for hydrocarbons, 3 for construction raw-materials), 3 are for environmental geology (vulnerability to contamination, waste-disposal and nature-conservation versions), 2 for hydrogeology (prognostic and water movement of soil groundwater), 1 prognosis for engineering geology, and 1 geophysical version. Together with the metallogenetic page and the 4 paleogeographic maps, which unfortunately remained in manuscript form, the 24 pages of the Atlas were outstanding results of the Hungarian geology. This work is also unique in an international sense, and it is a stable foundation for any further detailed research, because it was compiled from thorough investigation and documentation of many key-sections and data of more than 30 000 boreholes, their detailed laboratory investigation and elaborate survey of geophysical sections.

During geological syntheses, we issued a four-version sedimentologic and palaeotransport map of the Senonian age of the CBGA (Carpato-Balcan Geological Association) area, and seven pages of the "Neogene Paleogeographic Atlas of Central and Eastern Europe", according to different ages, with four satellite photomaps. 94 researchers from 11 countries took part in the elaboration of the huge area from the Rhone basin to the Caspian Sea, from Gdansk–Szaratov in the north, to the Rome–Skopje–Tbilisi line in the south.

The novelty of this work (besides its dimensions) was the style of the maps, compared with their ancestors (working maps at a scale of 1:1 500 000, published maps at a scale of 1:3 000 000), the time-sections, based on radiometric ages, the simultaneous representation of the paleogeographic elements and the geo-, bio- and lithofacies, the sketch of magmatic-volcanic bodies, the illustration of the tectogenetic-geodynamic development with quantitative data, and finally the first publications of regional paleogeographic data in certain (mainly in the eastern) areas.

The Survey collaborated in the completion of 17 maps in the "National Atlas of Hungary" (1989, 2nd edition), which was issued by Hungarian Academy of Sciences.

The second basic task of the Survey was *regional geological surveying*, the results of which were manifest in the products of geological mapping and prognosis.

During the new program of *geological mapping*, we urgently finished the previous efforts, which persisted from the earlier years. Mapping was completed in the Börzsöny Mts (1980), in the Bakony Mts (1981), on the Great Hungarian Plain (1985) and in the western Mecsek Mts (1983). New geological mapping started in the Aggtelek–Rudabánya Mts (1980), Velence Hills and Balatonfő area (1980), on the Balaton Highlands (1982), in the Bükk Mts and its surroundings (1986) and in the Vértes–Gerecse Mts. With the exception of the latter two, all these programs finished with good results.

A new period started in the regional geological survey, when we began the 4th generation geological mapping on the low-land and hilly areas after serious methodological preparation. This work started on the Little Hungarian Plain (1982) and on the area of the Balaton suburbs (1983) at 1:50 000 and 1: 100 000 scale. During this complex work, the lessons of geological mapping on the Great Hungarian Plain, remote sensing, computer methods, sampling and agrogeological studies were all taken into consideration. Besides the traditional geological investigations, these surveys were also complemented by regional geophysical research, remote-sensing, and hydrogeological, agrogeological, geomorphologic, engineering-geological and environmental-geological observations. It was an important achievement that this work was carried out mainly by young scientists, who had appropriate qualifications in cartography, remote sensing, geomorphology, hydrogeology, agrogeology, engineering geology and computer technology, in addition to geology. We established a regular cooperation with other institutions [Eötvös Loránd Geophysical Institute of Hungary, Geological Planning Office at Dorog, MÉMNAÁ (i.e. Ministry of Agriculture, Plant Protection and Agricultural Chemistry Station) at Tanakajd, MTA–FKI (i.e. Geographical Research Institute), FTV (i.e. Geodesical and Soil Mechanical Company)].

With extreme efforts, we were able to establish the modern technical background of geological mapping and evaluation: rigs of 15 meters penetration depth, aerial photographs and instruments for their evaluation, computers and software for data recording and map editing. The capacity of the laboratories at Szolnok and Balatonfüred were re-organized. New elements in geological mapping of low-land areas (geomorphic map, genetic soil map, map of factors impairing fertility, carbonate content and chemical reaction of the soils, geological environmental protection, geophysical maps) appeared in the atlas of Győr S, (1990), Győr N, (1991) and Mosonmagyaróvár (1991).

The basic geological and applied geological versions were published at the original 1:100 000 scale. Although their condition reaches the requirements for maps of 1:100 000 scale, printing problems caused the 17 subsequent maps to be published at a reduced (50%) scale. The maps contained, of course, all the elements of the previous maps of the Great Hungarian Plain, including the observation network of the wells. A regrettable weakness of this survey was the sparse network of medium and deep drilling, and the general poor knowledge about the Paleozoic–Mesozoic basement. However, its quality is marked by its potentially widespread utilization (geological, engineering geological, hydrogeological, agrogeological, environmental geological).

This brief introduction demonstrates that the new-type regional work already contained the important elements of prognosis, too: the detailed hydrogeological, engineering-geological, environmental-geological and agrogeological prognosis of local raw-materials appeared in the different versions.

The extremely important *prognostic work* in the Survey was completed by the regional and national forecast during the first part of the period under investigation. The paleogeographic prognostic map of the Middle-Upper Cretaceous bauxites (1983) and a bauxite prognostic map were published with the accompanying data of the covering and underlying beds, depth and hydrogeological elements (1987), which was a pioneering work. Prognostic maps of the lignite beds at Cserhát–Mátra–Bükkalja were published in four versions (1982). Basin analysis, which supported the national hydrocarbon prognosis also had fine results; maps at 1:500 000 scale were issued. Its outstanding results were published in two volumes of the RCMNS 8th Congress (1985) and in a symposium of raw-material prospecting. Perlite prognosis in the Tokaj Mts and the national alginite prognosis also had useful results. Their important scientific value was, that the paleoenvironmental reconstructions were based on sedimentologic and facies analyses, and the results were synthesized on dynamic paleogeographic maps. A new characteristic element of these maps, which exceeded formal paleogeographic maps, was that they also filled the requirements of map representation. They were based on quantitative data, which were evaluated statistically, and they contained both the genetic and the applied geological elements, as well as hydrogeological and engineering geological aspects of raw-material prognosis.

The first part of this period concluded with the publication of the further studies: "Coal resources of Hungary" (1981), "Ore-, manganese-, copper-, lead- and zinc- mineral resources of Hungary" (1983), "A comprehensive evaluation of Hungarian raw-materials" (1983), "Nonmetallic raw-materials of Hungary" (1984), and "Raw-materials of Hungary" (1985). The first results of applied geological prognosis were the vulnerability map of Lake Balaton and its surroundings at 1:100 000 scale (with the cadastral survey of waste disposal) and the engineering geological map of Hungary at 1:500 000 scale.

During the 2nd part of this period (since 1986) prognosis developed in two directions:

– applied geology (hydrogeology, engineering geology, environmental geology, agrogeology);

– regional prognosis.

Both of them were possible due to the discontinuation of raw-material prognosis (free research capacity), and because of new requirements, including increasing economic authority of the regions, development of certain areas and settlements, and environmental protection.

Beside the international trends, the need for practical utilization of scientific research fostered the development of *applied geological sciences*. In addition, the Survey recognized that its profile isn't sufficient to solve every-day economic problems (e.g. hydraulic power plant at Gabčikovo-Nagymaros, "Eocene program", water pumping in the bauxite mines at Halimba-Nyirád, the problem of Hévíz, radioactive waste deposit at Ófalu, local hazardous waste disposal sites, etc.). At the same time, these things made it possible to supply the missing basic research and prognostic data of applied geological work. Its background was served by the engineering geological, agrogeological and hydrogeological maps of the lowland and hilly areas, because their scale was originally planned for prognosis. Their improvement and interpretation at different scales can happen during the applied geological interpretation of the lithostratigraphic formations (construction raw-materials), and during the studies of the geological-geophysical parameters of the different rock bodies.

As a result, the hydrogeological, engineering-geological, environmental-geological and agrogeological databases were established, and the first applied geological prognostic maps and studies were issued. Without the claim of completeness, we mention the engineering geological maps of Budapest, Balaton, metropolitan areas of Balaton and Salgótarján, the environmental geological map and the vulnerability map of suburban area of Lake Balaton, and the agrogeological maps of the Little Hungarian Plain. Engineering geological prognostic maps (vulnerability to contamination, waste disposal) were also published in the "Geological Atlas of Hungary" at 1:500 000 scale.

The experience of the previous 30 years made clear that *areal prognosis* (1984) is an important task. It turned out that only some specialists used the geological, raw-material prognostic and applied-geological maps. Geology didn't infiltrate the work of planning, economics, institutions and offices of the higher authorities, partly because of their lack of receptiveness, partly because of the too-technical language of our work. That's why we aimed to publish all the geological elements of the natural environment in the form of various maps and atlases, which were based on well-evaluated data. Areal prognosis must fulfill the competing demands of simultaneous utilization and protection of the natural environment. Interpreted versions of maps must be edited, which gives a complete introduction to the environmental potential of the area: the effects and barriers of raw-material utilization, regional technical, agricultural and communal interventions, and possibilities for nature protection. Suitable computer data and keys make possible their various (engineering, economic, authority) utilization during any planning, execution or production work.

The importance of this work is the possibility of various utilization of the huge amount of data gained from different types of research in the Survey over the past 30 years, and the expedient concentration of the dispersed works. Its importance in scientific politics is, that the Survey could break out of isolation, and can weigh possible future research alternatives. Another important factor is, that the Survey could gain a certain advantage in the international geological life through the possession of high technology.

The program "Regional complex geological prognosis of Hungary" readied maps of eight counties. The first atlas of Komárom–Esztergom county at 1:100 000 scale was issued with five different maps (with a color Cromalin fast issue method on trial in a restricted number). The map of "Utilizable raw-materials" gives a simplified geologic map, shows the sites of all the useful raw-material resources, the state codes of survey and their prognostic possibilities. The "Surface and soil groundwaters" map presents the hydrogeological situation and groundwater-movement patterns, data of the aquifers and a monitoring system. The map of "Hydrogeological properties" presents a classical high-resolution hydrogeological map with 40 keys. The map of "Engineering geology and vulnerability to contamination" contains the qualification of the rocks, concerning their vulnerability to different contamination, the conditions of the relief, the sites of waste disposal and other objects of contamination, the position of the aquifers, the protected areas and the anthropogene factors. The map of "Geology and complex utilization of the area" gives a synthesis about the present technical conditions, the pattern of areal utilization and its restrictive or excluding effects.

The outstanding value of the atlas is, that it shows the possibilities of utilization of geological and environmental data. Its complex character is a novelty in applied geological maps. It is clear to all, so the science of geology may appear in the evaluation of environmental potential, areal development, investments in construction, forestry and agriculture, economy, etc. The arising problems can be only solved on the basis of scientific data and with specific geological research. This may establish the division of basic functions of the state and market, and can guarantee the priority of the Survey.

The Survey carried out and/or took part in 38 raw-material explorations (as an own task, or because of the change of the industrial conceptions). Of these, 17 were for coal (Liassic of the eastern Mecsek Mts, Upper Cretaceous of the Transdanubian Central Range, Eocene/Miocene coals of northern Hungary), 10 were for bauxite (Transdanubian Central Range and its forelands, Villány Mts), and 11 were for different other raw-material resources (ore minerals in the western Mátra Mts, gypsum and anhydrite at Alsótelekes, alginite at Pula and Gérce, perlite and bentonite in the Tokaj Mts, bentonite at Várkeszõ).

These projects were complemented by the results of prospecting for construction and soil-conditioning raw-materials, which were made by the Regional Geological Services, and which contributed significantly to the national raw-material statements and prognosis.

The *scientific provisions* (database, library, map store, museum, printing office), which are the 3rd most important task of the Survey, also developed. The database (with the help of the microfilm laboratory) was compiled with the data from hydrocarbon drilling, bauxite and hydrogeological surveys, and issued in the annual volumes of "Data of deep drillings in Hungary" and ten retrospective volumes (from 1851!). It also gathered the documentation of mines, which were already exhausted, so it really became a national geological database. Its technical development was marked by the investment in new compact storing boxes, by the modernization of the reading room, and by the procurement of photocopy and microfilm-reading machines. The recording of archival data on computers also started. The holdings of the library were also enriched by a collection of the scientific history of geology. Beyond accounts of personal achievements, valuable volumes were issued about the research relationships of Hungarian geologists with Italy and North America, about the history of raw-material prospecting, and about the geological history of the Hungarian museums and collections. The map store was enriched by some 10,000 copies of 486 maps, which were issued during this period, and by the establishment of a central map-store.

The circulation of previously secret maps increased after the lifting of restrictions in 1989. The organizational attachment of the regional core stores in four different parts of the country (Pécs–Vasas, Szépvízér, Rákóczibánya, Szolnok) was significant in the development of the collections. Besides the cores of mapping, tectonic and raw-material prospecting, and that of the key bore-holes, the most important industrial research cores (because of the liquidation of the mines; MÉV (i.e. Mecsek Ore Mining Company), OFKFV (i.e. Mining Research and Deep Drilling Company), coal mines at Nógrád, Borsod and Tatabánya, [OÉÁV (i.e. National Ore and Mineral Mining Company)] also became the part of these collections (except the cores of hydrocarbon prospecting after the 2nd World War). The approx. 3,000 km cores are the most valuable wealth of Hungarian geology, which can be converted in any recent or future research. The further development of the other parts of the collection became impossible, because of the lack of space. The less valuable materials, with their original chests of drawers were placed in different core stores in the country, or in the new compact storing boxes, which were constructed between 1982 and 1984.

We wished to improve the *publishing efforts* of the Survey to the level of the national scientific publishing houses. That's why we increased the number of traditional volumes, expanded the group of authors, issued new proceedings (Prodinform since 1986, Geoinform since 1981, explanation volumes of the atlas of 1:500 000 scale in 1985, prospectus of technical literature of geology and geophysics since 1983). We also improved the technical background of publishing (word editors, printing instruments). The results are shown in Fig. 1. The number of volumes issued in the two previous periods (684 and 538) was almost duplicated during this period (1,122).

The new directions of development of scientific provision are marked by the improvement of information, laboratory work and computer techniques. The "Atlas of deep bore-holes in Hungary" (at 1:150 000 scale on 35 pages (1984), publication of the data of observation wells on the Great Hungarian Plain between 1967 and 1981 (1982), catalogues of maps and proceedings, reports about the activity of the Survey, new series, scientific meetings together with Hungarian Academy of Sciences and the Geological Society are all good examples of the improvement of information.

The laboratory provisions of the Survey were determined by three factors: we tried to maintain the volume of laboratory work, required both by the research of the Survey itself and by the orders of other institutions and surveys (partly because of economic considerations). We also aspired to a leading role (because of scientific political considerations) and tried to catch up with the international level with investments (obtaining automatic and computer-controlled high-technology instruments to improve analytical sensitivity, and to decrease the amount of labor employed). As a result, the geological knowledge about the country grew rich with a huge number of data from laboratory investigations (mainly from cores of industrial research, which were analyzed on behalf of other institutions). Geochemistry was also enriched by specific research projects (improvement of organic geochemistry and hydrogeochemistry). New laboratories of palynology and for conodont determinations were also established.

After surmounting financial difficulties and the relaxation of the Cocom system (since 1985), the Survey began serious investment in big analytical instruments, supported financially by the EEC-Phare program and by the OTKA (i.e. National Scientific Research Fund) Instrument Center. We bought an ICP spectrometer, later an ICP mass spectrometer, a cryogenic magnetometer, an SEM microscope and modernized the classical instruments, too; which made possible the exact analyses of major and trace elements for hydrogeological, environmental-geological, agrogeological, and paleontological research until the end of this century.

To avoid squandering development, we cooperated with certain institutions: in K/Ar dating with ATOMKI (i.e. Institute of Nuclear Research), in agrogeological research with MÉMNAÁ (i.e. Plant Protection and Agrochemical Station), in soil mechanics and survey of construction raw-materials with FTV (i.e. Geodesical and Soil Mechanical Company) and Budapest Technical University, in stable-isotope investigations with ARSENAL in Vienna, in technological classification with KBFI (i.e. Central Institute for Mining Development), in microprobe investigations with the Geochemical Laboratory of Hungarian Academy of Sciences, and in other research with certain university departments and industrial surveys.

Computer provisions of the Survey were characterized by duality during this period. After long quarrels without any conceptions, or sometimes even with exaggerations, a critical moment came when the Survey could afford an advance in computer technology. This made possible the investment in PC's, establishing the usage of computers, the foundation of education, and finally the employment of scientists who had qualifications both in geology and in computer science. The Survey was able to overcome the handicaps of the lack of time, money and expertise in computer technology of the past decades only by 1989, with the installation of a MICRO VAX 3800 computer.

The department of raw-material evaluation and computer techniques significantly contributed to the results with the completion of raw-material statements together with Eötvös Loránd Geophysical Institute of Hungary. They also developed new systems for quality-selective evaluation, and further recorded data from 35,000 drillings on computers. The different departments worked out valuable software in geological mapping, interpretation of maps, remote sensing, hydrogeology, engineering geology, laboratory investigations, handling of databases, and their work was limited only by technical fundamentals. The complex geological data banks of certain counties of the regional geological surveys are of great value. The most important result is, that a complex computer system has developed in the Survey, which is the basis for further development. In informatics, we followed some international systems, too.

The *international connections* of the Survey significantly improved during this period, as a result of favorable changes in politics, improving supply of foreign currency, and finally due to our efforts. Besides the traditional cooperations with the geological institutes of the surrounding countries, we signed bilateral contracts with the geological institutes of 16 countries on 3 continents. Our expeditions carried out successful geological mapping and raw-material prospecting in Mongolia, Cuba and Vietnam; other experts worked in 22 countries. 14 researchers of the Survey were members of different international geological commissions. We regularly presented our results at international conferences, and published them worldwide in scientific journals.

The commission of "Geological Maps of the World" of IUGS appreciated our methodological results in geological mapping and publishing, and also proposed our admission to the "Association of West-European Geological Institutes". This succeeded only in 1992, because earlier most members voted against, i.e. not to make an exception with an East-European country. A certain path to approval was winning the right to organize some international scientific meetings: International Congress of Diatoms (1981), 10th Symposium of INHIGEO (1982), Symposium of American-Hungarian Geological Cooperation (1984), 8th Congress of RCMNS (1985), European Micropalaeontological Colloquium (1989), IAS 10th Regional Meeting (1989). From the published results of international cooperations, we emphasized the "Neogene Palaeogeographic Atlas of Middle- and East-Europe", the explanation volumes of the geologic-tectonic map of Cuba-Oriente, and the volumes of the

American-Hungarian and Austrian-Hungarian cooperations.

Of course, this period also had its unrealized plans, defeats and unfinished works. However, it may be reasonable that lasting results dominate in this jubilee volume. I would like to finish this report with the results of development of intellectual and financial properties: the number of the employees in the Survey in 1991 was 550, from this 206 researchers (40 with a second degree), 80 qualified, 18 give courses at different universities. It was a special delight that we could cooperate with the generations: between 1980 and 1989 37 young geologists were employed. The Eötvös Loránd University established a Regional Geological Department in the Survey in 1988, and approved our educational work in this way. The reconstructed and modernized main building, the enlarged building of the laboratories and other background establishments assure a calm atmosphere for creative scientific work. The accumulated experience and knowledge of the past 125 years, and the necessity of geological science is the pawn of the future of the Survey. Even the restrictive episode at the end of this period, and the forced and groundless regression, which greatly exceeded the average of any of the other scientific branches, can't change the direction of development. When we really arrive in Europe, geology will take again its worthy position in the economic and social life.

THE HUNGARIAN GEOLOGICAL SURVEY – THE NEAR PAST THE PRESENT AND THE FUTURE

by GÁBOR GAÁL, LÁSZLÓ KUTI

1980–1990: ANTECEDENTS OF THE TRANSFORMATION

Demands to the function of geology underwent radical changes at the end of the seventies and at the beginning of the eighties. Political changes in the developing countries, the oil crisis, growing uncertainty of access to certain raw-materials, and the considerable increase of costs sent a powerful wave of restrictive economic measures through the developed countries. The new situation resulted in a gradual decrease of demand for the exploration of mineral resources and for mining in general.

Simultaneously to the shrinkage of the traditional fields of geological activity the protection of the environment became at first fashionable, later a political device, and finally essential of life, formulating new demands towards the natural sciences, including geology. In the developed countries the geologists realized, although with a certain hesitation, the importance of looking for new horizons. The geology focusing on the mineral resources has been replaced more and more by a geology focused on the environment. The Hungarian Geological Survey was not bypassed by this development. The first studies taking into consideration also the various requirements of environmental protection were carried out in the framework of programmes which aimed originally at targets of different nature, such as the surveying of the lowlands or the mapping of regions of unconsolidated sediments. Hydrogeological, engineering geological and agrogeological research was performed in the Survey already in the time when the governmental instances were only willing to accept those geological activities which were related to the mining of raw-materials. The first tasks of the protection of environment; i.e. of environmental geology, emerged in the work of the Regional Geological Services of the Survey. Subsequently to a methodological preparation, the compilation of a pollution-vulnerability map of Hungary has begun, and regular mapping of the environmental-geological state covering the areas of their competence was executed. Regarding both the organization and the research policy, the year 1986 brought substantial changes. The new organisation initiated by the Central Office of Geology took shape in that year. This was erroneously regarded by later criticism as having been in force already in the preceding decades. The so called "independent divisions" formed at that time had the task of giving directions to the departments placed under them. Thus the heads of divisions were entrusted with new competences. Their role as doing independent research work along with giving directives for the scientific work of the departments was replaced by the administrative authority to supervise and to direct the work of the departments. Simultaneously, considerable personal changes and broad-scaled "rejuvenation" of the Heads of Departments took place. More than the half of the departments were placed under new leaders. The majority of them did not occupy any leading position earlier. The rightness of their appointment has been proven both by the time elapsed since then and by their professional activity; namely nowadays almost all of them are key-personalities of the Survey.

In 1986 the geological mapping programmes which had been carried on by the Survey during so many years in the Great Hungarian Plain, in the Velence Hills and in the Lake Balaton Resort Area were completed. The new directions of environmental research were based partly on the achievements of these programmes, and they became inserted accordingly into the framework of the Surveys organization. The Agrogeological Department was reorganized and for the first time since the foundation of the Survey, departments were set up for Environmental Geology and for Remote Sensing. The Regional Geological Services began to compile a series of synthetizing maps entitled: "Atlas of complex regional prediction maps of the counties of Hungary."

1990–1991: THE NEED FOR RESTRUCTURING

By 1990 it became clear that the position occupied by the geological research in the public administration was going to be changed. As the market economy was taking shape, the outlines of a new arrangement were becoming visible. Due to the shrinkage of the engagement of the state in the geological research, reconsideration and reformulation of the public role of geological research were needed. Consequently, by reducing the volume both of basic research and mineral exploration and by directing the activities towards the new demands, a process of change took shape within the Survey itself. As early as in 1990 the management drafted a programme, in which special emphasis was put on the strengthening of the applied geological activity. However, the fundamental priority still was given to the regional geological mapping and as the most important task of the Survey the basic geological research was specified. This conception accepted the decreasing volume of mineral exploration subsidized by the State already as a fact.

The proposals put forward in 1990 by the Survey could not keep pace with the accelerated evolution of events. As the conceptions of the new legislation on mining began to took shape, the whole system of geological institutions fell into the stream of the nationwide changes. The management of the reorganization, i.e. the destiny of the Survey, was taken in hands by the Central Office of Geology at first, and later, from 1993 on, by the Ministry of Industry and Commerce.

The Hungarian Geological Survey as part of the system of geological institutions was evaluated in 1990 and 1991. The results of the evaluation and the conclusions drawn there from were summarized by P. Teleki, USGS (10th August 1990); J. F. Devine, USGS (10th February 1991); Gy. Komlóssy President of the Central Office of Geology (28th March 1991); P. Teleki in his capacity as Adviser to the Hungarian Government (5th July 1991) and P. M. Allen geologist of the British Geological Survey (15th July 1991).

The criticism touched the Survey painfully, as it has made every effort since its foundation in 1869 to acquire and maintain a solid position in the first line of the geological research, and the international acceptance of the Surveys results gave proof of the fact that this endeavour was not a failure. The research associates of Hungarian Geological Survey, while accepting the well-founded and constructive observations, even regarding them as the verification of their own ideas, in many cases had the feeling that the charges brought against them or against their activity were unfair, as they have done their work according to the expectations of the State and fulfilling the tasks entrusted to them.

The scientific and practical achievements of the period lasting from 1947 to 1991 were not questioned by the experts, and the experiences of the last three year testified that past activity was founded on a base of stable values, and even this base was further developed. The survey, just like a number of other geological Surveys in the world, arrived in 1991 at the crossroads mainly on the way of economic difficulties. It had to be decided, how to proceed. In Hungary these problems were even aggravated by the fact, that the new economic and social situation required new ideas, a renewal of the way of thinking and a new type of management.

The criticism

The main critical remarks were as follows:

– Active participation is needed in the economic development, by submitting a research programme satisfying the demands of the government regarding energy-policy, environmental protection, regional development, agriculture, water supply and public health.

Simultaneously the Survey should strengthen connections with the public, arousing its interest for the achievements of the geology and for the earth sciences in general.

- In the years preceding 1990 the Survey attained considerable achievements in the fields of basic geological research, regional geological research and in the exploration of mineral resources. The financial support of the State made an extensive development possible, but it brought into existence capacities for which the demand was lost after 1990.

Some examples brought forth by the evaluating experts:

- The stratigraphic research previously focused on the determination of Formations turned out to be overdimensioned, while at the same time the complex research of paleoenvironments by integrating the results of diverse methods, facies-analysis and sedimentological research were more and more needed.

- The economy of the geological mapping methods applied is questionable due to the rigid use of drill-hole grids, and to the expensive form of the publication.

- In the course of privatization, following the withdrawal of the State from the field of mineral exploration, considerable scientific and drilling capacities became unnecessary.

- Considerable problems arose relative to the instrumentation of the Survey. The former regime put enormous sums of money at the surveys disposal for financing the exploratory drillings and the geological key-section programme, but no sufficient financial support for the modernization of the instrumentation of the laboratories and for the adaptation of up-to-date computer techniques was given in the central state-budget.

- Forming the background of the problems mentioned above, an obsolete public-administration together with the administration of the Survey itself were to be reformed. As the old-fashioned methods demanded excessive manpower, the auxiliary personnel/research associate ratio was too high. In the excessively subdivided division-department system each individualized unit defended interests, meant to be its own.

- The separation of the different branches of earth-sciences by forming independent institutes of geology, geophysics, geochemistry and hydrogeology was a characteristic phenomenon of the past decades. A serious problem inherited from this period is the still existing separation and alienation of geology and geophysics. One of the most important tasks for the future is the integration of geological and geophysical activities, which requires the establishment of close co-operation between the Hungarian Geological Survey and the Eötvös Loránd Geophysical Institute of Hungary or, according to some opinions, their fusion.

The statements and criticism of the evaluation contained many relevant observations which influenced the elaboration of the new strategical concepts of the Survey. Some elements of these opinions, however, reflected the lack of adequate knowledge of the circumstances or their misinterpretation.

Opinion of the research associates about the state and the future of the Survey

By the end of 1990 it became obvious that the authority supervising the Survey had the intention to put it and the entire system of the geological institutions of the country under a new management which should have new ideas. On 14th December 1990 Gy. Komlóssy was appointed President of the Central Office of Geology by the Minister of Industry and Commerce, charged with the reorganization of the entire system of geological institutions.

On the occassion of his first visit to the Survey Gy. Komlóssy invited the research associates to express their opinions on the future of the Survey and to produce an analysis of the state-of-art. The so called "Committee of the 27", set up on the iniative of the research associates, after working several weeks on the appraisal of both the situation and the activity of the Survey, put forward a programme, which would have ensured the safeguarding of all the values which might be rightly claimed both by professional circles and the society. The Committee did not know the results of the evaluation by the international experts at that time. The Committee formulated the legal status of the Survey by the following words: "The Hungarian Geological Survey is the scientific research institute of the Hungarian State in geology..., having the task of the geological reconnaissance Survey of the country and that of performing the geological activities required by the national economy". In the document the finances of the Survey and its organization were also discussed. The authors of the document made it clear that due to the recent changes of both the circumstances and tasks, the structure of the Survey had to be reformed. Due emphasis was put on the necessity of cooperation with other institutions active in the earth sciences as well; in the first place Eötvös Loránd Geophysical Institute of Hungary was mentioned. As particularly important tasks of the Survey the following were pointed out:

– the popularization of the Survey's activity, by making known the achievements of geological research and exploration in the public spheres;

– participation in the education institutionally or by the personal activity of research associates) and by undertaking services in the popularization of the earth-sciences in general. In the professional part of the elaborate the activities which the representatives of research associates considered to be of fundamental importance for the future development were specified. Accordingly, geological mapping, moreover environmental geology, hydrogeology, engineering geology and agrogeology were stressed.

1991: THE PERIOD OF PLANNING

The President of the Central Office of Geology invited applications for the post of Director of the Hungarian Geological Survey. The competition was won by Dr. G. Gaál who returned from Finland. He took over the management of the Survey from Dr. G. Hámor on 1st July 1991. In the second half of that year an other programme was elaborated by 14 working groups led by the new director, which embraced the following fields: basin analysis, tectonics, basic research, regional surveys, environmental geology, hydrogeology, engineering geology, agrogeology, exploration of mineral resources, databases, computer techniques, laboratories and development of instrumentation, the infrastructure of research activity, and international co-operation. Also the staff of the Eötvös Loránd Geophysical Institute of Hungary took part in the planning.

This teamwork was adequate to the new requirement to do the planning with a wide participation of the research associates, utilizing in this way the available intellectual values and to safeguard or even to increase the involvement of the research staff in the Surveys issues.

The programme for 1992 and the draft plans for the following years were completed by 1st August 1991. For the first time in the history of geological research in Hungary the ideas of the two institutions, i.e. those of the Hungarian Geological Survey and the Eötvös Loránd Geophysical Institute of Hungary were integrated in a common conception and summed up in a single volume. The effort of finding new directions well reflected by the draft plan and also the activities done in the period lasting from 1990 to 1994 were of this tendency. The proportion of the investigations related to environmental protection grew from 17% to 43%, thus filling the space left void by the mineral exploration dropping from 33% to 8% in the same period (see Fig. 1).

For the implementation of the plans a new programme-project organization was set up. The long-term programmes are executed by units – "projects" – having durations determined by the nature of the task.

1991–1994: RESEARCH ACTIVITY, AND CHANGING CONDITIONS OF MAN-POWER AND BUDGET

The new organizaton of the Hungarian Geological Survey took shape during 1992, by establishing projects for the research activity and by organizing departments providing an infrastructure for the former ones. Important contribution was given by J. O. Carlsson, Director of the Swedish Geological Survey (SGU), who held consultation in the Hungarian Geological Survey from 1st to the 3rd of February 1992 discussing the topic: "Reform of a geological survey considering the new requirements and tasks – the Swedish example". For the execution of the surveys research tasks five programmes were organized. These and their respective leaders from the 1st January 1992 on were:

– environmental geology (Gy. Raincsák – till 22 October 1992, Gy. Tóth from 26 October 1992);

– geological mapping (G. Chikán);

– mineral resources assessment and exploration (I. Vörös till 24 of August 1993, J. Knauer from 25 August 1993);

– basic research (Z. Balla);

– geochemistry (I. Horváth).

The programmes were executed by projects. There were 31 projects in 1991, 25 in 1992, 22 in 1993 and 18 in 1994 (see Table 1).

The auxiliary services were carried out by the Offices of the Survey, built up by departments (see Table 2). In 1992 and 1993 these units were:

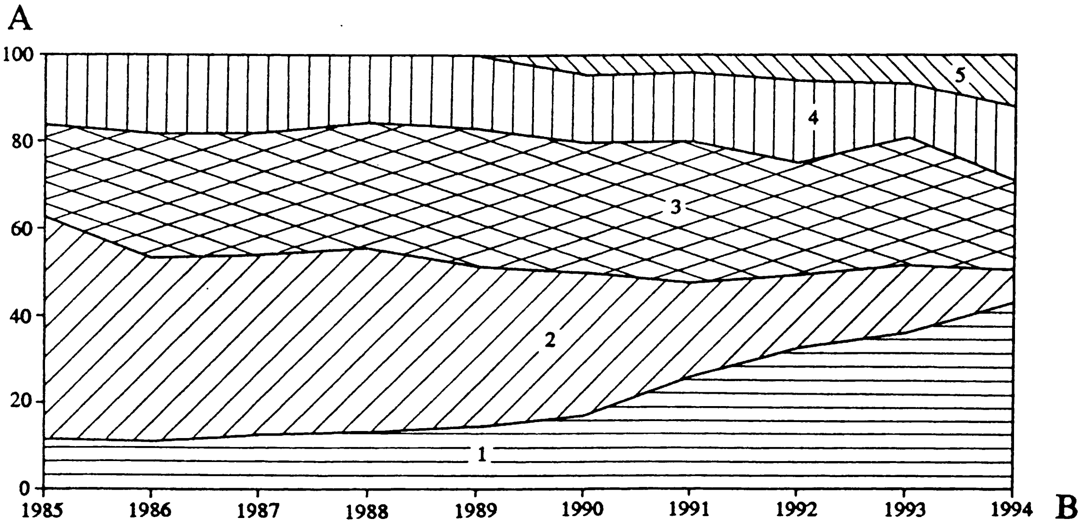


Fig. 1. Proportions of the expenditures of the Hungarian Geological Survey in the period 1985–1994
1. Environmental geology; 2. Exploration of raw-materials; 3. Mapping; 4. Basic research; 5. Geochemistry

- Information Office (E. Erdélyi), consisting of the National Geological Database, the Museum, the National Geological Library, the Computer Department the Central Databases and the Editorial team;
- Laboratories (R. Horváth);
- Office of External Relations (E. Dudich);
- Office of Economics (Mrs. J. Szaller).

At the beginning of 1994 the National Geological Database and the Central Databases, maintaining their respective functions, were transferred into the Information Centre of the successor of the Central Office of Geology calling itself now Hungarian Geological Survey.

The Regional Geological Services were integral parts of the Hungarian Geological Survey up to the end of 1993. Taking part in the execution of certain projects, these services had their own research activity, moreover they performed the tasks as state authorities in geological issues. At the end of 1993 these services were separated from the Hungarian Geological Survey and incorporated into legal successor of the Central Office of Geology calling itself the Hungarian Geological Survey and subordinating them to the Division of Professional Authority of that organization. Thus their research activity terminated.

Since 1990 both the incomes and the staff of the Survey have been decreasing. This tendency gained strength in 1991. Till now the worst of it was reached in 1994. The nominal income was 388.7 million HUF in 1991, 339.8 million HUF in 1992, 354.8 million HUF in 1993, while the figure for 1994 can be estimated at 167 million HUF. The incomes of each year between 1969 and 1994 – given on the price level of 1994 –S are shown on Fig. 2. The costs of the activities done by subcontractors between the years 1985-1991 are worth of consideration. This category contains the costs of the nationwide exploration drilling programme, which was financed by the Central Office of Geology in the framework of the Surveys budget, but the latter had no voice in this activity.

The numerical changes of the staff reflect clearly the respective amounts of financial resources being at the disposal of the Survey between the years 1969–1994 (see Fig. 3). The total number of employees was 655 persons at the peak reached in 1980. The reduction of the staff being in course since 1991 is shown by the following figures of the statistical mean numbers of the staff: 1991: 512, 1992: 368, 1993: 381 and at the 31st of May 1994: 142. The cutback was carried out by the reduction of the number of auxiliary forces relative to that of the research associates. The auxiliary forces/research associates ratio was 2:1 at the beginning of 1993, while by the end of March 1994 it has been reversed to 1:3. One of the causes for the considerable reduction of the numbers from 1993 to 1994 is the fact that the National Geological Database, the Regional Geological Services and the Mineral Resource Assessment Project were transferred to the successor of the Central Office of Geology calling itself the Hungarian Geological Survey.

Table 1

Developments in the research activity of the Hungarian Geological Survey during the 1990-1994 period
The projects to be continued also in 1995 are indicated

Denomination	1990	1991		1992		1993		1994		
	b	a	b	a	b	a	b	a	b	
Hydrogeological mapping survey of Hungary	5,9	91	9,5	117	16,0	79	9,4	62	9,8	→
Engineering-geological research	3,2	41	3,6	81	7,6	84	7,4	70	5,4	→
Agrogeological research	5,0	79	7,4	135	10,4	147	10,9	79	8,3	→
Environmental geology of the Lake Balaton region	4,4	30	2,8	32	3,4	63	7,5	26	2,2	
Mapping of the environment state	2,4	32	3,0	34	2,8	34	3,5	78	7,4	→
Regional review of the environment	4,5	54	7,0	97	7,8	122	7,0			
Engineering geological investigations in the Lake Balaton region	2,4	26	2,2							
Characterizations of the Formations of Hungary	2,8	40	3,9							
Engineering-geological mapping of the town of Szeged	2,1	2	0,2							
Preliminary geological investigations for large-investment projects	1,7									
Investigation of potential pollutants		142	13,2	121	9,5	138	10,9			
Landslide- and erosion risk in Hungary				30	2,5					
Karst-hydrogeological research of the Transdanubian Central Range						46	7,0	54	4,2	→
ENVIRONMENTAL GEOLOGICAL ACTIVITY SUMMARIZED	**34,4**	**537**	**52,8**	**647**	**60,0**	**713**	**63,6**	**369**	**37,3**	
Exploration for energy sources	13,9	92	7,9	86	9,2	89	6,8	56	4,1	→
Exploration for construction materials	2,9	34	3,3	40	4,4					
Eocene brown-coal prediction and preliminary prospecting	5,7	33	2,8							
Other coal-exploration activities	3,7	16	1,9	53	2,4					
Bauxite-prediction and preliminary prospecting	5,1	38	2,3							
Exploration of industrial minerals	4,5	45	4,4							
Methodology of the exploration and evaluation of mineral resources	1,2									
Exploration of placer deposits	2,8									
Geological tasks of granting concession rights		130	9,9	73	9,9	91	7,3			
Assessment of the potential reserves of mineral resources								42	3,3	→
Genetics of mineral raw-materials								24	2,6	→
EXPLORATION OF MINERAL RESOURCES SUMMARIZED	**39,9**	**388**	**32,5**	**252**	**25,9**	**180**	**14,1**	**122**	**10,0**	
Little Hungarian Plain, Vas and Zala counties	9,4	116	11,7	98	9,6	93	9,7	73	6,4	→
Somogy and Baranya counties	6,8	87	10,1	94	9,5	103	9,7	78	10,5	→
Bükk Mts and forelands	15,3	206	17,6	141	14,4	118	12,5			
Transdanubian Central Range	9,0	146	13,8	67	7,9	80	8,2			
Remote sensing and aerborne geophysics	7,2	72	5,0	20	3,0	50	3,0			
DANREG		22	4,8	36	3,7	44	5,9	65	5,7	→
Unified Geological Map System				48	4,4	86	8,6	48	3,6	→
GEOLOGICAL MAPPING SUMMARIZED	**47,7**	**649**	**63,0**	**504**	**52,5**	**574**	**57,6**	**264**	**26,2**	
National Geological Key-section Programme	18,5	303	25,2							
Country-wide geological syntheses (Atlas on scale 1:500 000)	2,5	36	3,7							
Basic research in international co-operation	2,5	20	3,2							
Paleokarst investigations	0,8	35	3,0							
Seismic risks in Hungary		32	3,2							
Basin-analysis				85	9,2	124	11,9	90	8,1	→
Tectonics and neo-tectonics				70	7,0	76	8,0	70	6,3	→
Paleoenvironmental studies, Biostratigraphy				109	14,0	133	11,9	86	8,6	→
BASIC RESEARCH SUMMARIZED	**24,3**	**426**	**38,3**	**264**	**30,2**	**333**	**31,8**	**246**	**23,0**	
Hydrogeochemical investigations	2,0	67	4,9	30	2,8	64	9,3	77	8,9	→
Geochemical prospecting of placer-deposits	3,2	46	4,1	25	2,0					
Recsk ore-deposit: geochemical standards	2,1	2	0,2							
Country-wide geochemical mapping				41	4,2	52	7,0	53	6,5	→
GEOCHEMISTRY SUMMARIZED	**7,3**	**115**	**9,2**	**96**	**9,0**	**116**	**16,3**	**130**	**15,4**	
TOTAL	**153,6**	**2115**	**195,8**	**1763**	**177,6**	**1916**	**183,4**	**1131**	**111,9**	
NUMBER OF THE PROJECTS	**30**	**31**		**25**		**22**		**18**		

a: month/man, b: expenditure in million HUF, → continued in 1995

EVOLUTION OF THE RESEARCH ACTIVITY

The most important changes in this field took place in 1991 and 1992 (see Table 1). In this period 11 projects were terminated, and 7 new projects were begun; i.e. the number of the "living" projects sank from 31 to 25.

Mineral exploration and basic research were touched the most drastically. Coal and bauxite exploration was given up, but at the same time a more general exploration programme of mineral resources was launched, aimed at the surveying of the mineral potential of the entire national territory. This programme included also the research of the genesis of the mineral raw-materials. The National Geological Key-section Programme and the International Basic Research were abandoned as well. The renewed geological basic research is focused on three points. These are: basin analysis, comprehensive research of the tectonic structure of Hungary and paleoenvironmental research. The geochemical research which had been done as part of diverse programmes was concentrated into an integrated programme; uniform geochemical mapping of the entire country has begun.

The geological mapping had dominant role until 1993. The radical reduction of the funds obtained from the state-budget terminated the projects of mapping the mountainous regions, although only temporarily, as it is hoped.

The environmental geological research which had already commenced, received new impetus in 1991. The main lines of this research activity are hydrogeological studies, engineering geological studies, the agrogeological mapping, and mapping of the state of the geological environment. The research aimed at the protection of environment or belonging to the sphere of this activity, is developed by commissioned works financed by other institutions and by subsidies won at competitions. Our vitality is testified to by the fact that the incomes arising from these sources have been remained on the same level regarding their real-value. Since 1990 the staff was reduced proportionally 1:4, while the real-value of the subsidies given by the state-budget was lowered 1:2.5 proportionally. Thus the incomes arising from the activities of our own play an increasing role in financing research. In 1994 17% of our income are obtained from sources of this kind.

RESULTS

The fact, that the Survey is performing active and successful research despite the large-scale reduction of subsidies by the state-budget and cutback of the staff, can be regarded as a success of the reform. The effectiveness of the activity done in the past three years is shown by the following outstanding performances mentioned:

- Remarkable development has been achieved in the methodology of geological mapping in lowland-type terrains. The highly complex set of data gathered during the mapping of the Little Hungarian Plain was processed by the INTERGRAPH-based Geographical Information System. Thus for the first time in our Survey, the fully automatized plotting of geological maps was achieved. In cooperation with French, German and British geological surveys the development of computing-techniques is on the right way of repairing the omissions of the past years.
- The geochemical mapping of the entire territory of the country was initiated. The first geochemical mapping, carried out in co-operation with the Geological Survey of Finland proved to be useful for assessment of the mineral raw-material potential and for environmental studies. The mapping resulted in pointing out that the levels of arsenic, antimony and mercury associated with the gold-occurrences of the Zemplén Mts surpassed the norms of the soil-hygiene thus being harmful to the living organisms.
- Progress was made in the detection of the geological origin of arsenic-bearing drinking waters harmful to the health.
- Equipment of the laboratories has been modernized to meet the demands of the new professional activities. The funds for the development of the laboratories (more than 65 million HUF) were provided by winning domestic and international competitions. Also application of personal computers has been further developed. Important results were obtained in the study of the sedimentation of the Pannonian Basin by using methods of modern basin analysis, including facies-analysis and sequence-stratigraphy. This activity has outstanding importance for the estimation of the hydrocarbon and thermal-energy reserves.
- The first regional overlook of the environmental state of Hungary was completed. The Regional Geological Services of the survey compiled integrated map-series (atlases) serv-

Table 2

Infrastructure and services during the period of 1990–1994

Denomination	1990	1991		1992		1993		1994		
	b	a	b	a	b	a	b	a	b	
Reserve estimation of mineral resources	10,8	72	5,6	80	7,7	95	17,5			
Regional Geological Services	9,5	123	11,0	165	11,0	168	11,7			
External relations	5,0	32	7,6	40	11,6	48	10,0			
Instrumentation centres	.	36	4,7							
National Geological Database				132	8,8	104	9,9			
National Geological Library					8,1	90	11,9	60	9,2	→
Collections (Museum)	32,1	647	40,0	273	22,3	245	13,9	72	6,0	→
Databases and data processing				106	18,7	150	15,7			
Editorial team				289	17,8	348	20,9			
Computerization, Geographical Information System				95	17,4	101	13,0	84	5,6	→
Development of the laboratories				64	12,0	40	11,9	24	2,3	→
Hungarian Geological Survey totalled	**57,4**	**910**	**68,9**	**1244**	**135,4**	**1389**	**136,4**	**240**	**23,1**	

a: month/man, b: expenditure in million HUF, → – continued

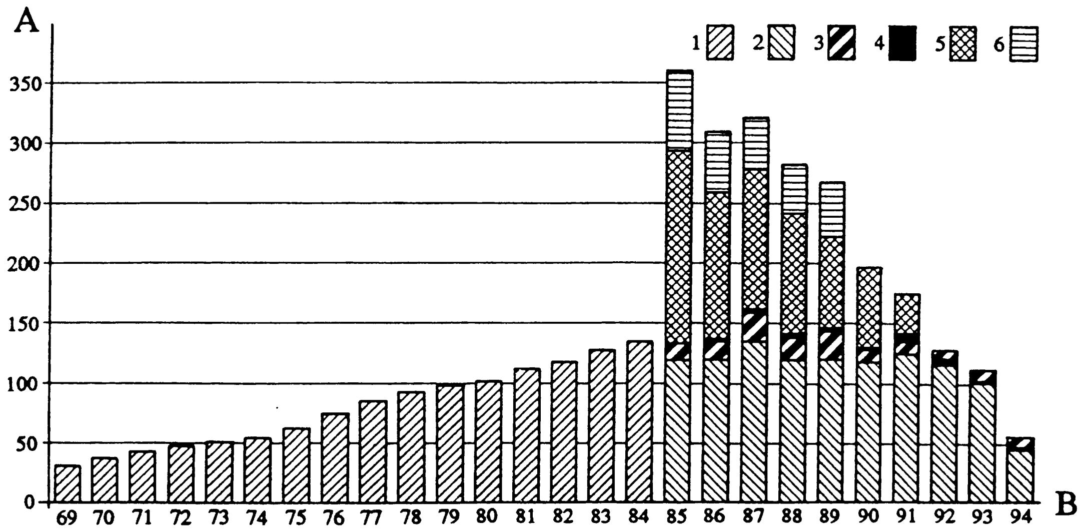


Fig. 2. The incomes of the Hungarian Geological Survey from 1969 to 1994. (The figures of the 1969–1984 period were calculated on the current price level.)

1. Total of the surveys own activity, 2. Subsidies from the State budget, 3. External contracts, 4. Competitions won, 5. Subcontractors (drilling), 6. Geophysics

ing the aims of the regional development-policy. These maps cover the counties on scale 1:100 000 and the areas of groups of settlements on scale 1:25 000. The atlases include the following thematic sheets: map of mineral resources, map of the surface and subsurface waters, hydrogeological map, map of environmental geology and pollution-vulnerability, and a complex geological-land use map.

– Investigations were carried out concerning the site selection for the radioactive wastes of the Paks nuclear power plant, and the designation of the site of a new nuclear power plant.

– The Survey mapped the areas influenced by the water-regime of the Danube in the Szigetköz area and those situated between Visegrád and Tass villages. The documentation is available e.g. for the reconnaissance of the geological environment of the Gabčikovo–Nagymaros Dam Project.

– The environmental research of Lake Balaton and the resort area around it has been completed by now. Thus a geological monitoring system can be set up in the lake and in its close environment. Moreover activities promoting the rehabilitation of the lake (e.g. dredging) can be planned.

– At present a country-wide hydrogeological, geochemical and environmental-geological monitoring system is in operation, based on

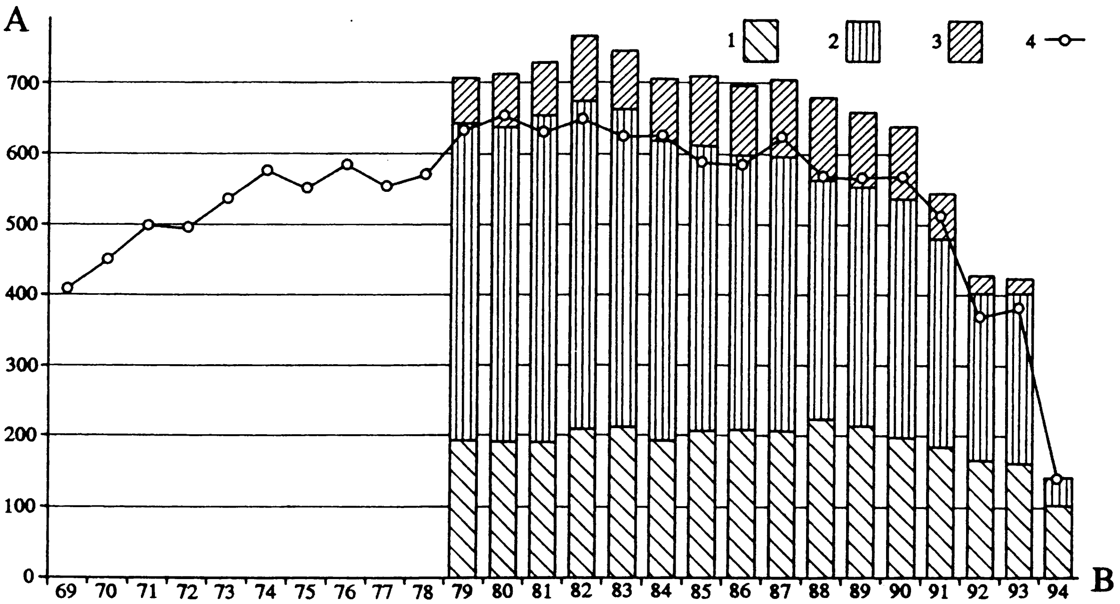


Fig. 3. The staff of the Survey from 1969 to 1994

1. Legal staff of the research associates, 2. Legal staff of auxiliary forces, 3. Legal number of retired persons employed by contracts, 4. General statistical number of the staff in 1994 — state of 31st March

more than 300 controll-wells of the national groundwater monitoring system.

- Documentation packages, so called "concession packages" were compiled characterizing the economic-geological features of raw-material deposits for granting exploration and mining concession rights.

- Up to the end of 1993 the annual inventory of mineral reserves of Hungary was compiled by the Survey.

- Agrogeological research of the country, was carried out complemented with the detailed investigation of type-areas.

- The stock of the National Geological Database was growing steadily. At the end of 1993 it included more than thirty thousand manuscript reports and expert's opinions. This expansion is due partly to the incorporation of the archives of state-owned enterprises being in regress or closed down already. The Database holds the data of nearly 200,000 drillings; more than the half of them are fully documented. During the four years from 1990 to 1994 39,316 documents were put at the disposal of 3,250 clients by the reading room service.

- There are 302,123 inventory units (books, periodicals and manuscripts) in the stock of the Library. During the years 1990–1994 the Library was visited by 16,844 persons, and 60,196 documents were borrowed by them.

- The aerial geophysical survey of the Eger region was completed. The magnetometric, electromagnetic and radiometric data of an area of 40 x 40 sqkm extension provide important new information on the state of environment and the mineral potential.

- The Metallogenetic Map of Hungary on a scale 1:500 000 and its explanatory notes were completed.

CHANGES OF THE LEGAL STATE OF THE HUNGARIAN GEOLOGICAL SURVEY AND ITS CHANGING POSITION IN THE ORGANIZATION SCHEME BETWEEN 1991–1994

The directives of the government concerning the reform of the geological institutions took shape at the beginning of 1991 in the following points:

- due to the change-over to market-economy the Central Office of Geology was no more needed;

- the functions of the Central Office of Geology which are of geological character have to be transferred to another organization – i.e. to the later Hungarian Mining Office;

- the authoritive rights of the Central Office of Geology to supervise and to finance the two research institutes should be abolished and simultaneously the Hungarian Geological Survey and the Eötvös Loránd Geophysical Institute of Hungary have to be united in a single organization.

During the years 1991–1993 these directives were not carried out consistently. One of the reasons is the fact, that the reform of the system was entrusted by the Minister of Industry and Commerce to the president of an institution which was also to be liquidated; i.e. the Central Office of Geology. Another reason of this inconsistency was the twofold change of the Minister's person. As a consequence, three different conceptions, i.e. drafts of governmental decrees, were formulated. Finally the exigency which arose from coming into force of the new Mining Law led to the compromise more or less conserving the old structure: the Central Office of Geology has a legal successor which claims the title of the Hungarian Geological Survey and supervises the Geological Institute of Hungary, formerly Hungarian Geological Survey, and the Eötvös Loránd Geophysical Institute of Hungary, both independent research institutes.

In the following we sketch the succesive development of the abovementioned conceptions.

The first draft of the governmental decree on the establishment of a "Hungarian Institute of Geosciences" and its competences

In the time of developing the first conception the ideas of P. Teleki, Adviser to the Hungarian Government determined the course of events. The blueprint of a uniform system of geological institutions was given by him in a note dated the 5th July 1991 to Á. P. Bod, the Minister of Industry and Commerce. Later a proposal concerning the modernisation both of the activity and the structure of the Hungarian Geological Survey was submitted to P. Teleki on 3rd Sept. 1991 by G. Gaál, Director of the Survey. As the base for the system of institutions to be set up he recommended the Hungarian Geological Survey. Accepting this concept, P. Teleki suggested the reform of the geological institutions of the state by setting up an unified geological survey (4th Oct. 1991). The first proposal of the Ministry of Industry and Commerce concerning the foundation of the Hungarian Geological Survey was completed on 27th Nov. 1991. By drafting the governmental decree the foundation of a united Hungarian Institute of Geosciences as the legal successor of the Central Office of Geology and of the two institutes was put on the agenda.

The draft of the decree was sent to the Central Office of Geology, the Hungarian Academy of Sciences, the Hungarian Geological Society, and some other organizations in order to be discussed also by the wider professional community. This draft was received by the professionals with resentment and both P. Teleki, Adviser to the Government, and G. Gaál, Director of the Survey got unfavourably criticism. A large number of letters and petitions were sent to the Ministry of Industry and Commerce. The new minister I. Szabó when taking over his office in the January of 1992 was "welcomed' by a considerable heap of letters, which induced him to take the matter personally in hand and to shape a new conception.

The second concept: the Hungarian Geological Foundation

This idea was put forward in a letter of Zs. Kesserű, Director General of the KBFI (i.e. Central Institute for Mining Development), sent on 20th January 1992 to I. Szabó, Minister of Industry and Commerce. According to the new conception the institutions having geological or mining spheres of activity should be integrated in an uniform system by creating a public foundation having its own finances. In order to elaborate this conception on 8th February 1992 a Committe was organized by the minister. The team was led by J. Pakucs, its members were Gy. Komlóssy, P. Esztó and Zs. Kesserű. The essential points of their proposal were to abolish the Central Office of Geology and to establish a Hungarian Mining Office. According to this proposal both the Hungarian Geological Survey and the and the Eötvös Loránd Geophysical Institute of Hungary would have functioned as state-owned one person Ltd companies. The staff of the Hungarian State-owned Geological Company Ltd would have been formed by uniting the staff of the Hungarian Geological Survey with that of the Central Institute for Mining Development.

In June the draft plan 1-860/1992 of the Ministry of Industry and Commerce was completed, proposing the establishment of the Foundation. This plan met general refusal, mainly for the reason, that the character of a "foundation" belonging to the sphere of civil law is not adequate to perform the legal and professional duties of a geological authority, representing the state in specific issues; moreover the law regulating the legal state of public foundations had not been promulgated so far.

The third concept: the Hungarian Geological Service

Disregarding the resistance of the directors, and research associates of the geological institutions I. Szabó, Minister for Industry and Commerce declined from the reconsideration of the foundation/public foundation idea. In the debates on the draft of the Mining Law the experts acting on the professional interests of the geosciences defended their ideas in the Parliamentary Committee of Environmental Protection against those of the minister with success. Thus the President of the Central Office of Geology, Gy. Komlóssy, managed to achieve that his conception relative to the establishment of a Hungarian Geological Service became accepted by the Committee, and by its help by the entire legislative body, too.

Dated on 30th September 1992 the resolution N° 8/1992 of the Committee on the restructuring of the existing system of geological institutions, formulated with the efficient co-operation of J. Gyurkó, later Minister of the Environment and Regional Policy, proposed the creation of the Hungarian Geological Service as the legal successor of the Central Office of Geology, charged with the execution of tasks of public administrative character, moreover to carry out scientific basic research and doing services of public interest. The Committee emphasized the importance of "performing the activities of professional authority for providing the base of official decision-making in the domains of the environmental protection, water management, agriculture, regional development of the infrastructure, nature conservation, and the maintenance of a professional database and monitoring system, moreover to evaluate and register the raw-material reserves owned by the state".

The resolution of the Parliamentary Committee of Environmental Protection had a decisive role in formulating the text of the governmental decree on the Hungarian Geological Service. The first variant of this text was submitted by the Minister of Industry and Commerce, J. Latorcai to the government on 23rd April 1993. On 29 June 1993 J. Latorcai charged I. Farkas, Head of Department in the Eötvös Loránd Geophysical Institute of Hungary with the formulation of the Organizational and Operational Regulations of the Hungarian Geological Service. The minister determined also the funds being at its disposal for 1994 in 400 millions HUF. The staff of the organization was limited to 400 employees. The decree on the Hungarian Geological Service called therein in English "Hungarian Geological Survey" (Magyar Geológiai Szolgálat) came into force on 29th November 1993. The Organizational and Operational Regulations determining the present organization and legal status of the Hungarian Geological Survey were approved by the Minister of Industry and Commerce J. Latorcai, and the Minister of Environment and Regional Policy J. Gyurkó on 15th December 1993.

Along with the establishment of Service which calls itself hereforth the Hungarian Geological Survey, the legal status of the former Hungarian Geological Survey called hereforth the Geological Institute of Hungary was modified, too. The main points of the change are:

- the Institute is an independent legal person, autonomous in the quality as a research institute, but only partially independent from the economic point of view. From the beginning of 1994 the economic issues of the Institute, together with those of the Hungarian Geological Survey and the Loránd Eötvös Geophysical Institute of Hungary, are managed by an Economical Office common for all of them;
- the Database of the Institute as a whole is ceded to the Hungarian Geological Survey;
- the Regional Geological Services of the Institute come under the competence of the Division of Professional Authority of the Hungarian Geological Survey;
- the staff of employees of the Institute should be reduced to 137 persons in 1994. (At the end of May 1994 the entire staff consisted of 141 persons).

These changes had painful effects in the survey. Nevertheless the measures of constraint must be carried out. We are doing the reduction with the hope that the restructuring continues to be a transitory state of processes which directs us towards the formation of a modern geological-survey type organization.

1994 AND FORTH

Hungarian Geological Survey or as it is called at present the Geological Institute of Hungary is proud of arriving at the 125th year of his existence as an independent research organization. The past 4 years brought a critical period into the life of the Institute: it had to fight not only for being capable of performing its activities, but also for the mere survival. As a consequence of the restructuring requested by the difficult economic situation, in spite of shrinking subsidies by the state budget and by the criticisms received, it is a fact that this scientific community has stood the test. The project organization turned out to be sufficiently flexible. By reformulating the tasks of the geology the foundations of a new development have been laid.

The profile of the Institute changed because several service units like the National Geological Database and the Regional Geological Services were attached to the recently formed comprehensive organization of the Hungarian Geological Service which calls itself now Hungarian Geological Survey. In the new organization the latter mentioned units constitute the Division of Professional Authority, while the first one the Information Centre. From this time on the Geological Institute of Hungary should be engaged exclusively in scientific research. Thus the work of the Institute will be judged by the practical value of the results of its work and its work in the future should meet the demands of the society, while its standard should be constantly improved. Provided that we shall be able to proceed in this direction, funds can be added to the modest subsidies available at present through commissions, ensuring the development of our methodology and instrumentation.

An important precondition of improving the quality is to have partners from whom we can learn. During the past four years we developed our western connections considerably. For the time being we have joint projects with the Geological Survey of the United States (USGS), with the French Geological Survey (BRGM), and with the Austrian Geological Survey (GBA). These co-operations are also financially profitable, but more important is the updating of the professional knowledge of our research associates. These connections must be fostered in the future too, as they provide a possibility of establishing partnership relations of mutual benefit also with geological institutions in Central and East Europe. A good example of this new connections is the recent "Copernicus-competition" of the Institute, in which professionals from France, Albania, Greece and Hungary are involved.

The reduction of the subsidies from the state-budget was of such an extent that not only the development but the mere existence of the infrastructure operated to public use (i.e. that of the Museum, the National Geological Library and of the Editorial team) become endangered. Also geological field work (e.g. geological mapping in mountainous areas) which is considerably expensive, but of fundamental importance to geology had to be strongly reduced.

The period 1991–1994 was one of the most difficult ones in the history of the Hungarian Geological Survey: it was, in fact, forced to struggle for survival. The restructuring of the system of the Hungarian geological institutions, announced with so much enthusiasm, ended in a veritable disaster for the Institute. The logical conception that this Institute, which has been performing the geological research required by the Hungarian State for 125 years, should play a leading role also in the future, was not accepted. While the Institute succeeded in safeguarding its professional independence, it had to give away activities of high importance: the National Database (Archives), the scientific databases, and the Mineral Resources Assessment Project. As the National Database and the scientific databases do not belong to the Institute any more, there is considerably less motivation to maintain and develop them. In the new arrangement, the annual funds allotted from the state budget are less than the half of the previous amount. This affects negatively also our publication activity. If no additional support is available it can be feared that we shall have no means to present to the society, the science and the industry the significant achievements of the past ten years.

We intend to concentrate our efforts on activities of fundamental importance also in the future. The overlapping of activities have been eliminated. Attention must be paid to the requirement that only vital working teams should exist in the organization and the capacities of the research staff should not be dispersed. Apparently, existing programmes, i.e. the Divisions, can successfully operate 2–3 projects at best and that only those projects can be supported which develop vigorously. We shall elaborate a method of appraisal already in this year, in order to obtain an objective knowledge of the capacities and performances of research associates and projects.

PART II

1969—1994

GEOLOGICAL MAPPING

by GÉZA CHIKÁN

Since its foundation, one of the principal tasks of the Hungarian Geological Survey has been the overall mapping of the country. This includes the representation on map of the survey results, that is the plotting and publication of small-scale and large-scale geological maps.

The staff members of the Survey have always tried to do their best in keeping the work standard as high as possible. Economic and social conditions, however, have often prohibited the geologists from being "perfectionists" in making plans for their work. Nonetheless, the geological mapping has been in progress at all times since its beginning and the high standard of the work done by the Hungarian surveyors has widely been acknowledged. Already in the first hundred years of their activity, high-quality geological maps were produced on varied scales. At a later date, the quality and also the necessitiy of the mapping was fully admitted by the one-time Director of the Survey, J. Fülöp, as testified to by the fact that he himself discussed the history, situation and tasks of the geological mapping in a book written on the hundred-year history of the Hungarian Geological Survey. Without repeating these data, but relying upon them, the author of the present paper intends to review the facts of the development in surveying Hungary's territory during the past 25 years. As for this, Fig. 1 and 2 show the situation in 1970 and in 1994, respectively.

As widely known, the geological mapping is an examination of the geological setting of an area, formed during millions of years, with the collection of all data and information available thereon, which have to be interpreted and represented on a map showing the combined results of the geological processes. Accordingly, the priorites of a survey are pre-determined by the level of geological knowledge attained in given area, in conjunction with the stage of the general progress of geosciences. At the same time, the execution of this work much depends on the existence and size of the claims laid by the society to the geological sciences. Thus the events and proceedings of the geological mapping in Hungary have been largely affected by the economic and social changes taking place in Hungary and abroad.

The most important factors influencing the expected results and the financial background of the work are related not only to global phenomena but also to the modification of the economic policy inside the country. At the beginning of the seventies the energy crisis, about the turning of the seventies into the eighties the forging ahead of the "green" movements and of the environment-protectional views, moreover the accidents in nuclear power plants, the great natural disasters taking place in the eighties and, last but not least, the political changes in Eastern Europe have produced quite an effect on the research strategy direction and possibilities of the geological activities in Hungary, in general, and on the geological mapping in particular.

The guiding principle of J. Fülöp's review given in 1969 was characterized by the leading idea of those times. Accordingly, the most important aim of geological mapping was to lay foundations to the exploration of mineral resources. This very aim determined all the priorities in selecting areas and slinging out methods. The mapping of the mountainous regions was

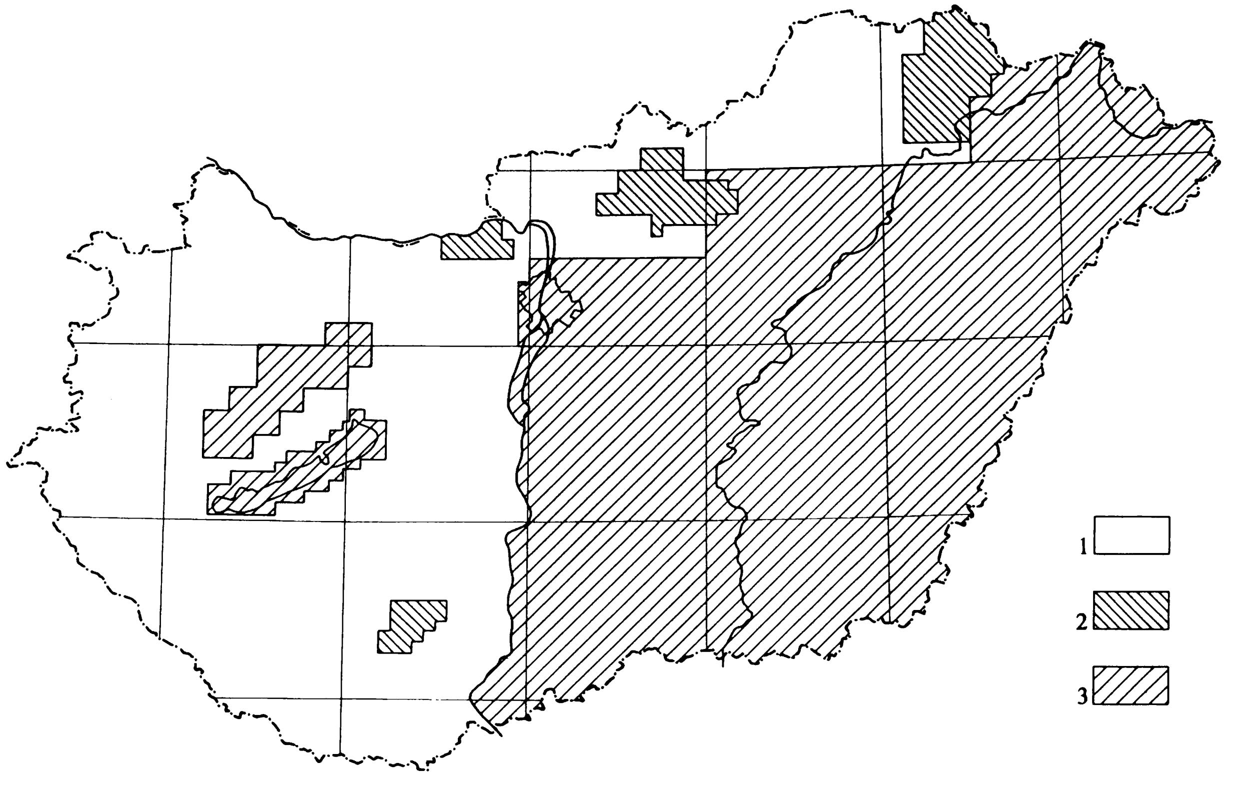


Fig. 1. Index of mapping 1970
1. 1:200 000-scaled maps completed, 2. New maps completed, 3. Mapping areas for 1970

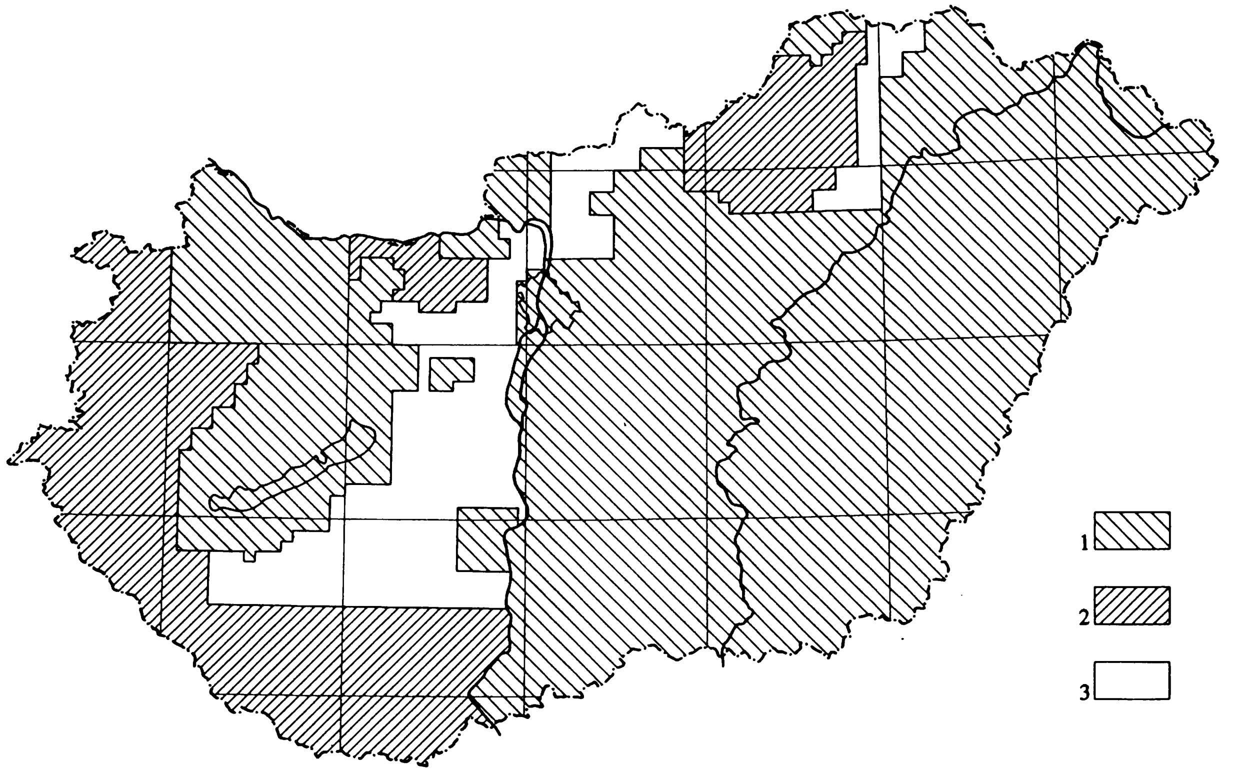


Fig. 2. Index of mapping 1994
1. Maps ready for computer processing, 2. Mapping areas for 1994, 3. Areas without detailed mapping

in the limelight, and even there the study of the features and in the limelight, and even there the study of the features and areal extent of the Quaternary cover was more or less neglected. The maps predicting mineral resources were prioritary and planned to be done on the long run. Besides the prediction of minerals, however, other practical purposes also came into the centre of interest, e.g. those of engineering geology. The strategy outlined for the first years after the centenary was based upon the viewpoints mentioned above. Thus besides the survey bound to the idea of laying foundations to mineral exploration in various regions (Transdanubian Central Range, Börzsöny Mts, Mecsek Mts, Cserhát Mts and Tokaj Mts) considerable attention was paid to the 1:100 000-scale mapping of the Great Hungarian Plain, started in the early sixties. Also the detailed and at the same time comprehensive engineering-geological mapping of the Lake Balaton region and of the metropolitan area of Budapest, were introduced (Konda 1972, 1973, 1974, 1976a, b). In spite of this fact, in the first half of the seventies the main emphasis was on the search for mineral resources. Joining the mapping done in the mountainous regions, "pre-forecast of expectable mineral resources" were elaborated for the same areas. The contemporaneous economic trends seemed to justify this work. The oil crisis and the broadening of the international market urged the planners of the Hungarian economy to exploit the mineral resources of the country to the largest extent possible. Discussion was going on in professional circles and even in the press whether Hungary is poor or rich in mineral resources. However, just in view of the oil crisis it became soon obvious that Hungary cannot act independently from the trends and facts of world economics, consequently only the market-competitive mineral resources can be taken into account as a numeral wealth.

During those years, and partly in terms of the above-described considerations the geological mapping and map plotting was still continued in the Transdanubian Central Range, in North Hungary and, to a lesser extent, in the Great Hungarian Plain. At the same time, the engineering-geological mapping of the Lake Balaton region and that of Budapest and other towns were terminated. In accordance with the scheduling of the related work procedures, publication activity was first concentrated on sending to press the 1:200 000-scale map series, planned to be a country-wide one and editing mapsheets of Tokaj, eastern Mecsek, Mátra Mts, and of Dorog Basin, surveyed in the sixties, with the pertinent explanatory notes. A new mapping was initiated in the Börzsöny Mts as "a complex study for outlining occurrences of metallic mineral resources". The mapping of the Recsk–Rudabánya tectonic belt (Darnó Line zone), as well as the fieldwork conducted in the Velence Hills and at Balatonfő had by and large the same goal. In that period the geological profession was so highly appreciated socially and financially that the Survey was able to finance, at least partially, geological exploration carried out by outside companies. Funds at hand allowed the Survey to deepen lots of deep drillings and survey boreholes, and even in some years some money was saved due to the lack of available drilling capacity. New, mostly instrumental methods were introduced. Among others, aerial photo interpretation and satellite imagery became institutional in the geological mapping. Between 1970 and 1980 about 60 maps were published on different scales, some of them in more than ten versions, and with explanatory notes (Konda 1977, 1978, 1979, 1980).

By the end of the seventies, the impact of the energy crisis and the subsequent economic recession made itself felt: funding became reduced. At the same time a problem which had been disregarded or neglected took a conspicuous shape: the disclosure and extraction of mineral resources seriously affects the natural environment. For a long time the "green" movements focused on the preservation of the still existing natural treasures. Later on they started to call attention to the fact that all kinds of human activity are affecting processes taking place in the nature, and in most cases negatively. Damages cannot be avoided even by careful planning and organized supervision thereto. Three Miles Island and Chernobyl exemplified the starting up of potentially uncontrollable processes triggered by certain elements of human intervention. The earthquake of August 1985 in the region of Peremarton, Hungary, was a minor event on a world scale, however, it worried the people thinking e.g. of the security of the Paks Nuclear Power Plant. This was a warning saying that the geological understanding of such seismic zones should be improved.

The forging ahead of applied geological research is characteristic from the point of view of geological mapping in the period concerned (Hámor 1981b, 1982, 1983, 1984a, 1985a). In line with the advancement of practical studies in geology the mapping of the Great Hungarian Plain was successfully terminated in 1984, involving one-third of the country and producing lots of information and maps of manysided usefulness. Upon these experiences, a similar mapping was launched in the Little Hungarian Plain, with the use of even more modern and efficient methods and tools, including computerized map plotting. At the end of the eighties a likewise modern and complex geological survey was started in the adjacent region of southern Transdanubia, where no such detailed and integrated geological mapping has been executed so far. By this time the environmental conditions around Lake Balaton have become almost disastrous. The Survey contributed to the solution of the problem with an environmental-geological surveying of the holiday resort area bordering Lake Balaton. The mapping of the Darnó Line region became somewhat reduced in comparison with that planned beforehand. From here the focus of work was transferred to the Aggtelek–Rudabánya Mts, the map of which was later published. During this period new large-scale mapping was begun only in a few regions such as the Balaton Highland bordered by the Bakony Mts, the NE Transdanubian Central Range and the Bükk Mts. Of these, the map of the Balaton Highland has been completed in draft manuscript form, whereas the fieldwork in the two other regions had to be suspended in 1994.

In the second half of the eighties the deterioration of environmental conditions raised many problems to be solved partly by means of contribution from geology. Many times it was necessary to meet long-felt needs of mapping to be executed now quickly and at the cost of considerable effort. The debate on the Gabcikovo-Nagymaros Dam System, the security problems related to the Nuclear Power Plant of Paks as regards potential earthquakes, the problems of waste disposal, all these reflected the necessity of continuing large-scale geological surveys, since they are important also from the point of view of society.

Economic troubles have resulted in the decrease of orders expectable from outside companies. In the early eighties the Survey made a renewed attempt at the synthesising of achievements to the extent permitted by the existing intellectual capacity (Hámor 1987, 1988, 1989, 1990, 1991, 1992).

The plotting of a series of 1:500 000-scale geological maps was commenced. The first sheet, a surface geological map, was issued in 1983. It was followed by different thematic maps on tectonics, subsurface geology, lithostratigraphy, engineering geology, hydrogeology etc. Some regional maps representing the details of large-scale mapping generalized on a smaller scale, also were published. Nevertheless, the number of the maps published in the former years was no longer attained.

After the change of the political system in Hungary in 1990, new conditions set in. It was necessary to reconsider the necessities and possibilities of the geological mapping in Hungary (Chikán et al. 1992). A new conception had to be outlined for the forthcoming years, taking into account the restricted possibilities. As based upon the Geographic Information System (GIS) starting to be developed at the end of the eighties creation of a "Unified Geological Map System" was decided. The work aimed at the preparation of uniformly plotted maps published on a scale of 1:25 000 for the mountain regions on a 1:100 000 scale for the lowland and hilly regions. The necessity of producing such maps is backed up by the fact that the map material issued in older times is considerably heterogenous. These maps plotted at very different times should be updated, unified and made ready for computer processing. Thereby the demands that would be laid in this field to the information service of the Survey from outside clients could be suitably met. Pattern maps for mountains and lowlands have already been prepared, and they constitute a good basis for the further unification. To this, however, the completion of mapping in many areas is also needed. As being short of money, the plan of the large-scale mapping had to be given up, and only small-scale surveying is now in progress in areas where the surveyors are charged with the accomplishment of special tasks (the Little Hungarian Plain and Transdanubia). Since as long as two years ago, no boreholes deeper than 10 metres have been drilled. To the solution of environmental problems, a manysided work is being done in the framework of an Austrian–Slovak–Hungarian Danube Region (DANREG) Projekt. Within the declining map publication, only one piece of 1:100 000-scale map series of the Little Hungarian Plain was issued in 1993.

During the seventies and the eighties Hungarian survey expeditions worked in Cuba, Mongolia and Vietnam. The experience gained in foreign countries might be of help at home, too.

The importance of geological mapping has always been more or less acknowledged in professional circles. However, even some geologists expected of it the performance of such duties which do not belong to the scope of this survey type if taken in the proper sense. According to the prevailing economic trends the success of geological mapping was assessed now upon the mineral resources discovered during the work, then according to its usefulness for the purposes of engineering or environmental protection. Nevertheless, it should be made clear that the mapping and representation of the geological setting of an area has to be done independently from the tendencies predominant at a given time. The making of topographic map is also necessary in itself, whatever its superimposed content is, that is to say their later use might be. Naturally, the possible practical utilization of the results of geological mapping should be taken into consideration, but the conceptions of a country-wide geological survey must not be changed repeatedly under way upon momentaneous practical claims. Priorities should be determined in advance, before the elaboration of the basic strategy to be properly considered in time together with the appropriate scale and working methods, as well as the predictable manpower, expenditure and schedule. When all these requirements are clear and the programme has been accepted, the work can be started. In this way, with the use of the formerly gathered experience and in harmony with the needs of the society, the grade of the geological knowledge of Hungary will be kept up with the general advancement of science.

ACHIEVEMENTS IN STRATIGRAPHY

by GÉZA CSÁSZÁR

INTRODUCTION

The results achieved in the field of stratigraphy in the first century of the Hungarian Geological Survey, formerly called Royal Geological Survey, have been summarized in a publication issued on the occassion of the 100th anniversary of its foundation. It can be gathered from reading this book that in a major part of the century-long past the scientific achievements were in proportion to the scale of the work, mostly to that of the geological mapping. Technical methods and means gained greater importance during the past two decades ago. It cannot be denied that the scale of mapping has invariably played an important role. The development in techniques, methodology and at least so much in view has become primary during the past one-fourth of a century. When the financial conditions were much more favourable to the Survey, also subcontractors were employed with the involvement of key researchers of the university departments and of the industrial research centres belonging to the sphere of venturers, in order to get questions answered if the Survey was in no position to deal properly with certain problems. The results achieved due to this co-operation or to OTKA (i.e. National Scientific Research Fund) have also been included in the present account.

The achievments will be treated here according to four topic as it follows: the influence of international stratigraphic organizations; the state of affairs in the field of different branches and methods of stratigraphy; the state of the chronostratigraphic units; Hungarian stratigraphers' activity abroad.

THE INFLUENCE OF INTERNATIONAL STRATIGRAPHIC ORGANIZATIONS

The dissipation of the isolation formerly so typical of the East European societies began in the field of geology with the Mesozoic Conference organized in Budapest in 1959. The thawing was even accelerated after the Centenary Celebrations of the Geological Survey (1969). More and more Hungarian experts were allowed to take part in the work of scientific organizations. It was probably due to the meetings arranged in Hungary that J. Fülöp was honoured with the presidency of the Committee of the Mediterranean Mesozoic of the International Geological Congress, between 1960 and 1968. Since 1964, G. Hámor has been a member of the (Regional) Committee of the Mediterranean Neogene Stratigraphy (CMNS, later RCMNS), being also charmain of the RCMNS Congress held in Budapest in 1985. From 1975, J. Halmai has served as the secretary of the Subcommittee of the Neogene Stratigraphy. From the point of view of the Neogene studies in Hungary, the Congress of the organization held at Bratislava in 1975 is regarded as being of decisive importance because the regional parastratigraphic scale accepted there is effective up to this day. At the Budapest Congress the Hungarian party submitted a proposal for dealing with Miocene stages. In the field of Mesozoic studies, J. Haas was elected corresponding member of the Triassic Subcommittee and G. Császár ordinary member of the Cretaceous Subcommittee. At the same time, the latter was also requested to organize a Tethys Working Group.

In stratigraphy, divergent views manifested themselves in different approaches and in the use of different terminologies, or in the fact that the same terminology was used with different contents. To co-ordinate the ways of approach and to develop a common stratigraphical language an International Subcommittee of Stratigraphic Classification (ISSC) was created and joined by M. Kretzoi at first privately then as an organizational member, starting from the establishment of the Hungarian Stratigraphic Committee in 1973. A work of more than two decades resulted in the publication of the International Stratigraphic Guide (1976). Prior to this, with the use of the rough draft of the Guide, a work entitled "Stratigraphic classification and nomenclature and Guidelines for their use" was issued by the Hungarian Geological Survey in 1975. The majority of the members of this Committee were chosen from the Survey (J. Konda, K. Szepesházy, M. Kassai, K. Balogh, G. Scholz, J. Haas, E. Dudich, L. Gidai, L. Korpás, G. Hámor, Á. Jámbor, I. Horváth, A. Rónai and E. Krolopp). After due discussions, the guidelines were edited and published by the Survey. The tasks of the Hungarian Stratigraphic Committee were formulated in the Introduction as follows:

(1) Promotion of an up-to-date study of the stratigraphic units of Hungary and the harmonization of the results attained in the country and abroad,

(2) Edition and publication of a Stratigraphic Encyclopaedia in Hungarian,

(3) Consultations to be held and positions to be taken up in timely theoretical and practical questions of stratigraphy.

It was for the first time in this publication that distinction was made between the stratigraphic areas on the basis of their particular lithological and paleontological features, together with their time of formation. Lithostratigraphy, biostratigraphy and chronostratigraphy were distinguished as independent branches. The authors claimed that the differences between chronostratigraphy and geochronology should be emphasized.

The work conducted in the scope of ISSC was later extended to other stratigraphic branches too.

It may not be underrated the influence generated by the creation of the International Geological Correlation Program (IGCP) whose post of Secretary was occupied during three cycles by a former Deputy Director of the Survey, E. Dudich. Among the large number of IGCP projects quite a few ones are stratigraphic or at least somewhat related to stratigraphy. From the Hungarian angle the following projects were most important: Nos. 5 and 276 (Early Palaeozoic and Precambrian), Nos. 4 and 106 (Permian and Triassic), Nos. 58, 245, 262 and 362 (Cretaceous), No. 174 (Eocene and Oligocene), No. 25 (Neogene) and No. 148 (Quantitative Stratigraphy). Particularly outstanding is No 25 (Stratigraphic Correlation Tethys–Paratethys Neogene), in which Hungary was represented first by T. Báldi, and later by G. Hámor. In the series dealing with the description of stratotypes the Pannonian volume was edited by the Hungarian Academy of Sciences. As far as the Neogene stratotypes are concerned that of the Egerian stage is found in Hungary. Project No. 262 (Tethyan Cretaceous Correlation) was the first one with a coleader from the Survey (G. Császár). It supported the work of the Tethys Working Group of IUGS, also financially, in dealing with the correlation of pelagic, shelf (carbonate platform and clastic)-type and terrestrial deposits. Hungarian scientists, mainly of the Survey, were very active in the projects related to the Palaeozoic and to the problem of the Permian/Triassic boundary.

SITUATION OF THE BRANCHES OF STRATIGRAPHY IN HUNGARY

Lithostratigraphy

According to the principles of stratigraphy, lithostratigraphy is expected to define natural units of the Earth's crust in terms of lithology. The basic unit is the formation: the rock sequences have to be divided entirely into formations. The Survey has undertaken this work officially to be done upon uniform principles. Some traditional names such as "Kiscell Clay" and "Schichten von Zirc" have also been adopted as official and normative denominations. At the same time, numerous new names have been introduced as originating from the respective type localities of the formations. The intensive work has resulted in the preparation of a chart showing Hungary's lithostratigraphic formations, published by the Survey (Császár&Haas, eds. 1983). It demonstrates the facial and palaeoenvironmental characteristics of the formations distinguished and denominated till the day, according to a grouping of systems, from the Triassic up to the Quaternary, illustrated by raster and colours. Due to uncertainties related to the classification of the Palaeozoic and Precambrian terraines, the units are represented by their names only and according to their approximate age. The chart contains in total 286 units of formation rank, 1 unit without a standard name, moreover 5 bare rock names and 57 units without rank put in the Palaeozoic-Precambrian block. The overall number of official and unofficial names is 292.

The Editorial Board consisted of T. Báldi, A. Barabás, G. Császár, E. Dudich, J. Fülöp, J. Haas, G. Hámor, Á. Jámbor, B. Jantsky, A. Rónai and T. Szederkényi.

By 1991 the subcommittees have produced concise descriptions of the formations and also have revised the charts. The extended and specified key enabled the editors to depict the grade and the prevailing lithological features of the metamorphic units, making thereby the Palaeozoic rocks to be of equal rank in the representation. The material intended to be printed in the form of brochure contained 61 lithostratigraphic units (50 formations, 1 formation group and 10 complexes) with English and Hungarian denominations. The pertinent short descriptions of the formations have also been given in two languages. The community of Hungarian geologists regrets that the long-expected work has remained in manuscript because of lack of funds.

Data of the 1983 chart and of that prepared for publication are compared below

Table 1

	Formation		With no rank and name	Formation group	Complex
	1983	1993	1983	1993	1993
Quaternary	41	35			
Pannonian	38	47		9	
Miocene	39	52	1		
Oligocene	10	11	2	1	
Eocene	15	18		1	
Cretaceous	28	44		1	
Jurassic	31	44		2	
Triassic	42	77		2	
Permian	21	15			
Earlier Palaeozoic	33	50	4	1	10
Total	286	393	7	17	10

In all, 357 key-and-reference geological sections have been registered in the territory of Hungary. Their study was shared by many colleagues working at universities, museums or in the industrial sector. The maintenance of exposures belonging to the key sections, however, has almost entirely been undertaken by the Geological Survey. Till 1991, the number of exposures being under some kind of protection (local, regional or national) came to 368 as shown in Table 2

Table 2

Geological system	A	B	C	D	E	F
Quaternary	35	1	14	13	7	21
Pannonian	47		34	13	2	36
Miocene	52		30	20		30
Oligocene	11	3	18	9		18
Eocene	18		16	11		16
Cretaceous	44		50	24	2	52
Jurassic	44		68	35		68
Triassic	77	2	79	42		79
Permian	15		10	3		10
Earlier Palaeozoic	50		43	23	1	43
Total	393	7	357	188	12	368

A: All formations, B: Chronostratigraphic key-section, C: Lithostratigraphic key-and-reference section, D: Formation represented by key-section, E: Exposure protected for other reason, F: All exposures to be protected

The detailed stratigraphic study of the geological key section was done parallelly with the editorial work described above. The results are contained in 266 reports stored in the National Geological Data Base. Three-page excursion guides have been printed for 169 sections.

However, only the first steps have been taken for an applied geological evaluation of the formations described. Only the hydrogeological description of the Triassic formations in the Balaton Highland has been completed.

Since many formations have no surface key section or even they have no outcrops at all, it was necessary to introduce a system of subsurface i.e. borehole key sections. Thanks to the former intensive mineral exploration activity, lots of well logs were available with precious core samples stored in sample depositories. At present core samples of 261 boreholes qualified as key sections are guarded. The short description of 236 drilled sections have been published.

Biostratigraphy

The use of the widely applied term "biostratigraphy" involves many inconsistencies given by the mixing of the terms "biozone" and "chronozone" of unclear contents. A fundamental characteristic of biostratigraphy gets recognized very slowly by the geologists. This is the principle that the existence of a biozone is strictly dependent on the presence (or absence) of the relevant fossil. Thus the boundaries of a biozone are not necessarily (and generally) formed by time horizons but they are defined by the uneven surfaces of a rock body. Any fossil group or its elements can be used to create a biozone. For marking out chronozones or standard zones the fossils of planktonic or nectonic organisms are the most suitable tools, however, many times the possibility is taken for a fact, and the biozone is represented as chronozone without checking in time and space the real conditions. Not accidentally, this deeply rooted "branch" triggers most of the debates inside the ISSC.

At least in the Mesozoic, the fossil group of **Ammonites** has been used for a long time for correlation. The significance of ammonites, nevertheless, has somewhat decreased because of the increasing role of nannofossils and microorganisms, which are more common and easier to examine, moreover sometimes they offer more favourable time range than ammonites can do. Nonetheless, the global scale is invariably based on Cephalopoda, and we, Hungarians feel quite lucky, for professor B. Géczy has founded a school in this respect. Despite the fact that these palaeontologists have not been staff members of the Survey, a living contact existed between us up to several years ago.

Cephalopods older than Triassic are rare in present-day Hungary. Some specimens, mainly orthocone nautiloids were found in North Hungary. Because of their rarity they cannot be used for designating zones. The largest number of taxa have been collected from the Permian Nagyvisnyó Limestone (14) and from the Silurian olistolite of the Strázsahegy Formation (6). Some specimens have also been found in the Carboniferous Mályinka Formation (Schréter 1974),

The importance of ammonites in the stratigraphy of the Balaton Highland has been well known for a long time. The pertinent studies made in the past century and about the beginning of this century were continued by I. Szabó, followed by A. Vörös. Vörös joined the systematic key section studies relating to the geological mapping of the Balaton Highland. In the Aszófő type locality section of the Pelsonian substage A. Vörös has divided the *Balatonites balatonicus* zone into three subzones, in accordance with Assereto's zoning, and recognized also the lower subzone of the *Paraceratites trinodosus* zone. He proposed this section as the stratotype of the Pelsonian substage. Equally important is the study and evaluation of the ammonites collected from eight sections recovering the Anisian/Ladinian boundary beds, these sections comprise the interval between the *trinodosus* and the *curionii* zones, with the inclusion of the *reitzi* zone representing the base of the Ladinian, and being divided into five horizons.

Numerous papers and a few monographs are dealing with the study, description and a many-sided stratigraphic evaluation of the ammonites collected systematically from the Jurassic sections of the Transdanubian Central Range mainly during the 60's.

From the results the significance of the monograph written on the Tata Mesozoic block by J. Fülöp can be stressed (Fülöp 1975). This is the only one to offer a comprehensive description of all the fossils, including the ammonites contained in a thin (43 m) Jurassic sequence of a quasi-continuous deposition. Upon the ammonite zones defined by specialists it has been established that despite the apparently conformable succession of beds the top of the Rhaetian stage and the lower half of the Hettangian are missing, and the Dogger zones are also incomplete. The Kimmeridgian/Berriasian interval (Pálihálás and Szentistvánhegy Limestones) excels with an incredibly rich ammonite fauna. The study of the Sinemurian/Toarcian interval, as based mainly upon the Bakony sections, was done by B. Géczy (Géczy 1972, 1974 and 1993) at the level of zone and subzone. The presence of the following zones has been recognized in the Middle Jurassic sections: all the 5 Sinemurian, 6 Pliensbachian and 4 Bajocian zones ranging from the *humphriesianum* zone to the *parkinsonii* zone, moreover 4 out of the 5 ammonite zones ranging from the *zigzag* zone up to the *raricostatum* zone (Galácz 1984). Vigh, G. (1984) has marked out genuine ammonite biozones in three Malm sections of the Transdanubian Central Range, some of which differ from the standard zones even by their names, too. On the basis of 145 taxa found in the Mogyorós-domb section at Sümeg, Vigh has established altogether 3 Middle Tithonian and 2 Upper Tithonian zones. On the basis of 112 taxa encountered in the Lókút-domb section, he has divided the Lower and Middle Tithonian into 2 subzones. Upon examining 50 taxa, he described the very condensed sequence of the Papréti-árok section to have been uncertainly divisible (Lower Tithonian: 2 zones, Middle and Upper Tithonian: one zone each). He considered 29 taxa to be sufficient to demonstrate the presence of all the three chronozone-type zones of the Berriasian stage. G. Vigh concluded that the Felsővadács breccia lying over the *bossieri* zone may belong to the to the Valanginian stage. At the same place Galácz, A. (1984) recorded the existence of two Oxfordian zones and of three Tithonian zones separated by hiatuses.

In some Malm sections of the Bakony Mts Főzy, I. (1987) recognized evidences of quasi-continous sedimentation (Pálihálás) and strongly broken deposition (Eperkéshegy at Olaszfalu) on the basis of detecting zones. He recognized several hiatuses of different importance in the Malm sections of the Gerecse Mountains, at Szél-hegy and Asszony-hegy near Tardos (Főzy 1992, unpublished report).

Upon the study of ammonites collected from the Közöskúti-árok section of Hárskút in the Bakony Mts, A. Horváth (in Knauer&Horváth 1986) has divided the Berriasian portion of the section into 3 zones and 7 subzones. The Albian age of the Bersek Marl (Gerecse) dated on the basis of nannoplanktonic floral elements was denied unambiguously by Főzy (1993, unpublished report), because the ammonites collected from the uppermost part of the Bersek Marl Formation and from the lowermost part of the Lábatlan Sandstone testify to the presence of the Lowermost Hauterivian. In contrast with the Barremian age of the youngest detrital strata of the sequence (Köszörűkőbánya Conglomerate Member of the Lábatlan Sandstone Formation), faunal evidence (ammonites) indicates an Aptian age for its underlying beds drilled by borehole Neszmély 4.

The zoning based upon a rich ammonite assemblage of the Pénzeskút Marl in the Transdanubian Central Range (Scholz 1979) has been made more accurate by Horváth (In Császár et al. 1987a), outlining three ammonite zones and two subzones situated between the Vraconian substage and the Middle Cenomanian. A specimen of *Placenticeras polyopsis* as determined by Summesberger, found in Upper Cretaceous rocks almost devoid of ammonites dates the age of the lower part of the Jákó Marl as late Santonian (in Partényi 1986).

The Hidasivölgy Marl in the Mecsek Mts that had been classified into the Hauterivian, was reassigned to the upper two zones of the Lower Valanginian and to the lower zone of the Upper Valanginian (Bujtor 1993). In the Bisse Marl and Bóly Sandstone belonging to the Villány belt the Upper Albian *inflatum* zone (with all its four subzones) and *dispar* zone, moreover the presence of the Cenomanian *mantelli* zone were recognized by the same author (1990, M.Sc. thesis).

Conodonta studies date back to the 1960's, but really important stratigraphic results first appeared from the end of the 1970's linked with the names of S. Kovács and H. Kozur. Due to the almost entire lack of graptolites and trilobites the biostratigraphic and chronostratigraphic subdivision of the Hungarian Palaeozoic has become feasible by means of conodonts as the most important fossil group thereto, however, they rival with ammonites for a distinctive role also in Triassic stratigraphy.

Up to now conodonts have been collected from the Uppony, Szendrő, Bükk and Mecsek mountains, playing an important part in the fundamental change of the stratigraphy of these regions. The first successful work in this respect was done by Kozur and Mock (1977). Kovács joined the Conodonta studies in 1979, and thereby the respective investigations have become systematic, efficient and well-balanced. Thanks to the publications of S. Kovács, made by himself or in co-authorship with Kozur, Mock or Péró, moreover to the studies of Kozur, the complicated geological-tectonic setting of the Uppony and Szendrő Paleozoic has been clarified. Accordingly, the oldest geological unit of this region is made up of the limestone-olistolite of the Strázsahegy Formation. This unit referred to, resembling the Cellone facies of the Southern Alps, belongs to the *Spathognathodus sagittus* zone of the Wenlockian stage (Silurian) according to Kovács, or to the Lower Ludlovian *Ancoradella ploeckensis* zone according to Kozur (Kozur 1984a). The presence of limestone blocks of early Devonian age in the olistostrome has also been proved by conodonts. An unbroken succession of Middle Devonian to Upper Carboniferous beds has been established in the consecutive series of thrust sheets and nappes, however mostly without any specification of zones.

The Conodonts found in the Palaeozoic of the Bükk Mts were examined by Kozur (1984a, 1985). Conodonts are less common in the rich faunal assemblage of the Mályingka Formation and the Nagyvisnyó Limestone Formation, however, in the latter a zonal guide fossil is present, i.e. *Stepanovites inflatus*.

The only conodont-bearing sequence of the Tisza tectonic unit is the Szalatnak Formation. Despite the relatively low number of conodont species and specimens contained, its stratigraphic position can be determined as belonging to the *Pterosphatodus amorphognathoides* zone representing the top of the Llandoverian stage in the Silurian (Kozur 1984e). Kozur&Mostler (1971) wrote on the first Conodonta findings in the Hungarian Triassic. Kovács, S. (1993), on the basis of his own work and upon Kozur's results, has succeeded in the setting up of a Conodonta zoning for the Anisian/Ladinian boundary sequences of the Balaton Highland area, marking out four lineage zones and one interval zone embraced by the range of four ammonite zones situated between the *trinodosus* and *curionii* zones. From the Villány Mountains, J. Bóna (1976) reported the presence of conodonts indicative of the Anisian stage.

The stratigraphic importance of **Radiolaria,** however being known long since, has tended to increase during the past one and a half decade only. The revolutionary new results achieved in the clarification of the geological and even tectonic setting of the Bükk Mountains are mostly due to radiolarian stratigraphy. Radiolarians are significant in the Mesozoic and also in the Palaezoic sequences of Hungary. Results of the up-to-date radiolarian studies were first mentioned by Kozur&Mostler (1981), with the description of numerous new species from the Triassic beds of the Balaton Highland. The latter were later assigned into the Illyrian (Felsőörs Formation of the Middle Triassic), by Kozur (1984g), on the basis of five taxa. Taking into account other biostratigraphic methods too, Dosztály (1993) has defined the Anisian/Ladinian and the Ladinian/Carnian boundaries by designating the following radiolarian zones: *Archaeosprongoprunum mesotriassicum, Oertlispongus inaequispinosus, Muelleritortis cochleata* and *Palaeosaturnalis triassicus*.

An account of the first truly successful investigations made in Hungary was written by De Wever (1984). He dated the well-stratified radiolarite of the Dalla-puszta section (Darnó-hegy, North Hungary) as being of Late Ladinian age upon the evaluation of 13 taxa, whereas he identified 6 taxa of the Mélyvölgy section as characteristic early Ladinian forms. Kozur (1984a, 1984g) in addition to describing five new species from the fossil assemblage of the radiolarite included by the black schist of the Vesszős Formation (Bükk Mts), established the presence of the *Lupherium officense* and *Yaocapsa mastoidea* subzones of the *Unuma echinatus* zone belonging to the Bajocian stage. Radiolarites of the Szentistvánhegy Formation belonging to the "parautochtonous" Triassic sequence of the Bükk Mts have been assigned to the Ladinian stage, whereas the Bányahegy Radiolarite has to be assigned to the Callovian-Oxfordian (Dosztály in Csontos et al. 1991). He found radiolarites in the olistostromes of the nappes situated in the vicinity of Szarvaskő-Mónosbél.

Following Kozur's generalizing studies, Dosztály (in an unpublished report) separates three radiolarian zones in the Aggtelek-Rudabánya Mountains stating that a deep-sea sedimentation must have taken place there from the end of Liassic time (*Laxtorum jurassicum* zone) till the end of the Dogger (*Tricolocapsa plicarum* and *T. conexa* zones).

Borehole section Tornakápolna 3 testifies to a Ladinian age of the ophiolites (Kozur in Kozur&Réti, 1986).

According to Kozur and Mock (1990) the Mátyáshegy Limestone in the Buda Mts is assignable to the Norian–? Pliensbachian. However, the recent investigations carried out by Dosztály have not proved the presence of post-Norian.

From the blocks situated in the Danube's left-bank region radiolarians indicative of the Lower Jurassic (Upper Hettangian) were first described by Kozur and Mostler (in Kozur 1993). They were studied in more details by Dosztály.

Lately, Dosztály also has proved the existence of Jurassic rocks in the Middle-Transdanubian tectonic unit, since the siliceous schists drilled by borehole Iharosberény 1 contain Middle Jurassic radiolarians.

When examining the drilled section Szalatnak 4 and the Palaeozoic siliceous deposits in the areas of Nekézseny, Velence Hills and Alsóörs, Kozur (1984f, h, i) classified the 13 new *Muellerisphaerida* species, described by him, into 4 genera. These species are of uncertain taxonomic position but they are possibly assigned to the Radiolaria. Upon them, Kozur ranged the Szalatnak and Lovas shales into the Wenlockian stage of the Silurian and into the Devonian, respectively, whereas he assigned the Tapolcsány Formation to the Lower Devonian.

One of the stratigraphically most important fossil groups is that of the **planktonic Foraminifera**, being most significant from the top of the Lower Cretaceous up to the basal Miocene. In the latest years Á. Görög commenced the recovery of planktonic foraminifers from Jurassic deposits, but the stratigraphic significance of the new species she described is not known yet. In Hungary, M. Sidó was first before anyone to use planktonic foraminifers for the stratigraphic subdivision of Cretaceous sequences. In her summarizing study (Sidó 1973) she makes a threefold division in the lineage of the Cretaceous planktonic Foraminifera: (a) Valanginian to Middle Albian, (b) Late Albian to Turonian and (c) Turonian-Senonian. The first smaller planktonic foraminifers appeared in the Barremian stage. *Ticinella* and *Globigerinelloides* are linked with the Aptian and Albian stages. *Globigerinelloides blowi* and *G. algerianus* are zonal guide fossils of the Lower and Upper Albian, respectively. Sidó refined the above-described division after studying the borehole section Sümeg Süt-17. Accordingly, of the Barremian/Aptian boundary zone, the presence of the *Globigerinelloides typicus* zone is characteristic, whereas in the Aptian the *Globigerinelloides blowi–Hedbergella aptiana* and the *Globigerinelloides algerianus* zones can be distinguished (Sidó in Haas et al. 1984b). At the top horizon of the Aptian succession a "ticinella-bearing association" is present (Sidó 1975). In the Middle Albian, zonal guide fossils are *Schackoina* sp. *Hedbergella* div. sp. and *Praeglobotruncana stephani.*

In the upper Albian substage the *Planomalina buxtorfi–Rotalipora appenninica* zone, and in the Lower Cenomanian substage the *Globigerinelloides aeglefordenis–Rotalipora* cf. *greenhornensis* and *Rotalipora greenhornensis–Rotalipora cushmani* zones have been established by Sidó, M. for the Transdanubian Central Range. In the Vékény Marl of the Mecsek Mts *Rotalipora montsalvensis* and *Praeglobotruncana stephani* zonal guide fossils are present in Cenomanian beds, younger than the former ones. Planktonic forms of a rich fauna collected from borehole Kerekegyháza 5, *Praeglobotruncana renzi, Praeglobotruncana helvetica* and *Globotruncana lapparenti* are zonal indices. Later the author modified her former opinion (Sidó 1983) saying that taking into account the zonal division accepted at the International Plankton Conference of 1975, *Globotruncana concavata, G. calcarata, G. conica* and *G. mayaroensis* range zones, moreover the Globotruncana globigerinoides–*G. marginata, G. arca–G. elevata, G. stuartiformis–G. calciformis–G. subspinosa* and *G. stuarti–G. conica,* furthermore *G. contusa–G. mayaroensis* cenozones can be distinguished inside the Upper Cretaceous sedimentary cycle of the Transdanubian Central Range. According to M. Sidó, the above-mentioned zones should embrace the Santonian and Maastrichtian stages. Bodnár, E. (in print) has a different position, suggesting that a *Globotruncana elevata* partial-range zone and a *Globotruncanita calcarata* lineage zone should be indicative of Santonian-Late Campanian age.

To Sidó's Cretaceous stratigraphy based upon planktonic oraminifers I. Bodrogi had something to add by describing new species and identifying more zones. Bodrogi states that *Hedbergella sigali* and its connective forms are indicative of an Early Barremian age, whereas *Globigerina hauterivica* and the associated planktonic assamblage show the presence of the Upper Barremian in the sections drilled by boreholes Tatabánya 1472 and 1486. In the borehole section Neszmély 4, the presence of species belonging to the *Hedbergella trocoidea* and the *Ticinella bejauensis–Hedbergella planispira* zones confirms a Late Aptian age in accordance with the evidence of ammonites. Bodrogi assigns the occurrences of the Tata Limestone Formation (Tata basin) to the *Ticinella bejauensis* zone and the Lower Albian Vértessomló Siltstone (Agostyán) to the *Ticinella primula* zone. Bodrogi has modified the planktonic-foraminiferal zoning of the Pénzeskút Marl Formation as follows: Upper Albian: *Rotalipora appenninica* interval zone with the *R. appenninica–Guembelitria cenomana* and the *R. ticinensis–Planomalina buxtorfi* partial-range zones contained therein, Lower Cenomanian: *Rotalipora brotzeni* interval zone. She applies the same subdivision to the Bisse and Bóly Formations of the Villány belt, adding that in the latter area the presence of the deeper-situated *Rotalipora ticinensis* interval zone has also been proved. Bodrogi considers the *Rotalipora reicheli* interval zone drilled at Szigetvár to have been formed in the Middle Cenomanian.

She determined more precisely also the age of the Vékény Marl (Mecsek Mts) upon the upper part of *Whiteinella archeocretacea* zone and the recognition of the lower part of the *Helvetoglobotruncana helvetica* zone (Early and Middle Turonian), thus restricting it to the Lower and Middle Turonian (Balla&Bodrogi 1993).

As regards the Eocene, the planktonic-foraminiferal zoning of the Dorog basin made by Vitális-Zilahy (Vitálisné Zilahy 1968) has not stood the test of time, rather better the division made by Toumarkine (1971), for the Bakony Mountains. The zoning of Samuel (1972), also relating to the Bakony Mts, makes all ages a bit younger, and the pertinent zone names are also mostly different. Horváthné Kollányi (1983b) states the presence of the following Middle and Upper Eocene zones of Bolli's in the borehole section Bakonyszentkirály Bszk 3 (Northern Bakony): *Globorotalia lehneri, Orbulinoides beckmanni, Truncorotaloides rohri* and *Globigerinatheka semiinvoluta*. The section in concern shows transitional features between the sequences of the Bakony Mts and Dorog Basin. Probably it can be attributed to this fact that the zoning of the concerned area is simpler than that of Toumarkine's which has been extended to the entire Bakony Mts, however, it seems to be applicable to the Transdanubian Central Range as a whole. To the zoning of the Dorog basin an Upper Eocene *Globorotalia cerroazulensies* zone of Bolli's should be added (Horváthné Kollányi 1983a). Likely but less surely, the Middle Eocene *Globigerinatheka subconglobata subconglobata* zone is to be inserted in the zoning of the S Bakony Mts (in Bernhardt et al. 1988). Samuel (1972) has indicated the presence of the *Globigerina angustiumbilicata* zone in the Upper Eocene of the Bakony Mts and Sztrákos (1974), that of the *Globorotalia increbescens* zone in the Buda Marl. With Horváth-Kollányi, Sztrákos showed the presence of the *Globigerina postcretacea* zone in the beds ranging also into the Tard Clay.

According to Nagyné Gellai (1983), neither of the two zonings (Majzon's and Bolli's) may be applied to the Hungarian Palaeogene. On account of the frequency and practical applicability of the species to be used as statigraphic tool, and also upon her experiences gained in the Budapest region, Nagyné Gellai suggests to use the *Globigerina liverovskae–Chiloguembelina zone* instead of *Globigerina postcretacea* and to introduce the "*Globigerina praebulloides* group of form" for the Middle Oligocene. She is aware, however, of the fact that this would not take us far towards the international correlation.

Koreczné Laky (1983) established planktonic foraminifers belonging to the genera *Globigerina, Globigerinoides, Globoquadrina* and *Orbulina* are present in four horizons of the Miocene (upper part of Eggenburgian, top of Ottnangian, top of Karpathian and basal Badenian) of various regions (first of all North Hungary, moreover the Mecsek Mts and the Transdanubian Central Range), without making any zonal subdivision. For stratigraphic classification, Korecz-Laky thinks the above-mentioned fossils and the benthonic forms to be of equal importance, enlisting also the former into her faunal assamblages. Summing up what has been deduced from their work done in the Börzsöny Mountains, Koreczné Laky and Nagyné Gellai (1985) correlate three planktonic assamblages considered as zonal markers and present in various stages (Kiscell stage 2, Egerian 2, Karpatian 1 and Lower Badenian 3) with the individual horizons marked by benthonic assemblages, thereby enabling us to make a much more detailed division. With reference to Koreczné Laky, G. Hámor (1985b) distinguishes the following horizons of Blow's "foraminiferal zoning": N 5, lower part of Eggenburgian, N 7, 8, lower and middle part of the Karpatian, N 8, 9, base of the Badenian, N 12 top of the Badenian and N 13, 14 top of the Sarmatian. No other stratigraphers of the Survey used Blow's zoning, contrary to Horváth (In Báldi et al. 1984) who has indicated the presence of zones P 16 to P 20 in the Eocene/Oligocene boundary interval.

Planktonic Crinoidea are considered a promising fossil group in terms of stratigraphy, the knowledge of which, however, is not uniform. The presence of *Saccocoma* called also *Lombardia* in the Kimmeridgian to Lower Tithonian is well-known as being at places microcrinoids (*Roveacrinidae*) displaying similar characteristics are scarcely known in Hungary. Oravecz-Scheffer (1979) has described six species from the pelitic Triassic of the Transdanubian Central Range, from among some forms are indicative of the Cordevolian substage. Their detailed study might yield important results.

Benthonic Foraminifera play a varied role in the stratigraphic classification in Hungary and also internationally – a role which has remained a little subordinate as compared to that they might deserve. Just as the benthonic organisms in general, foraminifers are used for stratigraphic zoning only when no planktonic or semiplanktonic forms are present. However, benthonic and planktonic organisms may have short or long time-ranges. Among benthonic foraminifers, larger foraminifers are credited with a great importance, but they have to be submitted to a thorough examination requiring special techniques too, which may go beyond the limits of the traditional study methods.

The earliest virulence of the foraminifers is attested to by the fossils of the Carboniferous Mályinka Formation. Here smaller foraminifers are poor in species, whereas larger foraminifers (*Fusulinidae*) occur with a large number of species and specimens. Among the latter, a great many zonal indices can be found. Their study, together with that of the microfauna included in the Upper Permian Nagyvisnyó Formation is linked with the names of A. Bérczi-Makk and E. Tardi-Filácz. The last-mentioned formation contains 44 foraminiferal taxa including numerous age-marker *Fusulinidae* (in Fülöp 1994).

Inasmuch as other fossils are rather scarce, foraminifers are of importance in the Triassic stratigraphy in spite of their small number in species and specimens. Consequently, their use in making a widely applicable zoning is not an easy task. The Triassic sequences of the Transdanubian Central Range have been studied most thoroughly. In the monograph of Oravecz-Scheffer (1987) different approaches are offered. Oravecz-Scheffer differentiates zones as follows here: cenozones or assemblage zones (*Cyclogyra?mahajeri–Rectocornuspira kalhori* cenozone lying near the base of the Triassic), acme zones (*Meandrospira pusilla* acme zone in the Csopak Marl indicating the end of the Lower Triassic and the *Triasina hantkeni* acme zone in Dachsteinkalk), uncertainly outlined i.e. variable associations (*Glomospira–Glomospirella* in the Csopak Marl) or even more uncertain associations (*Duostomina* assemblage in the Carnian Veszprém Marl). Oravecz-Scheffer takes *Turrispirillina minima* for a Norian index fossil and *Gsolbergella spiroloculiformis* for a Carnian one. Most taxa appear within wider confines showing a changing frequency therein. One should not disregard the faxt that the majority of the taxa are bound to facies.

A similar evaluation of the Triassic foraminifers of the Mecsek-Villány belt manifests itself in the works of A. Bérczi-Makk.

The number of species and speciments shows a trend of rapid increase within the Cretaceous and they become constant at a high number. The same trend can be observed for the Eocene, Oligocene and to a certain extent also for the Miocene. The works of Sidó and even more those of Bodrogi and Bérczi-Makk show that there are enough smaller foraminifers of short time-range present to mark out fine-stratigraphic zones. Nonetheless, inasmuch as there are more comfortable methods at our disposal, the use of smaller forams is still under development methodologically, in the frame work of IGCP Projects Nos. 262 and 362.

Larger foraminifers have already played an important part in the elaboration of the stratigraphic division of Cretaceous platform carbonates. Since the pioneering activities of K. Méhes in the 1960's, Á. Görög has made the greatest progress in this fiels of work by solving and section-making techniques. In her Ph. D. thesis Á. Görög gives a full overlook on the *Orbitolinae* of all geological units of Hungary. Her stratigraphic zoning is based upon that of Peybernes' zoning (Görög 1993).

The characteristic Eocene larger foraminifers *Nummulites* were used for zoning already in the past quarter of a century. In the course of decades only minor modifications have been made in the *Nummulites* zoning. Other groups (*Alveolina, Assilina*) have played a less important part in stratigraphic classification since they occur in the S Bakony Mts only (Jámborné Kness 1981). Two palaeontologists, namely T. Kecskeméti (Museum of Natural Sciences) and M. Jámbor-Kness (Geological Survey) were provided with work by coal and bauxite exploration companies.

A group of larger Foraminifera, **Orthophragminae** starting from the Eocene and coming into full development in the Oligocene, has been described monographically by Less (1987). Less has elaborated a method of stratigraphic zoning based upon mathematical statistics derived from the model of linear size growing. Besides that it has become a widely used practice of designating foraminiferal assemblages in the Oligocene (Nagyné Gellai 1973, 1985) and mainly in the Miocene (Koreczné Laky 1985), with stratigraphic interpretations involved. The individual assemblages are, however, largely indicative of palaeoenvironment, therefore they are most suitable for detecting facies differences. At present Neogene foraminiferal studies are continued by É. Szegő who intends to outline Grill's cenozones to be applied in stratigraphic classification.

Ostracoda as a group of organisms enduring changes in salinity are important owing to their particularities displayed by them in the course of Earth's history. Species and even genera of the Ostracoda are used as salinity indicator but, in some cases, they have turned out to be excellent tool in the hands of stratigraphers. In the Carboniferous of the Bükk Mountains (Mályinka Formation) a considerable number of ostracods taxa have been found, but from a stratigraphic point of view they are still less significant. In this respect, they reach the significance of conodonts in the Permian only. In the Szentlélek Formation only the presence of ostracods enabled Kozur (in Fülöp 1994) to assign it into the Middle Permian. Here Kozur enlisted 176 Ostracoda taxa in all with 132 ones therefrom described by him. Thereupon Kozur set up a zoning for the Middle and Upper Permian composed of 5 cenozones and 3 unqualified zones.

Ostracods are present in the Cenozoic with changing abundance never again reaching their level of significance experienced for Permian beds. From the Triassic Kozur and Kristan-Tollmann, from the Createaceous and Palaeogene Monostory published relevant data, in each with stratigraphic evaluation.

The part played by **benthonic Mollusca** in stratigraphic correlation is subordinate. In the past quarter of a century some monographs were issued, nonetheless the faunae rarely were stratigraphically evaluated, they mostly offer only habitual faunal interpretations. However, the potential role of the molluscs is by far not exploited regarding, first of all, the study of reef environments.

The first **bivalves** of stratigraphic importance are those of the Lower Triassic of the Balaton Highland, which has been subdivided on the basis of lamellibranchs into three zones (*Claraia, Eumorphotis* and *Costatoria*) with two subzones in the middle zone (Broglio Loriga et al. 1990). Bivalves, however, have come to real importance in the Upper Triassic by means of *Megalodus*. Data of the former study and description of *Megalodus* have recently been revised and reinterpreted in a treatise by E. Végh-Neubrandt (1982). A traditional stratigraphic interpretation of the molluscs in the Middle and Upper Cretaceous carbonate platforms of the Transdanubian Central Range has been given by L. Czabalay (1982). The same is true for the monograph dealing with the Nagyharsány Limestone of Villány (Czabalay in print). Similar judgement may be made on the monographic description of Eocene molluscan fauna (Kecskemétiné Körmendy 1972). As for the Oligocene and Miocene biostratigraphic zoning upon molluscs, the first proposal made in this respect is linked with the name of T. Báldi (1975). As based upon Pectinidae, the above mentioned biozoning was later revised by Báldi, in co-operation with M. Bohn-Havas et al. (1987). In their work they have distinguished five cenozones between the Egerian and the Badenian, with two subzones in each of the upper zones.

The zoning of the Pannonian stage has been made on the basis of molluscan faunas since the very beginning. According to data obtained from the detailed examination of core samples taken from boreholes set in the north-western foreland of the Transdanubian Central Range by Korpásné Hódi (1983), the *Congeria czjzeki–Paradacna abichi* and the *Dreissena auricularis--Melanopsis pygmea* cenozones, as well as the transitional *Paradachna abichi–Dreissena auricularis* interval zone situates between them are interpreted as ecozones. Thus they show changes with the progress in space of the deltaic system, consequently the individual zones (horizons) cannot be considered as time horizons at all. To a lesser extent, the same applies to the eight palaeo-associations found by Korpás-Hódi. Her statements by and large, go well also with the respective conditions observed in the Danube-Tisza Interfluve. Due to her studies, ecostratighraphy has been introduced also in Hungary as a special kind of biostratigraphy suited for the detection of palaeoenvironmental conditions and their changes. Müller and Magyar (1992a, 1992b, Pogácsás et al. 1993) studied changes of evolutionary lineages of Pannonian and Pontian molluscs in time. They demonstrated that within each facies the evolution of benthic molluscs is of chronostratigarphic significance. On this basis different biozone systems were proposed for different ecological settings. With the use of molluscan fossils, Krolopp (1983a, b) divided the Pleistocene succession into 5 Oppel-zones and 8 subzones.

Brachiopoda are of varying importance as regards their role in stratigraphy. They may be common in some horizons, yet they are neglected because of the presence of other more useful fossils. An exception is made for the Szabadbattyán Limestone assigned to the Upper Viséan and Lower Namurian substages on the basis of *Gigantoproductus* sp. found therein (Detre 1971b). The Carboniferous Mályinka Formation (not subdivided into biozones) and the Upper Permian Nagyvisnyó Limestone contain a brachiopodal assemblages of stratigraphic significance, which are rich in species and also in specimens (in Fülöp 1994).

The latest studies and evaluations on Triassic brachiopods are due to Pálfy, J. (1992). From the Pelsonian substage he mentions two index fossils (1986). Near Gánt, at the largest place of occurrence of brachiopods in the Mediterranean Triassic, Detre (in Gyalog et al. 1993) has distinguished the presence of the Cordevolian, Julian and Tuvalian substages, without mentioning any zone. On the basis of brachiopods, Detre has determined Carnian age at other places, too. Also stratigraphically, brachiopods are the most important components in the fauna of some Liassic crinoidal limestones in the Transdanubian Central Range. The study and evaluation of branchiopodal faunae have been done by Vörös (1993). Vörös has contrived to make described Carixian and Domerian substages only, with two and one brachiopodal zones respectively. Otherwise he has made a stage-level classification upon brachiopods but without zonal distinctions.

In Hungary, **corals** have been used for age determination only exceptionally. *Hexaphyllia mirabilis* indicates the presence of an Upper Viséan (? Lower Namurian) *Dibunophyllum* biozone in the Szabadbattyán Limestone (Mihály 1973).

Vertebrata biostratigraphy has been most completely developed for the Neogene sequences. For the Badenian/Lower Pliocene interval Kordos (1987b) distinguished the following zones: *Megacricetodon* zone, *Democricetodon Deperetomys–Hipparion* FAD zone, *Neocrietodon schaubi–Anomalomys gaillardi* zone, *Neocrietodon fahlbuschi–Allospalax petteri* zone, *Karstocricetus–Anomalospalax tardosi* zone, *Cricetus kormosi–Anomalospalax viretschaubi* zone and *Kowalskia* zone. On the basis of the succession of *Arvicolidae* (voles), for the first time Kordos described 3 biozones with various subzones to be present in a sequence formed from the Rissian-Würmian interglacial up to recent times. Later (Kordos, in print) modified his earlier zoning. He stated that the sedimentary sequences developed from the base of tthe Middle Miocene up to the Holocene can be divided into 7 range zones, 6 partial-range zones and 6 cenozones.

Calpionellidae are of overriding importance as being instrumental in the stratigraphic subdivision of the sediments deposited, however, by a short episode of the Earth's evolution history. As for their study, the pertinent results have been shared by Hungarian specialists to such an extent that it has turned out to be acknowledged also internationally. In their work Knauer (1986) and T. Lénárd dealt with Calpionellidae found in the sections of the Bakony Mountains, whereas I. Nagy scrutinized their occurrence in the Mecsek Mountains. Tardi-Filácz (1986) was also engaged in this work. Many zones and subzones were spotted and named even if being at places as thick as a centimetre or decimetre only. Their work was acknowledged at a meeting of the International Jurassic/Cretaceous Boundary Workshop held at Sümeg, when participants agreed upon the modification of the respective stratigraphic boundary. Upon the so-called Sümeg convention the Jurassic/Cretaceous boundary has been lowered to the base of the *jacobigrandis* zone. Observing the finest changes in the *Calpionella* lineage, Nagy, I. (1986) has formed new opinion of the species concept and described 2 new genera with 27 new species to be added to the already existing 17 ones. He also made a proposal for complementing the traditional 9 zones and subzones with 22 regional zones envisaging thereby the possibility of a most precise stratigraphic division never seen before. Unfortunately, his endeavours to apply in effect the new subdivision upon species and zones even improved have been rendered abortive because of his unexpected illness. Followers may hardly be expectable to join in, since his method requires exceptional personal ability and devotion.

A repetition of forms is represented by the group of **Colomiella** of minor importance. Of them, five taxa have been recognized in Hungary (Nagy, I. 1987, unpublished report).

Cadosinae, which are in size between the microplanktonic and nannoplanktonic forms, have not been used for zone-marking but for stratigraphic assignment from the Middle Jurassic to the Lower Cretaceous of our pelagic deposits (Nagy, Knauer and Tardi-Filácz). **Calcisphaerulidae** are likewise important in the Middle and Upper Cretaceous (Knauer 1970, Knauer&Gellai 1978).

Just as the remains of animal life, plant fossils are divided into different groups of unlike stratigraphic importance. Here also the role played by marine forms has to be stressed. **Nannoplanktonic** remains started to have come into the limelight during the past decades to occupy one of the key positions in making stratigraphic correlation within the Tertiary sequences. They have been used to a lesser but increasing extent in the Mesozoic, too. In dealing with the Cretaceous, nannoplanktonic organisms and other means of zoning are of equal rank, whereas in the Jurassic they are much behind other fossil groups.

In the Triassic, nannofossils are so scarce that they are negligible. As for the attention paid to the study of nannoplanktonic forms, it may be mentioned that for some time six researchers were engaged in this work. Almost each of them was in contact with the Survey. Jurassic deposits were not studied in this respect. The Cretaceous studies of Báldi-Beke made about the beginning of the 1960's were followed by some occasional examinations done by J. Bóna and M. Gál. Results worth of mentioning started to have issued from the end of the 1980's. Félegyházy and Nagymarosy (unpublished report) studied the poor nannoplankton of the marl quarry at Bersek-hegy (*Rhagodiscus angustus, Gartnerago preobliqum* and *Eiffellitus turriseffelii*) testifying to an Albian age of the Lábatlan Sandstone. Báldi-Beke (in Sztanó&Báldi-Beke 1992) considered the conglomerate of Köszörűkőbánya near Lábatlan to have been deposited in early Albian time upon examining surface samples. Then a borehole set at the quarry yard drilled a sequence from the upper part of which fossil identical with those of the Bersek marl quarry were collected and identified. Thereupon the concerned horizon was assigned to the Upper Albian by Félegyházy and Nagymarosy. With the results of the ammonite studies taken also into account, the age problem of the Gerecse Formation Group cannot be decided as settled.

According to Félegyházy (1991, unpublished report) the Vértessomló Siltstone drilled by borehole Vértessomló Vst 8 can be assigned into the Lower Albian without zonal subdivision, whereas the Pénzeskút Marl Formation, in its stratotype borehole section also drilled can be divided into the *Eifellithus turriseiffelii* and *Microrhabdulus decoratus* zones. Félegyházy (1985) recognized three nannoplanktonic zones in the Upper Cretaceous Jákó Marl and Polány Marl Formations (three boreholes). Thereupon he considered the marine sediments to have been deposited in Middle Santonian and Early Campanian times.

The first nannoplankton studies of the Hungarian Palaeogene, linked with the name of M. Báldiné Beke, are dated back to the end of the 50's. Báldi-Beke's first independent publications were followed by numerous papers written mostly together with A. Nagymarosy. Her stratigraphic results of studying the Transdanubian Paleogene were summarized in 1984 in a monograph. In this work Báldiné Beke distinguished 12 zones ranging from the Cuisian NP 13 *Discoaster lodoensis* zone to the NN 1 *Triquetrorhabdulus carinatus* zone, with taking zones 19 and 20, moreover zones 21 and 22 combined, stressing thereby the uncertainty of the existence of the lower zone and so that of the Lower Eocene. In the numbering of zones she followed Martini's system. Báldi-Beke also touched upon the biostratigraphic significance of a local zone marked by *Reticulofenestra tokodensis.*

Nagymarosy&Báldi-Beke (1988) wrote also on the individual Palaeogene zones putting them into the light of the standard nannoplanktonic zoning. In borehole section Somlóvásárhely 1, subjected to an integrated stratigraphic interpretation, they identified N 14 as the lowermost zone (Middle Eocene). As with the Transdanubian sequences, from the sediments deposited in the "flysch" trough of the Great Hungarian Plain they also found Middle Eocene beds to be the oldest in the Tertiary succession (Báldiné Beke et al. 1980c).

The studies dealing with the Neogene nannoplankton were also initiated by Báldi-Beke who was publishing her results with minor breaks from the beginning of the 1960's on. She published integrated work results mostly in common with Nagymarosy (1988, 1991 and 1993). They proved the presence of zone NN 1 situated above NP 25 in the stratotype section of the Egerian stage. They also reported on the presence of all nannoplanktonic zones ranging from the Eggenburgian through the Badenian stages, including that passing into the Sarmatian. As with the Palaeogene, all the Miocene formations with the pertinent zones have been described in detail. It turned out that the impoverishment of nannoflora observable in a part of zone NN 7 having been assigned to the Sarmatian was concomitant with a local, horizon-like enrichment of a single species. Nagymarosy considered (in Nagy et al. 1982) this phenomenon as a basis for correlation within the Carpathian Basin. In their opinion the Börzsöny mountains volcanism must have taken place in early Badenian time, in the time of formation of zone NN 5 (within 1 Ma).

Palynology has belonged to the store of means of stratigraphy for several decades as having been confronted solely with the task of dating non-marine deposits. The situation, however, has improved owing to an interrelation established between palynozoning and other methods to deal with sediments deposited not too far from the coastline. This has allowed comparisons with the zones set up on the basis of other fossils. In the past quarter of a century geologists paid much greater attention to the examination of sporomorphs, mainly in the case of younger Mesozoic and Tertiary rocks, the study of which was well-established by excellent forerunners. Contrary to the study of nannoplankton, the Geological Survey has turned out to be a "citadel" to palynology as far as the number of researchers engaged therein by concerned. From the investigations related to the Carboniferous, those of Góczán (1971) should be pointed out for their importance. He studied also the organic microfossils of other non-metamorphic Paleozoic pelitic rocks and those of the Mesozoic ones. He drew the P/T boundary together with Á. Stuhl who was studying mainly the non-marine Permian beds, on the basis of the presence or absence of certain taxa. For the uppermost Permian, Góczán has recently prepared a palynozoning with four components (unpublished report). For the Triassic sequences, Góczán has also coped with the task of creating an even formally regular palynological zoning (Góczán et al. 1983, Broglio Loriga et al. 1990). For the Alcsútdoboz, Hidegkút, Arács, Csopak and Aszófő Formations drilled by boreholes Köveskál 9 and Alcsútdoboz 2, he distinguished 2 Oppel-zones, 8 cenozones and 10 dominance zones, and described some new genera and species (In Haas et al. 1986, 1988b). Examinations of similar detail were related to the Middle Triassic pelitic rocks (Felsőörs and Buchenstein Formations) and to the Upper Triassic (Füred Limestone, Veszprém Marl and Kössen Formations), too (Góczán et al. 1983 and 1991). Nevertheless, he created palynozones only in 1983: *Aratriporites–Saturnisporites*, *Densoisporites karnicus–Infernopollenites hévízi* and *Patinasporites densus–Enzonalasporites tenuis* as dominance zones. In this latest works Góczán laid the foundations of future zone-making through the description of new species and separate associations with their assignment to the stratigraphic scale on the basis of clearing up dominance conditions (1993). The playnological study of the Triassic-Jurassic deposits in the Mecsek Mts was carried out by J. Bóna. When scrutinizing the relatively rich sporomorph assemblages of the Kantavár Limestone, Karolinavölgy Sandstone and of the Mecsek Coal Measures Formations, which are different from the assemblage found in the Transdanubian Central Range, Bóna made some age determinations but without setting up zones.

On account of the multivariate and rapid changes observed in the Cretaceous System, this stratigraphic unit has been in the centre of interest since the beginning of the palynological studies in Hungary. Before the new stratigraphic views became generally accepted, the first palynozones had already been marked out. Palynozones ranging from "A" to "H" were set up by Góczán (1964) when examining the sedimentary cycle of the Transdanubian Central Range. Taxon-names were given to the zones in 1973. A further subdivision of the zones was made by Siegl-Farkas (1983, 1991a) who distinguished eight dominance subzones. Thereby she was able to correlate different Upper Cretaceous facies (1993a) contributing also to the more accurate determination of the age of bauxite deposits (1991b).

Of great importance was the recognition of angiosperm pollens in the Middle Cretaceous (Juhász&Góczán, 1976). Juhász joined the study of the 1970's, and divided the Lower Cretaceous of the Transdanubian Central Range into two palynozones without giving types, and marked out six Oppel-zones in the Middle Cretaceous (Juhász 1979, 1983), representing the respective formations by floral associations, and cheking the authenticy of zones by examinations made in the neighbouring countries.

The remarkably rich assemblage of palynomorphs of the Palaeogene was studied by Rákosi (1973, Rákosi&Tóth 1980), with the separation of various associations therein. He made reference to Hochuli's zonal division, without, however, applying it in practice. Rákosi's Eocene associations represent types passing from continental to open marine environments. The biozones set up by him (6 cenozones and 10 sub-cenozones) almost without exception can be identified with the above-mentioned types of environment. This means that instead of time correlation they can be used for facies correlation. Accordingly this zoning reflects changes brought about by facial changes: in the Transdanubian Central Range e.g. in the SW Central Range identical zones got to be assigned partly to the Middle Eocene while partly to the Lower Eocene in the NE Central Range.

E. Nagy has been continually engaged in palynological studies starting from the late fifties. However, she started making stratigraphic evaluations in addition to palaeoenvironmental and palaeoclimatological ones in the past decade only (1992b). She established a zoning of the interval between the Egerian and Sarmatian stages composed of 1 main zone, 6 Oppel-zones, 2 range zones, 1 acme zone and 2 subzones. E. Bodor, though she participated in the palynological study of the Neogene, displayed stratigraphic interpretation only when joining the Lake Balaton research programme and distinguishing 10 ecozones (from A to I) contained in 6 vegetation zones of the Holocene (in Cserny et al. 1991).

Microorganisms of organic test generalized under the name **Dinoflagellata** were already known in the previous quarter of a century, however palaeontologists mentioned or described them only occasionally till the end of the 1970's (Góczán 1971, Rákosi 1973). Acritarchs, occuring mostly in the Paleozoic only, aroused the paleontologists' interest even later. As early in 1971 Góczán recorded *Hystrichosphaerida* and *Micrhystridium* fragments from the paleozoic Szalatnak Formation. A revision organized by Lelkes-Felvári resulted in the finding of 14 taxa in the Kőszárhegy Shale drilled by borehole Szabadbattyán 9, as being indicative of a late Arenigian sub-age of the Ordovician (Albani et al. 1985). Within the Mesozoic, noteworthy results were achieved in the Cretaceous only. In the Pénzeskút Marl (borehole Jásd 42) 65 taxa, furthermore in some samples, taken from the Bóly Formation 28 taxa were recognized confirming a Late Albian age (Leereveld 1991). In those years some 53 Dinocysta taxa of the Vértessomló Siltstone (borehole Vst 8) were found as to be indicative of and Albian and in a part of the sequence Middle Albian age (Leereveld 1991 and 1992, unpublished report). In the above-mentioned borehole section the presence of *Tasmanitidae*, *Pterospermella* sp., and remains of *Acritarchae* were also recorded.

Rákosi (1973) determined 11 *Dinophycea* taxa, 11 *Chlorophycea* and 9 *Acritarcha* taxa from the Palaeogene of the Dorog basin, without any stratigraphic interpretation. On the basis of 43 Dinocysta examined in co-operation with French colleagues the authors excluded that the overlying beds of the coal measures complex should be older than Middle Eocene (Michoux et al. 1985). Results of the first systematic working-up of Dinoflagellata were communicated by M. Sütő-Szentai. She first subdivided the Pannonian sequence into four zones without rank, and an interval zone (1982, 1983). Sütő-Szentai later extended her division to the Sarmatian too, and put up the number of zones from four to nine (Sütő-Szentai 1988, Sütő-Szentai&Fuchs 1991). She included the greater part of the Lower Pannonian in the *Spiniferites bentori* main zone and placed the lower part of the Upper Pannonian in the *Spiniferites balcanica* main zone. Later, in an unpublished report, Sütő-Szentai slightly refined the zoning.

The oldest **calcareous algae** were found in a larger quantity in the Carboniferous and Permian rocks of the Bükk Mountains (in Fülöp 1994). Although no biostratigraphic zones have been based on the calcareous algae, the experts not exclude this possibility. Upon the study of Triassic successions in Hungary (mainly of those in the Aggtelek-Rudabánya region) and abroad, O. Piros (in print) set up six cenozones and two unqualified biozones for the middle part of the Triassic ranging between the Pelsonian and Tuvalian substages. Out of these, the *Diplopora annulatissima* zone can be taken for a chronozone as regards its content even in its present-day form. According to O. Piros, the zoning might be applied to the Triassic of the entire Transdanubian Central Range. Although no zoning for the Malm–Cretaceous succession is at our disposal just now, a high floral variability is attested to by former studies (Bodrogi, Piros, Schlagintweit etc.) upon which the elaboration of a zoning would be feasible.

Siliceous organisms such as **Diatomaceae** and **Silicoflagellata** play a much less important part in stratigraphic classification, however, they call for consideration when we deal with the Miocene sequences characterized by heavy volcanic episodes. M. Hajós is the specialist of this group, and her work has also been internationally acknowledged. She began her respetive studies in the second half of the 1950's, gradually extending the work to all the diatom-bearing formations of the country. Besides writing many papers, Hajós, M. summarized her achievements in a monograph (1986). Biozones based on diatoms and *Silicoflagellata* embrace a Miocene succession ranging from the Eggenburgian to the Sarmatian so that the biozones of the two groups can be used together and also separately. In the full denomination the units i.e. cenozones bear the name of the dominant diatom and also of the Silicoflagellata, whereas in the short form only the name of diatom makes appear. In the region proper, one of the seven zones suitable for correlation contains two subzones. Later (1987) M. Hajós marked out four diatomaceous cenozones between the Upper Sarmatian and the Pontian.

Magnetostratigraphy

The first palaeomagnetic determinations were executed on Tertiary and Lower Cretaceous volcanics by P. Márton and E. Márton-Szalay in the late sixties. In Hungary, the accelerated development of magnetostratigraphy began in the early seventies. A review of the related studies may convince us of the fact that the first measurements were done almost simultaneously at the Geophysical Department of the Eötvös Loránd University of Sciences and at the Dalhousie University of Halifax. At the university, and on behalf of M. Pécsi, it was P. Márton who made the first measaurements on different sections such as the ones drilled at the exposures of loess at the brickyards of Mende, Paks, and Hódmezővásárhely, moreover at Dunakömlőd, and on a normal geological section at Dunaföldvár (Márton 1979a, b, Márton et al. 1979). In the Paks, Dunakömlőd and Dunaföldvár sections, determinations have testified to the presence of deposits of the Brunhes period of normal polarity and of the Matuyama pediod of reversed polarity, in addition to the Jaramillo event was identified in the Dunakömlőd section.

The first substantial research programme was launched by the Geological Survey and the University of Halifax, with Cooke, Hall and Rónai (1979) in co-operation. Drill cores from the boreholes Dévaványa (1,116 m) and Vésztő (1,200 m) were involved in the determinations. The two drilled sections were successfully correlated with one another according to their palaeomagnetic properties. The following periods and events were distinguished: Brunhes normal period, Mutuyama reverse period with the Jaramillo, Olduwan events, and other normal events, the Gauss normal period; the Gilbert period and, in the experts' interpretation, the 5th and 6th periods. When making comparison with the borehole section of Jászladány, the boundary between the Pliocene (Upper "Levantian") and the Pleistocene was between 400 and 500 metres. The investigations have yielded a variety of results. As a novelty, it has been observed that in the zones of the Brunhes/Mutuyama and Mutuyama/Gauss boundaries there have been frequent and short reversals which cannot be found in the scale based upon deep-sea drillings of deposits of low sedimentation rate. Since the phenomenon has been experienced in both borehole sections, the authors mentioned above suggested that the material of deep-sea drillings should be thoroughly revised.

After a long pause, at the end of the seventies the magnetostratigraphic measures were continued in the scope of the key section programme and became extended to the Mesozoic sequences by the intervention of E. Márton-Szalay. Upon measurements made of 71 good-quality samples taken from the Pliensbachian portion of the Jurassic section of Tűzköves-árok (Bakonycsernye) dated previously by ammonites 5 and 6 horizons of normal and reversed polarity, respectively, have been clearly outlined (Márton, E. et al. 1980). At that time, however, there was no opportunity of comparing them with oceanic or continental sections. Márton (1982) examined 137 samples from the Malm–Lower Cretaceous section of Sümeg to make a joint palaeontological-palaeomagnetic interpretation of the succession in concern. Comparing the anomaly scale gained here and the oceanic anomalies as shown by Larson and Hilde (1975), similarities and also differences have become apparent. The number of the anomalies in the Sümeg section has exceeded by far that of the oceanic sections, in particular in the Berriasian part of the section, where in the oceanic scale besides M 15 anomaly merely a single reversed anomaly has been registered (in accordance with the concept of the Jurassic/Cretaceous boundary that time). In the Sümeg section M 16 and M 17 anomalies are inseparable i.e. instead of the only one normal anomaly of the oceanic scale here two short transitional anomalies do occur.

M. Lantos joined the work in cooperation with D. Elston, USGS (Elston et al. 1985). With the acquisition of a cryogenic magnetometer by the two Surveys (Geological and Geophysical), the efficiency of palaeomagnetic determinations has increased considerably. In the Great Hungarian Plain, borehole sections Kaskantyú 2 (1,184.8 m) and Tiszapalkonya 1 (1,987.8 m) were tested and interpreted in various respects: seismostratigraphy (Gy. Pogácsás), molluscs (M. Korpás-Hódi), ostracods (A. Korecz) and microplankton (M. Sütő-Szentai). At the same time, the magnetostratigraphic results obtained on the boreholes of Vésztő and Dévaványa, were revised (Elston et al. 1990). Accordingly, these two boreholes were completed in the approx. 4.25 Ma-old Late Pannonian beds representing the Gilbert period, whereas the strata drilled near Tiszapalkonya and Kaskantyú were found to be as old as 5.9 to 10.4 Ma (early Pannonian).

In the Transdanubian region, M. Lantos carried out measurements on the following borehole sections: Szombathely II, Iharosberény I, Berhida 3, Duka II and Torony I (Lantos et al. 1992). Besides the intercorrelation of the borehole sections, the paleomagnetic method combined with seismostratigraphy has been used as means of correlation of the Transdanubian horizons with those of the Great Hungarian Plain. It has been found that only borehole Berhida 3 has drilled a continous sequence between the Sarmatian and Pannonian stages, for which radiometric dating has yielded an age of 12.20 to 12.5 Ma. At the basin margin the lack of deposit may represent at least 2 Ma. By using more than one method, the Early Pannonian/Late Pannonian boundary has been found time-transgressive so as corresponding by and large to the age of the Pannonian/Pontain boundary (8.5 Ma).

Palaeomagnetic zones (16-19) found for the Eocene portion of borehole section Somlóvásárhely 1 (Darvastó, Szőc and Padrag Formations) are well-corresponding to those determined for the normal geological sections of the Gubbio region, Italy (Bottaccione, Contessa Highway etc.), moreover they are likewise correlatable with the zones of the deep-oceanic drill sections of the South Atlantic and with the magnetic time-scale (Bernhardt et al. 1988). The examination has confirmed the conclusion drawn from nannoplanktonic studies showing that the sedimentation must have started in Middle Eocene time.

A debate lasting for some decades has recently been concluded with the application of palaeomagnetic method regarding Upper Cretaceous successions. Beforehand, for the study of the basal formations of freshwater origin (Csehbánya and Ajka Formations) only palynological means were used. Thereupon the Late Cretaceous sedimentation was thought to have commenced at the beginning of Campanian time – a statement which was inconsistent with the chronostratigraphic scale set up on the of planktonic foraminiferal studies indicating a late Santonian age. According to the magnetostratigraphic survey the Middle to Upper Cretaceous zone of long normal polarity changed into a zone of reversed polarity when transgression began at the base of the Jákó Marl. The change coincides with the Santonian/Campanian boundary. In consequence, the deposition must have begun in Santonian time.

Radiometric dating

The use of the most reliable method of obtaining dates measured in million years for the geological units began nearly half a century ago. At first the radiometric method was mostly used for the age dating of the metamorphic rocks since no other methods were available for the accomplishment of this task. Thanks to the development of the knowledge and technics concerning radioactive processes since that time, the determinations have been made successively extended to the entire stratigraphic scale and to more and more rock varieties. From the middle of the seventies, many papers have been published furnishing data on the measurement results of increasing number being produced in ATOMKI (i.e. Research Institute for Nuclear Physics of the Hungarian Academy of Sciences), moreover in OKGT (i.e. Hungarian Oil and Gas Trust, a predecessor of MOL, Hungarian Oil Company) in co-operation with the Hungarian Geological Survey. Under the coordination practised by Á. Jámbor and G. Hámor, between 1975 and 1985 several hundred measurements on Neogene volcanics were executed, including the age determination by K-Ar method of some 250 basalt samples. The youngest volcanic rock in Hungary turned out to be the Bár Basalt, for which the K-Ar method has yielded an isochronous date of 2.17 Ma. Determinations made for Neogene rocks, considered as most important, have been summarized below (Hámor et al. 1980, Balogh, Kad. et al. 1982, Balogh, Kad.&Jámbor 1987, Balogh, Kad. et al. 1986 etc.).

Besides those shown above, many other Neogene volcanic rocks were subjected to K-Ar determination (Tengelic, Nagydorog, Paks, Sárszentmiklós, Albertirsa, Bánta-puszta, Börzsöny-Dunazúg Mts, Cserhát Mts etc.) with dates ranging from 14.3 Ma to 19.3 Ma (Hámor et al. 1987).

The K-Ar age of andesites found in the neighbourhood of Velence is 31.1 Ma i.e. early Oligocene (Darida-Tichy 1987). The radiometric date of the Budakeszi Picrite occurring here is 77 Ma (I. Horváth, oral communication).

Data bearing on the pre-Teriary igneous rocks usually show lower ages than the real ones, which is attributed to different processes of rock alteration generated not rarely by tectonic move-

Table 3

Locality	Rock	Minimum age Ma	Maximum age Ma	Isometric age Ma	Mean age Ma	Geological Age
Bár	Basalt	1.90	2.12	2.17		Early Pleistocene
Salgótarján	Basalt	2.27	3.81	2.01–2.76		Early Pleistocene to Late Pannonian
Balaton Highland -Little Plain	Basalt	2.70	5.54	2.79–4.89		Late Pannonian
SE Balaton Highland	Basalt	6.23	7.91	7.92		Early Pannonian
Danube–Tisza Interfluve	Basalt	8.13	10.4	9.61		Early Pannonian
Borsod	Andesite	9.6				Early Pannonian
Tokaj	Basalt	9.4	10.9			Early Pannonian
Tokaj	Andesite	10.6	11.5	10.4–11.3		Early Pannonian
Tokaj	Alunite	10.8	11.0	10.9		Early Pannonian
NE Great Plain	Andesite	10.0	12.1			Early Pannonian to Sarmatian
NE Great Plain	Dacite	10.4	12.1	10.5		Early Pannonian to Sarmatian
NE Great Plain	Rhyolite	11.0	11.4			Early Pannonian to Sarmatian
Galgavölgy	Rhyolite tuff	13.3	14.7		13.7	Middle Rhyolite Tuff, Badenian
Mátra	Rhyolite tuff	11.9	15.0		14.5	Middle Rhyolite Tuff, Badenian
Tar	Dacite tuff	15.0	17.8		16.4	Middle Rhyolite Tuff, Badenian
Hasznos	Andesite	17.3				Badenian
Gyulakeszi	Rhyolite tuff	17.0	22.3		19.6	Lower Rhyolite Tuff, Ottnangian
Komló	Andesite	19.1	23.5		20.5	Eggenburgian

ments. For this reason, only some samples taken from the Mecsekjánosi Basalt, only a single date of 136.5 Ma (Valanginian) derived from the biotite of two alkali gabbro samples of Billigavölgy seems to be acceptable. Dates yielded by radiometric determination on muscovite (165 Ma) and on amphibole (166 Ma) of the gabbro of Szarvaskő are indicative of a Middle Jurassic age, whereas biotite and amphibole from the gabbro of Bódvavölgy give 233 Ma and 256 Ma, respectively, indicating an Early to Middle Triassic age (Árva-Sós 1987). The average of values measured on the andesites of borehole Nagybátony 324 gives 154 Ma (Árva-Sós et al. 1988). The latter age seems to be younger than it may be in reality, however, the concerned volcanic activity may have been related oceanic rifting in the Middle Jurassic.

Utilizing the sericite fraction, the Lovas Shale and Alsóörs Porphyroid are dated at 311 to 327 Ma by Balogh, Kad. and the Balatonfőkajár Quartzphyllite at 264 Ma to 296 Ma (Dudkó&Lelkesné Felvári 1992). The Mórágy Granite is dated at 308 Ma (Sr-Rb) and at 329 Ma (K-Ar) as derived from biotite, and at 332 Ma upon muscovite. Determinations on the amphibole crystal of amphibolite schist yielded 321 Ma, whereas U-Pb method gave 365 Ma upon zircon and titanite (Balogh, Kad. et al. 1983, Árva-Sós&Balogh 1979).

Numerous attempts were made to date radiometrically the age of glauconite bearing sediments as the Kiscell Clay (Báldi et al. 1975), the Zirc Limestone and the Pénzeskút Marl (Császár 1984b). Nevertheless, these attempts were unsuccessful because of the escape of argon from the loose lattice of glauconite resulting in too young dates.

Other branches of stratigraphy

Emiliani's **climatostratigraphic system** includes 6 climate zones ranging in time from the Rissian glacial up too now. Kordos and Ringer (1991) when applying Emiliani's system to the conditions in Hungary recognized a close interrelation between the zoning based upon vole species and the climate zones.

Sequential stratigraphy, based on the global changes generated by movements taking place in the solar system, was introduced more than ten years ago. The method ran into a rapid spreading all over the world. Its successful application to the eological units of Hungary is linked with the names of young researchers: G. Tari and G. Vakarcs who were enganged in postgraduate studies under the guidance of Prof. P. Vail. To this day the method has been adopted in dealing with Tertiary, mainly Neogene units, which usually reflect third-order changes. For the cyclic sedimentation derived from orbital changes, and belonging to the scope of cycle stratigraphy, the first excellent example was elaborated by Haas (1987a, 1994) who analysed elaborated by Haas (1987a, 1994) who analysed Lofer cycles in Upper Triassic Dachsteinkalk. Haas identified the cyclic units with the Milankovic-cycles. A description of Lower Creaceous cycles in the Gerecse Mts by Fogarasi (1992, M.Sc. thesis) is of similar importance.

Seismostratigraphic studies are, naturally, undertaken by the Geophysical Exploration Company. Seismostratigraphy is a branch of discipline introduced into Hungary by Pogácsás (1985). Pogácsás started to use this method for the subdivision of the delataic Pannonian deposits. Taking into consideration the horizons outlined on seismic sections, Pogácsás has divided the Lower Pannonian unit into three subunits. The qualification of the rock bodies within the above-mentioned units has been established with the use of palaeontological and sedimentological means. The age in million years of the more or less isochronous confines of the individual units has been determined by radiometric, magnetostratigraphic and palaeontological tools. To this, the Survey also has contributed by the participation of M. Lantos and M. Korpás-Hódi.

Chronostratigraphic units of international significance

Although the fundamental chronostratigraphic units have been set up outside Hungary, it can not be said that the efforts of Hungarian experts in doing the creation reshaping or re-interpretation of such units would have been ineffectual. The chronostratigraphic unit of worldwide validity set up in Hungary is the Pelsonian substage of the Triassic Anisian stage. The subdivison based on the evolutionary features and distribution of Ammonites requires a continuously pursued level-keeping investigation. In the scope of the key section programme and in the framework of the geological mapping conducted in the Balaton Highland, and upon the study of some geological sections, A. Vörös re-difined the description of the Pelsonian substage that corresponds to the *Balatonites balatonicus* zone divided into three subzones. The results of the studies of conodonts, radiolarians, foraminifers and pollens have largely contributed to the increase of value of the Aszófő and other sections chosen for stratotype. Likewise detailed studies have secured a basis for making a proposal for the replacement in the Balaton Highland of the Anisian/Ladinian boundary stratotype. The stands taxen up in this case at the meeting convened in 1992 for this purpose have given rise to optimism.

The Pénzeskút Marl section (Bakony Mts) has been studied exhaustively (ammonites, planktonic and bentonic foraminifers, palynomorphs). The section referred to has been taken into account by the Cretaceous Subcommission of the International Stratigraphic Commission since the meeting held in 1983 in Copenhagen as a potential Albian/Cenomanian boundary stratotype. With a painstaking preparatory work aimed at the setting up of the Egerian and Kiscellian stages upon a proposal submitted by T. Báldi, the Hungarian party has contributed to the creation of a regional chronostratigraphic scale meeting the particular requirements of the Paratethys.

The results of an integrated molluscan-stratigraphic and magnetostratigraphic study of the stratotype for the Pannonian stage have been prepared for publication (Korpás-Hódi&Lantos).

To develop the stratigraphic division or "continental biochronology" of the Pannonian stage, Kretzoi (1987) has divided it into eight subunits (using a somewhat unusual terms as stage and age) as follows: Monacian, Bodvaian, Rhenohassian, Csákvárian, Sümegian, Hatvanian, Bérbaltavárian and Ruscinian. Kretzoi set up a local (country-wide) series of subdivision also for the Lower and Upper Pleistocene based invariably upon vertebrate remains (Lower Villányian, Upper Villányian, Lower Biharian and Upper Biharian), which was also used here and abroad in the past quarter of a century.

THE STATE OF THE CHRONOSTRATIGRAPHIC UNITS

The problems of the lithostratigraphic classification of the **(?) Precambrian and Palaeozoic** rocks of high-grade metamorphism have been solved as far as possible, thanks to the theses written by T. Szederkényi and Gy. Lelkes-Felvári, moreover to the revision carried out by J. Ivancsics. The geological mapping of the Velence, Szendrő and Uppony mountains and the monographic descriptions by J. Fülöp (1992, 1994) also have to be mentioned in this respect. The same statement can be applied to the Carboniferous and the Permian, with the following authors: J. Fülöp, A. Barabás, Gy. Majoros, M. Kassai and I. Szabó. For the areas covered by younger sediments the use of complexes instead of formations indicates uncertainties in classification. The subdivision of non-metamorphic or weakly metamorposed rocks has been carried out under the auspices of the Hungarian Stratigraphic Committee with the cooperation of S. Kovács beside those mentioned above.

The bio/chronostratigraphic knowledge of Hungary has progressed under the direction of J. Fülöp, and with the involvement of S. Kovács, H. Kozur and S. Mihály and many others (based on the study of conodonts, ostracods, radiolarians, holothuroides, coralline algae, foraminifers, etc.). Monographs relating to stratigraphy are as follows: Fülöp (1992, 1994), Kassai (1976), Mihály (1978a, b) and Raincsákné Kosáry (1978).

During the past quarter of a century the lithostratigraphic subdivision of the **Triassic** sequences has come, by and large, to completion owing to the following activities: geological mapping in the Bakony Mts and Balaton Highland (T. Budai, G. Csillag and L. Koloszár), moreover in the Aggtelek-Rudabánya Mts (S. Kovács) and the Bükk Mts (K. Balogh and P. Pelikán). Mapping was associated with widespread key section studies (Haas, Rálisch-Felgenhauer, Kassai and Konrád). Despite this, some modifications might be expected but only in the Bükk Mountains and in the basement of the Great Hungarian Plain. Thanks to the organizing work and personal participation of J. Haas, not only short definitions but also a full and detailed description of the lithostratigraphic units (mainly formations) have been prepared for publication.

The grade of stratigraphic knowledge of the Triassic system has attained a high level with an exception made for the basement to the Great Hungarian Plain's basin. Conodonts (S. Kovács and H. Kozur), ammonites (A. Vörös), radiolarians (L. Dosztály and H. Kozur), foraminifers (A. Oravecz-Scheffer and A. Bérczi-Makk) furthermore palynomorphs (F. Góczán) have been painstakingly scrutinized and described by the authors whose names do appear in brackets. Upon the results gained from these tudies, many units had to be re-assigned mainly in the Bükk Mts and the Aggtelek–Rudabánya Mts where even major re-classifications to the extent of age are not rare.

Monpgraphs relating to stratigraphy are as follows: Bohn (1979), Nagy, E.& Nagy, I. (1976) and Oravecz-Scheffer (1987).

The stratigraphic knowledge of the **Jurassic** system was significantly developed during the past fifteen years. Radiolarians were instrumental in the recognition of the more or less complete Jurassic succession in the Bükk Mountains. Various units had to be re-assigned in the Aggtelek-Rudabánya Mts, too. An authentic lithostratigraphic subdivision with formation definitions have been elaborated for the Jurassic sequences of the mountain regions. Some more considerable uncertainties and gaps in knowledge have been left unsolved and unfilled with respect to the basement of the Great Hungarian Plain.

There are considerable differencies in the bio- and chronostratigraphic knowledge of the Transdanubian Central Range have been studied at an up-to-date level by B. Géczy, A. Galácz, G. Vigh and I. Főzy. At the same time the rich collection of ammonites of the Mecsek Mts has not been determined and described yet. Calpionella stratigraphy is still instrumental (studies of I. Nagy, J. Knauer and E. Tardi-Filácz). Radiolarian examinations are in approach to the peak thanks to L. Dosztály, A. Barabás and H. Kozur. In the recovery and examination of planktonic foraminifers contained by different horizons of the Jurassic Á. Görög is in the forefront of the battle internationally.

Monographs relating to stratigraphy are as follows: Fülöp (1975), Galácz (1980), Géczy (1976), Haas et al. (1984b) and Vigh (1984).

The **Cretaceous** is one of the best-studied systems from the point of view of lithostratigraphy, probably with the largest number of units of lower rank than formation. In addition to the short definitions of formations for the stratigraphic chart prepared for publication and their detailed descriptions are also brought in a state of ready-to-print manuscript. Due to the intensive work, numerous units had to be re-assigned. In this respect the most important point is the re-classification of the youngest unit of the Gerecse Formation Group taken formerly for Barremian into the Upper Aptian–Lower Albian. Planktonic foraminifers (M. Sidó, I. Bodrogi and E. Bodnár), larger foraminifers (Á. Görög) and palynomorphs (Á. Siegl-Farkas) have been dealt with by the above mentioned palaeontologists in an up-to-date way enabling us to mark out biozones. Important ammonite studies were conducted by A. Horváth, L. Bujtor and I. Főzy. For the first time it was really possible to correlate the Bisse and Bóly Formations of the Villány zone with the Pénzeskút Marl in the Transdanubian Central Range. A long debate has been concluded by an integrated stratigraphic-magnetostratigraphic study of the basal beds of the Upper Cretaceous cycle allowing us to date the transgression at the Santonian/Campanian boundary.

Monographs relating to stratigraphy are here as follows: Bodrogi (1989), Császár (1986), Czabalay (1982), Haas (1979), Haas et al. cz (1984b).

Thanks to the existence of mineable mineral resources (coal, bauxite and metallic minerals), the **Eocene** epoch was in the foreground of interest also during a greater part of the last quarter of a century. Except two formations, the lithostratigraphic denomination are derived from that period due mainly to E. Dudich and B. Bernhardt in the main. A neuralgic question of the Hungarian Eocene stratigraphy has been answered by means of the following well-coordinated studies of faunal groups: nannoplankton (M. Báldi-Beke and A. Nagymarosy), planktonic foraminifers (K. Horváth-Kollányi), larger foraminifers (T. Kecskeméti and M. Jámbor-Kness), complemented with magnetostratigraphic survey (M. Lantos). Accordingly, it has been proved that the sedimentation in the present-day Transdanubian Central Range region must have commenced only as late as in the Middle Eocene and the transgression must have progressed from the south-west towards the north-east. The revised lithostratigraphic table already reflects this satement. In the same period the presence of continental Upper Eocene beds has been proved in the transdanubian portion of the Tisza tectonic unit. Nannoplankton studies have established the fact that from the Upper Cretaceous to Eocene sequence of the Szolnok flysch-trough, formerly considered as being of continuous deposition, the entire Paleogene is missing. The situation of nannoplanktonic, planktonic-foraminiferal and nummulitid zoning is reassuring. However, no summarizing descriptions have been produced except for the nannoplankton.

Monographs relating to stratigraphy are here as follows: Báldiné Beke (1984), Jámborné Kness (1981 and 1988), Kecskemétiné Körmendy (1972, 1980 and 1990), Kopek (1980), Less (1987) and Rákosi (1973).

Most classic lithostratigraphic names have been given to the units of the **Oligocene** system. The lithostratigraphic study of the Oligocene and the necessary denomination linked mainly with the names of T. Báldi and L. Korpás.

The most successful biostratigraphic activites have been displayed under the direction of T. Báldi in the Buda region and in North Hungary. The work has resulted in the elaboration and acceptance of the Egerian and Kiscellian as regional chronostratigraphic stages. In this work the role of the studies regarding the names of litostratigraphic units nannoplanktonic and foraminiferal stratigraphy has to be stressed. An unsolved problem is the age of the fluvial Csatka Formation.

Monographs relating to stratigraphy are as follows: Báldi (1973), Korpás (1981).

The **Miocene** is one of the chronostratigraphic units where, prior to the declaration of international stratigraphic directives, names were borrowed from paleontology or were amalgamated name combinations. A part of the regular names used in areas adjacent to Slovakia have been agreed upon in the framework of the Committe on the Mediterranean Neogene. The creation of the units is due to G. Hámor, T. Báldi, á. Jámbor, and J. Halmai. The setting up of the regional chronostratigraphic scale for the Neogene is a product of the past quarter of a century. This allows the correlation of the rock bodies and the events within the Carpathian Basin to be done at least for the greater lower part of the Neogene.

In chrono-correlation previously the widely spread tuff horizons were the tools of primary importance. They have been successfully complemented by nannoplankton stratigraphy and K-Ar dating. For the stage boundaries the following dates have been more or less agreed upon: Egerian/Eggenburgian 22 Ma, Eggenburgian/Ottnangian 19 Ma, Ottnangian/Karpatian 17.5 Ma, Karpatian/Lower Badenian 16.4 Ma, Lower Badenian/Middle Badenian 15.5 Ma, Middle Badenian/Upper Badenian 15,0 Ma, Upper Badenian/Lower Sarmatian 14.0 Ma, Sarmatian/Middle Sarmatian 12.7 Ma, Middle Sarmatian/Upper Sarmatian 12.6 Ma, Upper Sarmatian/Lower Pannonian 12.5 Ma.

Diatom zoning set up by M. Hajós might be useful in correlating units with those found in the neighbouring countries, whereas the palynozoning of E. Nagy provides a mean that should pass the test of practice.

Monographs relating to stratigraphy are as follows: Bohnné Havas (1985), Chikán (1991), Hajós (1986), Hámor (1985b), Koreczné Laky (1985b), Müller (1984) and Nagy, E. (1992a).

The greatest bulk in the geological setting of Hungary is represented by the **Pannonian** formations. Their better understanding is largely due to hydrocarbon exploratory drillings. Consequently, traditional names missing, the lithostratigraphic units of the Pannonian stage have recently been named by Jámbor (1980) and by competent experts of the Hungarian National Oil Company OKGT now called MOL.

The Pannonian sequence is of rather monotonous composition, at least in comparison with its volume, and the zones marked out upon molluscs have turned out to be ecozones (M. Korpásné Hódi). The stratigraphic assignment of some of the Pannonian lithostratigraphic units has also become a matter of doubts. However, use of the latest methods of stratigraphy, the respective controversy is coming to a rest nowadays. Dinoflagellata zoning has been proved applicable (Sütő-Szentai 1988), and the K-Ar dating of volcanic products has yielded dates of improved reliability.

Stratigraphers have adopted the following radiometric dates for the boundaries of chronostratigraphic units: Upper Sarmatian/Lower Pannonian 12.5 Ma, Lower Pannonian/Upper Pannonian 9.0 Ma and Upper Pannonian/Quaternary 2.4 Ma. Radiometric dates obtained for the two boundary surfaces within the Lower Pannonian should be revised.

Monographs relating to the Pannonian stratigraphy are: Jámbor (1980) and Korpásné Hódi (1983).

The lithostratigraphic subdivision of the **Quaternary** may be considered as formally settled (A. Rónai and E. Krolopp). Nevertheless, the requirements of the classification of the superficial sedimentary accumulations exceed by far the level of the traditional subdivision, thus we cannot be satisfied with the existing subdivision.

Among the means kept in store for the chronostratigraphy of the Quaternary there are fossil voles, representing a particular group of micromammals that are good indicators of climatic changes just as floral remains can be (Kordos 1987a). Age determinations in million years for the Quaternary subunits have been made more accurate by means of radiometric dating (Rónai 1985) with the following results: Upper Pannonian/Quaternary boundary 2.4 Ma, Lowermost Pleistocene/Lower Pleistocene boundary 1.8 Ma, Middle Pleistocene/Upper Pleistocene boundary 0.1 Ma and Pleistocene/Holocene boundary 0.012 Ma.

A monographic description of the Quaternary deposits in the Great Hungarian Plan has been accomplished by A. Rónai (1985).

HUNGARIAN STRATIGRAPHERS ABROAD

In view of the numerous details of information on our stratigrapher's activities in Hungary that have been described here it is deemed to be quite impracticable to include a similar account of their manysided work carried out in foreign countries.

The widest range of activities has been linked with the Austrian-Hungarian direct co-operation in the field of geological research. Some study results were published in Austria in 1992 in the form of a jubilee volume issued on the occassion of the twentieth anniversary of the cooperation (Haas, J., Knauer, J. and Kovács, S.). The second volume is expected to be out this year, with studies on stratigraphy prepared by the following authors: I. Bodrogi, M. Bohn-Havas, G. Császár, L. Czabalay, L. Dosztály, Gy. Lelkes-Felvári and Á. Siegl-Farkas. The Hungarian contribution by magnetostratigraphic determinations to the study of the stratotype of the Badenian stage is worth of special mention (M. Lantos).

The second most important group of activities was joined with the work of the international expeditions formed to make geological mapping abroad. Hungarian experts contributed to the stratigraphic classification of rock sequences in foreign countries by making the respective examinations here and also there. Expeditions working in Mongolia and Vietnam called for first of all radiometric dating of the Survey (L. Ravasz-Baranyai). The members of the mapping teams sent to Cuba, following one another by turns, asked mainly for the palaeontological-biostratigraphical examination of Tertiary formations, with the following subjects to be dealt with: palynology (Á. Siegl-Farkas), nannoplankton (M. Báldi-Beke), planktonic foraminifers (K. Horváth-Kollányi and F. Góczán), benthonic foraminifers (Á. Nagy-Gellai and M. Bohn-Havas), Cretaceous and Palaeogene foraminifers (I. Bodrogi) – a list not intended to be exhaustive.

Countless examinations were done by members of the research staff of the Survey unofficially, in the form of personal, friendly cooperation.

BASIC RESEARCH

by ZOLTÁN BALLA

INTRODUCTION

Basic research in geology can be interpreted as the opposite of applied geological investigation, i.e. those scientific studies that don't have a direct practical product. The aim of basic research is to develop a certain science, or branch, to provide the possibility of solving practical problems, to discover new objects, or phenomena, which were unknown before and to define the manner of their practical utilization. Moreover, the task of basic research is to give information to people about the Earth.

A big part of geological sciences belong to basic research, because there are only a few investigations that can provide direct information by themselves for practical utilization and not only the possibility of solving concrete problems. A big part of basic geological research is independent from its major department in the Geological Survey and is reviewed separately in this volume. We report only about those subjects, that don't belong to stratigraphy, geological mapping, environmental- or hydrogeology, engineering- and agrogeology, geochemistry or ore geology.

After this abbreviation, we introduce the synthesizing branches of basin analysis, tectonics, mineralogical, petrological and paleontological laboratory investigations, which were done in the Geological Survey during the past 25 years. Afterwards we also report about geological descriptions, which have an intermediate place in the process of basic data collection and synthesis.

Basic research (in the sense defined above) was very rich and multifaceted in the Geological Survey during the past 25 years, so its review is based on a certain classification. Because of the various subjects, numerous more or less arbitrary classifications may exist. Further information is given on the basis of the following subjects: basin analysis, tectonics, geological descriptions, paleontological investigations. Not only the researchers of the Geological Survey took part in these works, but this is only reflected in the References (i.e. co-authors) and there isn't a separate reference in the text.

BASIN ANALYSIS

The basin analysis project itself started in the Geological Institute in 1992. However, multifaceted sedimentological and paleogeographical research, accompanied by a huge amount of laboratory investigation, can be considered as its precursors. Below we give a separate introduction about sedimentological and paleogeographical research, mineralogical and petrological laboratory investigations and about basin analysis itself. Due to the reorganization in the Geological Survey, only the last one even exists today.

Sedimentology and Paleogeography

Former investigations concentrated in two main groups: the Middle and Upper Cretaceous sediments of the Transdanubian Central Range (Haas&Jocháné Edelényi 1979; Knauer&Gellai 1989, 1993; Császár 1984b; Haas et al. 1984a; Haas 1985; Jocha-Edelényi 1988a) and the paleogeography of the Neogene sediments in Hungary and its surroundings, and in the Transdanubian Central Range (Jaskó 1974, 1976a, b, 1977, 1979, 1981, 1984a, b; Jámbor 1980a, b, c; Jámbor et al. 1988; Hámor 1984b; Kókay 1987; Hámor&Bérczi 1986; Bérczi et al. 1988; Csirik 1993).

Further studies were published about paleogeographic reconstruction of the Late Permian of south Transdanubia (Kassai 1980a), about the Palaeozoic-Mesozoic olistostromes of north Hungary (Kovács 1987a, b), about the Hungarian Triassic facies and their paleogeography (Kovács 1980, 1984a; Haas 1988b), about the Jurassic sediments in the Bakony Mountains (Konda 1970), about the flysch sediments in the Great Hungarian Plain (Dudich 1982; Dudich&Bombita 1983), about the Tertiary paleogeography of the Börzsöny, Cserhát and Mátra Mts (Hámor 1973b, 1974) and about Late Pliocene-Quaternary subsidence of the Körös basin (Rónai 1982a).

Mineralogical-Petrological investigations

Those mineralogical-petrological investigations are listed here, which had sedimentologic and paleogeographic applications, the others are found among geological descriptions. We introduce micromineralogical, clay-mineral, organic-content and pyrite studies.

Micromineralogical investigations (Gedeonné Rajetzky 1973a, b, 1976; Elek 1982, 1987) were carried out on cores from drillings on the Great Hungarian Plain, and the results were used in interpreting sedimentological cycles and transport directions.

The aim of the investigations of clay minerals was to analyze diagenetic processes, first from a theoretical perspective (Árkai&Viczián 1975; Viczián 1985), and secondly in the Neogene sediments of the Pannonian Basin (Viczián 1975, 1977; Hámor-Vidó&Viczián 1993).

On the basis of organic-content analyses, sedimentary environments (Vető 1988b; Bruknerné Wein et al. 1984; Brukner-Wein 1988), processes of diagenesis (Hámor-Vidó&Viczián 1993; Vető 1980), burial and exposure conditions (Laczó 1982; Laczó&Jámbor 1988b; Iharosné Laczó&Vető 1983) were interpreted and the final conclusions were drawn concerning hydrocarbon formation and migration (Vető 1988a).

Hámor, T. (1988, 1991) elucidated diagenetic processes through the investigation of sedimentary pyrites.

Basin Analysis

The aim of basin analysis is to create widespread models all over the country, which are based on the uniform interpretation of all the available geological, geophysical and geochemical data, and to describe the tectonic, sedimentologic and diagenetic evolution of the young (Paleogene, Neogene) basins. For this reason, we analyze the different sub-basins of the Carpathian basin, which are situated in Hungary, and reconstruct their development. This work is based on the reevaluation of the key boreholes of the Geological Survey. The new interpretations are in accordance with the latest international results of basin analysis. Research has been carried out in the Duna-Tisza Interfluve, on the northern parts of the Great Hungarian Plain, on the Little Hungarian Plain and in the northern Paleogene basins.

TECTONICS

Tectonic investigations carried out in the Geological Survey are introduced in three groups: Paleogeography and Paleotectonics, Tectonic Development and Deep Structures.

Paleogeography and Paleotectonics

By the beginning of the period under consideration, a tectonic model of the basement of the Pannonian Basin was developed on the basis of work by Wein Gy. (1969, 1971, 1972b), which significantly influences the ideas of the researchers in the Geological Survey even today (Császár et al. 1982; Balogh 1983; Brezsnyánszky et al. 1986; Fülöp et al. 1987; Raincsák 1988). According to this model, the Pre-Neogene rocks of Hungary are arranged in blocks bordered by faults of SW-NE strike. The Zágreb Line, enters from SW, follows the Kapos Valley and turns to the northeast at Dombóvár. Then, it continues at the southern tip of the Csepel Island and at the southeastern edge of the Bugyi-Sári horst, follows the Hernád Valley, bends to the northeast, and finally leaves Hungary from northwest of the Zemplén Mts. Since Wein (1978a, b), this line is considered to be a primary megatectonic boundary, and the other blocks are considered to be situated within this main unit.

Another opinion, which is widespread abroad, has only now been accepted by the researchers of the Geological Survey (Balla&Bod-

rogi 1993). It describes the situation of this primary tectonic boundary otherwise. According to this model, the Zágreb Line doesn't turn northeast at Dombóvár with the Kapos Valley, but continues through the Duna at Paks towards the Szolnok Flysch Zone and leaves Hungary in the direction of Máramaros.

The original (Late Palaeozoic–Mesozoic) paleogeographic situation of the megatectonic units was described by Kovács (1980, 1982, 1983a, 1984b, c), who recognized that the Transdanubian Central Range escaped from the southern and central Alps, while the Mecsek-Erdély Unit was once found between the western and eastern Carpathians. Further research (Kázmér&Kovács 1985; Haas 1987b; Császár et al. 1989; Haas et al. 1990; Budai&Vörös 1992, 1993) underlined this model and gave more detailed descriptions.

Despite the many paleogeographic correlations and joint sketches, only Wein (1978a, b) made a paleotectonic reconstruction in the Geological Survey. As its main result, he recognized that the two main megatectonic units were displaced next to each other along a large-scale strike-slip fault during Alpine orogenesis. A detailed paleotectonic reconstruction of the northeastern part of the Transdanubian Central Range was given by Balla, Z. and Dudko, A. in 1989, in which the authors realized that the Tertiary strike-slip movements must have been accompanied by significant cartographic deformations.

Recent tectonic research in the Geological Survey is limited: we summarize the borehole data concerning the Tertiary basin floor and organize the GIS database. Moreover, little laboratory work or interpretation of the data have been done to create more detailed models of deep structures in certain regions.

Tectonic Development

According to the geological situation of Hungary, we discuss separately the tectonics of the Pre-Neogene and Neogene sediments, and the neotectonics, i.e. the Quaternary structures.

Pre-Neogene Tectonic Development

Most tectonic analyses have been carried out in the Transdanubian Central Range. The structure of the Variscian rocks at the southeastern margin was studied by Dudko, A. (1986, 1987, 1988; Dudko et al. 1989a; Dudko&Lelkes-Felvári 1992). During the Variscian tectonic development, which previously was believed to have been uniform, she recognized numerous stages of deformation, parallel with the different metamorphic textures. In he region of th Velence Lake, she outlined a large-scale pericline in the basin floor, and pointed out that the Balaton Line gradually finishes to the northeast in its central part. In the Eocene rocks, she recognized a series of dextral strike-slip faults, which are nearly parallel with the Balaton line.

In the Bakony Mts, Cretaceous (Mészáros 1980, 1982, 1986; Mészáros&Tóth 1981) and Miocene (Mészáros 1983) displacements along transverse faults were described, which also were used later on many tectonic sketches. During the geological mapping of the Balaton Highland, tectonic analyses revealed zig-zag and sygmoid-like transverse structures, but only a few transverse faults could have been followed.

In the Transdanubian Central Range, a comprehensive tectonic review was made in the Keszthely and Buda Mts (Szentes 1972; Wein 1974, 1977). Tectonic analyses were carried out on some other areas, too (Raincsák 1980; Maros 1988; Gyalog 1992; Knauer et al. 1993).

Besides the Transdanubian Central Range, the Geological Survey made detailed tectonic analyses in the Kőszeg Mts (Dudko&Younes 1990), where some different styles and directions of deformation were realized.

The deep structure of the Little Hungarian Plain was studied by Wein (1971, 1972a).

During sedimentological study in the Bükk Mts, Balogh et al. (1984) outlined a nappe structure, while that of the Aggtelek–Rudabánya Mts was studied by Grill (1989).

Since the reorganization of the Geological Survey, there hasn't been any further opportunity to study the Pre-Neogene tectonic development.

Neogene Tectonic Development

Tectonic research in the Geological Survey on the Neogene structures also concentrated on the Transdanubian Central Range. The different directions of fault-systems within the bigger units was studied by Jaskó (1988a, b). The Miocene basins in the southwestern parts were developed along young strike-slip faults, as determined by Dudko et al. (1992). Kókay (1976, 1984, 1985a, 1993) studied the Neogene compressional structures near Várpalota. Neogene folds were described from the Gellért Hill by Balla Z. and Dudko A. (1990). Neogene folds and thrusts were interpreted by an analysis of tectonic data from the region of the Balaton Line (Balla et al. 1987). The widespread occurrence of compressional structures in the background of the extensional Miocene tectonic style all over the country reflects the special tectonic development of the southeastern margin of the Transdanubian Central Range (Balla&Dudko 1989).

In the northern Central Range, two stages of Neogene and one phase of Quaternary tectonic movement were identified by Jaskó (1985, 1986, 1989, 1993). He separated different horsts, bordered by faults.

Since the reorganization of the Geological Survey, there has not been any further opportunity to analyze the Neogene tectonic development.

Neotectonics

When analyzing Quaternary tectonics, the researchers of the Geological Institute follow tradition and pay the most attention to faults. The existence and distribution of faults was inferred from the occurrence of thermal waters (Szebényi 1974), from the distribution and thickness of Quaternary sediments (Rónai 1977, 1986) and from the configuration of the topography (Moldvay 1971, 1972, 1976, 1977a, 1986, 1989; Jaskó 1986).

During the interpretation of satellite images, researchers (Czakó&Zelenka 1981; Kókai 1982; Kalafut 1987, 1990; Síkhegyi 1985; Brezsnyánszky&Síkhegyi 1987) also explained topographic lineaments with a tectonic origin. They also outlined many faults, rings and other objects that can not be identified by remote sensing, so their existence and geological interpretation is questionable.

Although geological mapping on the surface and remote-sensing surveys cover big parts of the country, the location of faults is still controversial on different maps. This means that there are serious problems with the criteria for detecting faults, as demonstrated in a quite small, but very important, area (region of the Paks Atom Power Station) by Balla et al. (1993). Therefore, the main goal of neotectonic research in the Geological Institute, which started in 1992, is to test suitable methods.

The most important question in neotectonic research, both theoretically and practically, may be the tectonic connection of earthquakes. The small-scale summary of Konrád (1990) can be considered a first attempt. Now we analyze the distribution of regularity of the earthquakes and their geological consequences.

Deep Structures

The deep structures can be studied best by geophysical data. Through a comparison of seismic and telluric data, Kassai (1980b) outlined the distribution of the Upper Carboniferous clastic sediments on the basin floor of southern Transdanubia. The megatectonic interpretation of the significantly corrected gravitational map is less convincing (Kassai 1982).

With the integrated interpretation of gravitational and seismic data, Balla et al. (1991) revealed a high-density body in the basin floor of the Little Hungarian Plain. This type of research has been done together with the Geophysical Institute.

GEOLOGICAL DESCRIPTIONS

We separate the geological descriptions into three main groups: regions, key boreholes and description of the different formations. This classification is subjective of course; the descriptions of the regions comprise different formations of a bigger stratigraphic unit.

Regions

The distribution of the described regions reflects the progress of geological mapping made by the Geological Survey. The results of regional geologic mapping on the Little Hungarian Plain were summarized by Síkhegyi (1984). In the Transdanubian Central Range the northwestern foreland of the Keszthely Mts was described by Jocháné Edelényi (1984), the surroundings of Sümeg by Haas et al. (1984b), the Berhida Basin by Kókay (1993) and the northwestern parts of the Pilis Mts by Nagy, G.(1982). Remarkable attention was paid to the palaeokarst of the Buda Mts in the past years (Kovács&Müller 1980; Nádor&Sásdi 1991; Nádor et al. 1993) and to the theoretical models of palaeokarst formation (Korpás&Juhász 1990; Müller 1974).

During geological-geophysical mapping in the Velence Hills and their surroundings, the eastern Velence paleovolcano (Darida-Tichy 1987; Dudko et al. 1989b), intrusive breccias (Ódor et al. 1983) and lamprophyres (Horváth et al. 1983; Horváth&Ódor 1984) were identified.

From the volcanic mountains, monographs were published about the Cserhát (Hámor 1985b), Mátra (Varga et al. 1975) and Tokaj Mts (Gyarmati 1977). Many studies discussed the geology of the Börzsöny Mts (Nagy, B. 1971c; Hámor et al. 1973; Gyarmati 1976; Nagy, G. 1976a, b; Balla et al. 1978, 1979; Balla&Csillagné Teplánszky 1979; Balla&Korpás 1980a; Csillag-Teplánszky et al. 1983), and two papers came out about the geology of the Dunazug Mts (Balla&Korpás 1980b; Bence et al. 1991).

The geology of the Aggtelek–Rudabánya Mts, which are built up of Palaeozoic and Mesozoic rocks, was studied by Balogh (1982). Later a new model of geological development was outlined by Grill et al. (1984) and Grill (1989), which describes the structures by thrusts. The lower and upper thrusts originated from a continental margin, whereas the middle one stemmed from an oceanic basin, which collided during Kimmerian orogenesis. The thrusts were significantly displaced during Cretaceous orogenesis.

In basin areas, the excellent work of Szepesházy (1979, 1980) drew parallels between the rocks in the basin floor of Tiszántúl with those in the Transylvanian Central Mts.

Key Boreholes

Although there are many key boreholes, only a few have been published in detail. Most of them are found in the Transdanubian Central Range and its surroundings. Lower Triassic formations were described in the Alcsútdoboz-2 (Oravecz et al. 1988), Alsószalmavár-1 (Tóthné Makk 1988), Bakonyszűcs-3 (Haas-Tóthné Makk-Oraveczné et al. 1988), Köveskál-9 (Haas et al. 1986, 1988b), Balatonudvari-1, Dinnyés-1, Gárdony-1, Iszkaszentgyörgy-3, Szigliget-1, Tabajd-5 and Zánka-2 boreholes (Haas&Tóthné Makk 1988). Their paleogeographic connections were also studied. A more detailed description of the Miocene sequence was given in the Berhida-3 (Kókay et al. 1991) and Nagygörbő-1 (Jámbor&Korpás 1974) boreholes.

The stratigraphy of the Pannonian-Quaternary sediments became more exact with the paleomagnetic investigations in the Dévaványa-1, Kaskantyú-2, Tiszapalkonya-1 and Vésztő-1 boreholes (Elston et al. 1985; Rónai&Szemethy 1979).

In the southern Transdanubia, Upper Carboniferous anthracites were described in the Siklósbodony-1 and Bogádmindszent-1 boreholes (Hetényi&Ravasz-Baranyai 1976). A thick Miocene rhyolite tuff sequence was studied in the Tengelic-2 borehole (Halmai et al. 1982).

Only a few data were issued from the key boreholes of the Geological Survey, and many others are still awaiting publication because some topics (Neogene sediments, Cretaceous sedimentary rocks of the Transdanubian Central Range) has priority in the past, both in laboratory investigations and in publication. In the past few years reorganization and serious financial problems made the publication of further volumes impossible. Thus, data of very expensive research remain inaccessible.

Formations

Descriptions are introduced in the following groups: Metamorphic Rocks and Palaeozoicum, Triassic and Jurassic, Cretaceous, Paleogene, Neogene and Quaternary.

Metamorphic Rocks and Palaeozoic

During the period under consideration, the petrological analysis of the metamorphic rocks in Hungary, and the stratigraphic study of the Palaeozoic formations progressed significantly.

The research of Lelkes-Felvári, Gy. provided many new pieces of information about the age and genesis of the metamorphic rocks in the Kőszeg- and Vashegy Mts (Lelkes-Felvári 1982), in the Sopron Mts (Lelkesné Felvári et al 1986) and in the southeastern foreland of the Transdanubian Central Range (Albani et al. 1985; Lelkesné Felvári 1978; Lelkes-Felvári et al. 1982). She also reviewed the Pre-Alpine metamorphic rocks of Hungary (Lelkesné Felvári&Sassi 1983; Árkai&Lelkes-Felvári 1987). She recognized fossils in the pelagic limestone of the Kékkút-4 borehole, which proved its Early Devonian age (Lelkesné Felvári et al. 1984). The crystalline rocks in the Sopron Mt s were studied in detail by Ivancsics (1982; Kisházi&Ivancsics 1985a, b, 1986, 1987a, b, 1989).

The crystalline rocks of the Hont-1 borehole in northern Hungary were described by Ravaszné Baranyai and Viczián (1976), while the Permo-Carboniferous sediments of the Nagybátony-324 borehole were studied by Kozur (1984b). Kovács et al. (1983) developed a new geologic model of the Palaeozoic in the Bükk, Uppony and Szendrő Mts. Kovács, S. and Vetőné Ákos, É. (1983) described the Late Palaeozoic basic volcanics in the Uppony Mts. The crystalline schists along to the northeast boundary of the country were investigated by Kisházi, P. and Ivancsics, J. (1988).

A monograph by Jantsky, B. about the crystalline basement of the Mecsek Mts in southern Transdanubia was published in 1979. In basin areas, Szepesházy, K. published detailed petrological analyses about the Tiszántúl area (Szepesházy 1973) and about the crystalline basement in the southern part of the Duna-Tisza Interfluve (Szepesházy 1976). Kassai (1976) summarized the borehole data of Permian formations exposed in the northern foreland of the Villány Mts.

Triassic and Jurassic

Many detailed descriptions were published about the Triassic formations in the Transdanubian Central Range (general review; Haas et al. 1977; Early Triassic at Köveskál: Haas et al. 1986; Lower Triassic key-sections: Haas-Tóthné Makk-Góczán et al. 1988; Middle Triassic tuffs: Ravasz 1973; Upper Triassic Lofer cycles: Haas 1988a). The Triassic formations in the southeastern foreland of the Transdanubian Central Range at Igal were described by Haas et al. (1988a). Knauer (1986, 1993) investigated the sediments of the Jurassic-Cretaceous boundary.

Jurassic formations in the Bükk Mts were first revealed by Pelikán, P. (Bérczi-Makk&Pelikán 1984). The stratigraphic position of the Triassic and Jurassic sequences in the Bükk and Darnó Mts became more exact after the radiolarian investigations of Dosztály, L. (Csontos et al. 1991; Dosztály&Józsa 1992). During geological mapping in the Aggtelek–Rudabánya Mts the stratigraphy and facies distribution of the Triassic formations were clarified (Kovács et al. 1988, 1989). A new result was the detection of Triassic ophiolites (Réti 1985c, 1988b; Kozur&Réti 1986), the examination of the Triassic–Jurassic boundary (Nádor 1990) and the detailed description of the Jurassic formations (Grill 1988).

A review of the Jakabhegy Sandstone in the western Mecsek Mts (Kassai 1984) and a detailed description of the Triassic formations in the Villány Mts (Nagy, El.&Nagy, I. 1976) were published from the southern Transdanubian area.

In basin areas, the recognition of the relationship between the Mecsek Mts and the Lower Triassic formations exposed by Vajta-3 borehole was an important result, as well as the review of the Jurassic formations of the Tiszántúl area (Szepesházy 1972).

Cretaceous

A general review of the Cretaceous sediments in Hungary was given by Császár&Haas (1984), while Haas et al. (1977) studied those of the Transdanubian Central Range. Detailed descriptions of the Cretaceous formations in the Transdanubian Central Range were published by Császár (1986), Haas (1979, 1983, 1991) and Lelkes (1985, 1990).

A new model of sedimentation of the Senonian conglomerates at Nekézseny in the Uppony Mts was outlined by Brezsnyánszky and Haas (1984) and by Clifton et al. (1985b).

Császár (1989, 1992a) described the Urgonian limestone of the Villány Mts and the Senonian sediments in the basement of the Great Hungarian Plain.

Paleogene

Facies distribution and occurrence of the Paleogene sediments in Hungary was described by Balázs et al. (1980).

Publications of the Geological Survey mostly discuss the Eocene sediments of the Transdanubian Central Range (Gidai 1971, 1972 a, b, 1976, 1977, 1984c, 1985; Dudich&Kopek 1980; Kopek 1980; Kókay 1989; Haas 1991). The monograph on the Oligocene-Lower Miocene sediments of the Transdanubian Central Range by Korpás, L. was published in 1981.

Halmai, J. (1974) described the Oligo-Miocene sediments from the left side of the Duna in northern Hungary, Szentpétery, I. (1988) discussed those of the Rudabánya Mts.

Neogene

The Miocene facies in Hungary were discussed by Hámor&Jámbor (1971) and Hámor et al. (1987). Pannonian sedimentation was summarized by Jámbor (1987a, 1989), Jámbor et al. (1988) and by Korpás-Hódi (1987b). Radócz et al. (1985) described the coal beds in the Neogene sediments. Jámbor (1980b) published a monograph about the Pannonian sediments of the Transdanubian Central Range. Rálischné Felgenhauer (1991) described a Miocene clastic sequence, exposed by the Som-1 borehole. Kókay (1990) discussed the Middle Badenian sediments in Budapest. The young basalts in Transdanubia were studied by Jugovics (1972, 1976) and by Jámbor et al. (1981).

The clastic sediments of northern Hungary were studied by Clifton et al. (1985a).

Hámor, G. published a monograph about the Miocene sediments in the eastern Mecsek Mountains in 1970. Ravaszné Baranyai, L. (1973) provided the mineralogical-petrological description of these sediments. Chikán, G. (1991) summarized the Cenozoic sediments of the western Mecsek Mts, Korpás-Hódi, M. (1992) studied the Pannonian sediments in the Duna–Tisza Interfluve.

Quaternary

The geological development of Hungary during the Quaternary was summarized by Rónai, A. (1982b). Jámbor, Á. (1992) described ventifacts.

Talus in the foreland of the Mátra and Bükk Mts was described by Franyó, F. (1982). Krolopp, E. et al. (1989) studied the genesis of freshwater limestones next to Eger.

Quaternary sediments were studied in detail by Rónai, A. (1972, 1981, 1985). The development of the Danube valley was discussed by Jaskó, S. and Krolopp, E. (1991) and by Jaskó, S (1992). Rónai, A. (1982a, 1983) introduced the geology of the Körös basin.

PALAEONTOLOGICAL RESEARCH

Palaeontological investigations are essential for geological research, as they study the age of the formations and make large-scale correlations possible. Moreover, it has an increasing role in characterizing sedimentary environments.

Specialists of the Geological Survey represented the forefront of Hungarian paleontology until recent years. Palynology in Hungary was developed here by E. Nagy. She did most of her research in the Neogene sediments (Báldi-Beke et al. 1980a; Hámor et al. 1987; Jámbor et al. 1988; Nagy, E. 1985, 1992 a, b; Nagy, E.&Kókay 1990, 1991; Nagy, E.&Planderová 1987; Nagy 1976, 1985, 1992a, b, 1993; Nagy-Bodor 1982). Palynology of the Neogene and Quaternary sediments were also studied by Nagy-Bodor, E. (Bodor 1983a, b, 1986; Nagyné Bodor, E. 1988; Nagyné Bodor 1982) and Mih// Miháltzné Faragó (1982a, b, 1983). Palynology of the Paleogene and Upper Cretaceous sediments was studied by Rákosi (Góczán et al. 1986b; Rákosi 1973, 1978, 1979, 1981, 1982, 1988, 1991, 1992a, b, 1993; Rákosi&Tóth 1980), while that of the Upper Cretaceous sediments was investigated by Á. Siegl-Farkas (Góczán et al. 1986b; Góczán&Siegl-Farkas 1988, 1990, Siegl-Farkas 1983, Sieglné Farkas 1984, 1986, 1991a, Siegl-Farkas 1991b, c, 1993b). Góczán studied the palynology of the Cretaceous sediments (Császár&Góczán 1988; Góczán&Haas 1987; Góczán&Juhász 1984, 1985 a, b; Góczán&Oravecz-Scheffer 1993; Góczán&Siegl-Farkas. 1988; Góczán et al. 1983, 1986a, b, 1992; Broglio Loriga et al. 1990).

The specialists of the Geological Survey also carried out other important micropaleontological investigations. Neogene diatoms were studied by Hajós (1978, 1982a, b, 1986, 1987a, b, 1988, 1989; Jámbor et al. 1988). Piros, O. investigated the Triassic *Dasycladaceae* (Budai et al. 1993; Kovács et al. 1988, 1989).

Miocene forams were studied by Korecz-Laky, I. (Báldi-Beke et al. 1980a; Bohnné Havas&Korecz 1980; Jámbor et al. 1988; Koreczné Laky 1976, 1982, 1983, 1985b, 1987a, b; Koreczné Laky&Nagyné Gellai 1977, 1985), Oligocene forams by Nagy-Gellai, Á. (Báldi-Beke et al. 1980a; Horváth-Kollányi&Nagy-Gellai 1988; Koreczné Laky&Nagyné Gellai 1977, 1985; Nagyné Gellai 1973, 1983, Nagy-Gellai 1988), Eocene forams by Jámborné Kness (1972, 1973, 1981, 1988), Horváth-Kollányi (Báldi-Beke et al. 1980b; Bernhardt et al. 1988; Horváthné Kollányi 1983a, b; Horváth-Kollányi&Nagy-Gellai 1988) and Less (1983, 1987, 1991, 1992). Cretaceous forams were investigated by Bodrogi, I. (Balla&Bodrogi 1993; Bodrogi 1985, 1988, 1989, 1993a, b; Bodrogi&Bodnár 1988; Császár et al. 1983, 1987a, b; Császár&Bodrogi 1985), while the Triassic ones together with pelagic crinoids were studied by A. Oravecz-Scheffer (Góczán et al. 1983, 1986a, 1990, 1992; Góczán&Oravecz-Scheffer 1993; Haas et al. 1984c, 1988c, d; Oravecz-Scheffer 1979, Oraveczné Scheffer 1980, 1983, Oravecz-Scheffer 1987).

Knauer (1986) and Nagy, I. (1986, 1988, 1989) studied calpionellids from the Jurassic–Cretaceous boundary. Szuromi-Korecz investigated Neogene ostracods (Jámbor et al. 1988; Korecz 1987 a, b; Nagy-Bodor&Szuromi-Korecz 1988). Müller described Miocene crustaceans (Kókay et al. 1984, 1991; Müller 1984, 1989).

Báldiné Beke did pioneering work in researching nannoplankton (1972, 1977, 1982a, b, 1983a, b, 1984; Báldiné Beke&Nagymarosy 1979; Báldiné Beke et al. 1980a, b, c, 1981; Báldiné Beke&Kecskeméti 1983; Báldi&Báldi-Beke 1985; Báldi et al. 1976; Bernhardt et al. 1988). Dosztály investigated radiolarians (Csontos et al. 1991; Detre et al. 1988; Dosztály 1988a, b, 1991, 1993;

Dosztály&Józsa 1992). Conodonts were studied by Kovács, S. (1981, 1983b, c, 1984a, 1986; Kovács&Árkai 1989; Kovács&Vetőné Ákos 1983; Kovács et al. 1983, 1988, 1989; Lelkesné Felvári et al. 1984) and Kozur (1984a, 1984d, 1985).

Many specialists studied molluscs: the Quaternary ones by Krolopp, E. (Jaskó&Krolopp 1991; Kordos&Krolopp 1990; Kretzoi&Krolopp 1977; Krolopp 1978, 1979, 1980, 1981, 1982a, b, 1983a, b, 1987; Krolopp et al. 1989), the Pannonian ones by Bartha, F. (1971, 1979), Korpás-Hódi, M. (Jámbor et al. 1988; Korpásné Hódi 1981, 1982, 1983, Korpás-Hódi 1985, Korpásné Hódi 1987a, b ; Korpás-Hódi et al. 1992), Müller &Magyar 1992a, b, Müller&Nagymarosy 1988, the Miocene ones by Kókay, J. (Bohn-Havas et al. 1987; Kókay 1985b, 1986, 1987, 1988, 1990, 1993; Kókay et al. 1984, 1991; Nagy, E.&Kókay 1990, 1991) and Bohn-Havas, M. (Báldi-Beke et al. 1980a; Bohnné Havas 1973, 1981, 1982, 1983, Bohn-Havas 1984a, b, Bohnné Havas 1985, 1990, 1992; Steininger et al. 1978; Bohn-Havas&Korecz 1980; Clifton et al. 1985a; Hámor et al. 1987), the Eocene ones by Kecskemétiné Körmendy, A. (1972, 1980, 1981, 1984, 1990; Kecskemétiné Körmendy&Mészáros 1980) and the Cretaceous ones by Czabalay, L. (Császár et al. 1987a; Czabalay 1976, 1981, 1982, 1983, 1984a, b, 1988).

Different Carboniferous, Permian and Triassic fossils were studied by Detre (1970, 1971a, b, 1974, 1981, 1983, 1989, 1990, 1991, 1993a, b ; Detre&Nagy 1971; Detre et al. 1971, 1985, 1986, 1988; Gyalog et al. 1993), Kozur 1984c), Lenner (1989) and Mihály (1973, 1976a, b, 1980, 1981, 1982, 1989b). Mihály, S. also studied different Tertiary fossils (Kókay et al. 1984; Mihály 1985, 1989a; Mihály&Vincze 1984). Senonian ammonites were recognized by Partényi (1986).

Hungarian vertebrates were investigated by Kordos, L. (1977, 1978, 1980, 1982a-d, 1983a, b, 1985a-d, 1988a, b, 1989, 1991; Kordos&Krolopp 1990; Kordos&Ringer 1991; Kordos-Szakály&Kordos 1985; Krolopp et al. 1989) and Kretzoi (1980, 1981, 1982). Pálfalvy, L. studied Miocene fossil plants (1976a, b, 1980, 1981). Different trace fossils were described by Jámbor (1978b), Kordos (1985e), Kordos&Morgós (1988) and Radócz (1977).

In the past few years the paleontological research in the Geological Survey was gradually repressed, as it was believed to have been oversized. During the reorganization, nobody replaced the retired paleontologists. The diminished paleontological research can exist now only in the framework of different projects, which concentrate on specific topics. Thus, several branches of paleontology are in danger of ceasing, which is alarming for the long-term development of geology not only in the Geological Survey, but in the whole country as well.

CONTRIBUTION TO MINERAL EXPLORATION

by JÓZSEF KNAUER

J. Noszky Jr. concluded his centenary commemoration on the hundred years long practical activity of our Survey with the following words: "Thus the Hungarian Geological Survey always and in every time fulfilled its duty also in the field of research of direct practical aim, and observed the principle expressed at its foundation, that it should fortify and enrich the mining and industry of our country by clarifying the geological circumstances of the known mineral resources, by exploring new occurrences, and by forwarding propositions for the utilization of materials hitherto unclaimed".

During the past 25 years this activity was carried on continously: only the emphasis was shifted from one point to another, the percentage of the permanent tasks relative to that of the occasional ones changed, the interpretation of the duty and the intentions of the people formulating them were modified, moreover the volume and proportion of the resources directed to the preliminary activities of the mineral exploration or to the exploration itself were not constant. Of course, the activities of preparatory character are bound for the most part tightly to the basic research. Naturally the total separation of the two phases is not possible at all, as it is well known that although indirectly, almost all branches of geological exploration are in connection with the mineral exploration anyhow.

From the standpoint of our Survey we may regard as belonging to the domain of the mineral exploration the whole spectrum embracing the appraisal of geological characteristics of an area for the purpose of selecting the perspective sites of raw-material occurrences, the management of the exploration activity, and the making of the summary of the results obtained. The present brief summary has been compiled accordingly to this concept. It is based on published Annual Reports, occasional accounts of the departments, reports on activities and costs, published studies, exploration reports etc. The participation of the Eötvös Loránd Geophysical Institute of Hungary was permanent very often in the period of planning already, but this is especially right in the case of prospecting ordered by the state moreover in the preliminary explorations.

In the field of mineral exploration the Centenary did not coincide with important changes. The reports on the activities done in 1969 for the most part deal with the continuation of former ones: the preparations for the ore-geological exploration of the Börzsöny Mts were carried on, the cores of the Recsk boreholes amounting to 20,000 running metres altogether were re-investigated, the results of the geological mapping done in the eastern part of the Cserhát Mts were evaluated from the economic-geological standpoint. The raw-materials of that area belong to the group of the so-called non-metallic minerals, such as the Felsőpetény fireclay-deposit (W Cserhát Mts) and the Pétervására bentonite which were also targets of exploration in the period considered. The report on the coal-exploration in the SE Gerecse Mts in 1964–1967, the rare-metal exploration in Nagybörzsöny and the exploration of Miocene brown coal done by mining methods at Kányás, Nógrád county, were also mentioned. The Survey was engaged in the appraisal of regions fit for the exploration of raw-materials and also their utilization; the economic-geological map of Nógrád county was completed in this time. As the beginning of a new mapping in this period that of the Vértes Mts on scale 1:10 000 can be mentioned, aimed at bauxite prediction, and contouring type-areas for this purpose. The performance of the technical supervision of ore-exploration in Recsk is an interesting patch of colour in the mineral exploration activity. Similar activities occurred also in case of explorations serving practical purposes, such as those carried out in areas of bauxite deposits on behalf of the industrial sector.

The first decade of this quarter of a century was characterized by ore-exploration. Parallelly with the systematic survey of the Börzsöny Mts, – together with that of the Dunazug Mts attached to the former one, by reasons of the research strategy – (Csillagné Teplánszky et al. 1976, Czakó&Nagy, B. 1976, Hámor 1976, Hámor et al. 1973, Korpás 1979, Nagy, B. 1973, 1978, Nagy, G. 1976a, b) prospecting was done during one year periods in the so-called Darnóbelt (Csalagovits 1973a), in the Aggtelek and Bükk Mts (Böjtösné Varrók 1974). Futhermore the Survey carried out explorations in Úrkút (sedimentary manganese-ore in the Nyikos area), in Recsk (exploration of sulphide ore by shallow-drillings) and in Rudabánya (sulphide ores). The monographical summary of the results of the exploration and the regional mapping covering the area of the Mátra Mts and its surroundings (Varga et al. 1975) has ore-geological importance too. The traces of Lower Triassic stratabound ore-mineralization in the Veszprém–Litér–Sóly, and Iszkaszentgyörgy areas were investigated (Raincsák 1984). Geological mapping aimed at bauxite took place also in the Southern Bakony Mts (Márkó–Tótvázsony–Úrkút area); the results obtained were utilized in the systematic geological mapping on scale 1:20 000, too. The Survey cooperated in the preliminary investigation of the area (Taliándörögd) of a planned telecommunication facility charged with the selection of areas where the occurrence of mineral deposits can be excluded – and in the evaluation of the results. The tasks for the long-term exploration of bauxite was determined (Jámbor&Szabadváry 1977), the compilation and subsequent publication of subcrop-maps serving bauxite prediction were begun (Császár et al. 1978, Haas&J. Edelényi 1980). This activity included also the complex–key-section-like–mineralogical and sedimentological investigation of the most characteristic bauxite sections, thus providing bases for the appraisal of indications from the standpoint of raw-material prediction. Some of these investigations served the purposes of mine-design, too (Jocháné Edelényi 1981).

In the period under consideration the Survey had the most diverse tasks of coal exploration. Anthracite exploration was carried out in the Baranya-county (Hetényi&Ravaszné Baranyai 1976, Nagy, El.&Forgó 1970), the newly found bitumenous coal-measures of Senonian age in the SW Bakony were investigated; of the Liassic coal-bearing sequences were investigated too, and the results were published (Nagy, El. 1969, 1971). Mr. El. Nagy had been charged with seeking Liassic coal measures exploitable in opencast workings; but even in the "Ófalu-East" area deemed to be the most suitable for this purpose it could not be managed to find workable coal having the required shallow setting. The Survey participated in the exploration of the "Máza-South" hard coal bearing area, executed the coal petrographical investigations of the classical sequences of Dorog (Iharos-Laczó 1973), and Gidai (1972a, 1974) published the geological, coal-petrographical and economic geological data of the Eocene formations of this area, gathered in the course of these activities.

Neogene lignites were studied by the Survey on the occasion of systematic geological mapping the Eastern Cserhát region (covering the area of the so called Zagyva graben, too). It was found, that in the area of study the Miocene lignite-bearing sequence was wedging out, the seams were unimportant, but exploration might be continued to the south more permissive of practicable Pannonian lignite deposits (Hámor 1972, 1973b).

Out of the explorations carried out in Eocene brown coal-bearing areas only the work done in the Vértessomlyó area was unsuccessful (later on, however, the investigations carried out in other parts of this area came up to the expectations). From the geological point of view the other exploration activities were more or less successful. It was found, however, that the reserves of the Várgesztes area (Gidai 1976) were too small to be workable, while the depth of those at Héreg-Tarján excluded any possibility of exploitation. The Survey took part in the preliminary prospecting at Dorog-Esztergom, and in the exploration of the Lencsehegy area which had been discovered by the mapping activity of the Survey. In the area of the "counter-limb" of the Vértes Mts complex preliminary prospecting of coal and bauxite was begun. The coal perspectives of the NE-foreland of the Bakony Mts were appraised at the beginning of the decade (by G. Kopek), a more recent exploration programme was elaborated, however, in 1978 only. As an extension of the regional exploration of SE Gerecse Mts the coal prediction of the areas East of Bicske, and in the region of Bajna–Gyermely were completed also in this time.

Occurrences of raw-materials became known also in course of systematic geological mapping. The recognition of the upper bauxite horizon of the Gyűr-hegy at Halimba, brown coal and bauxite occurring in the Bősomlyó-hill at Gyermely or the bentonite covered by basalt in the area of the Tálodi-erdő (at Pula village in the Southern-Bakony Mts) can be mentioned. It is important, that in the explanatory notes of the map-sheets there is a special chapter on the occurrences of mineral raw-materials, describing them systematically. The deposits being in exploitation, or partly or entirely exploited, are described; and the economic-geological features permissive of the existence of mineral deposits, which had been recognized in the course of the mapping are dealt with. Attached to the 1:10 000 scale map series of the mountainous areas 4 explanatory notes of the Dorog basin area (1971–1974), 10 of the Mecsek Mts (1972–1979) and 13 of sheets of the Mátra Mts were published. In this time (1970–1978) 7 explanatory notes were edited together with maps on scale 1:25 000 of the Tokaj Mts. The maps compiled on scale 1:200 000 were published in economic-geological version, too. Their explanatory notes provide a good overview of the mineral potential of the areas concerned. In the period (1971–1976) 13 explatory notes were published; two of them had a special chapter for the economic-geological map version, too. The atlases of the Great Hungarian Plain on scale 1:200 000 (the sheets were plotted on scale 1:100 000, but published on scale 1:200 000) include economic-geological versions too, with a brief explanation of registering character (save the "Szolnok" series of maps published 1969 on scale 1:100 000). Fifteen such atlases were published in the 1974–1991 period; the others exist even now in manuscript form only.

The recognition of the alginite filling the basalt crater at Pula village in the Southern-Bakony Mts is an interesting discovery of the decade – a "byproduct" of the systematic and detailed geological mapping. The lithological identification of the material and the clarification of its genesis was followed by search for similar ring structures (done also with remote-sensing methods) and by the subsequent testing of the material filling them (Bence et al. 1979, Jámbor 1976a, 1977a, 1978a, 1979, Jámbor&Solti 1976, 1980). The investigations were extended to other sedimentary basins of confined character, like lagoons etc – e.g. the Miocene swamp-basin of Várpalota can be mentioned – (Solti 1981b) and included also the reviewing of the formations and areas, which could be of interest. (Jámbor 1977b, Jámbor&Solti 1980, Radócz 1981a) – as it was hoped that this rock could be utilized as a new type of raw-material. For this purpose technological tests managed by the Survey had been carried out, which outlined the probability of the broad scale utilization of this material (Solti 1985, Solti&Szabó 1985a, Solti et al. 1985). Some of these possibilities has been proven to be feasible also in the practice, thus finally the alginite was officially registered as a new kind of raw-material. It was also found (Bence et al. 1979) that the crater at some places was filled, partly or entirely, by basaltic bentonite (Várkesző, Malomsok).

In the middle of the decade a perlite prediction for the Tokaj Mts was completed, backed by a map. On the purpose to establish a country-wide prediction of hydrocarbons, systematic geological activity was also begun in that time, including the target evaluation of the Pannonian of Transdanubia and a thorough analysis of the values of vitrinite-reflexion. Occasional commissions given by mining and drilling enterprises, as those of documenting and control of drillings for example, were also carried out. In 1977 the Division of Mineral Resources Prediction was organized, to co-ordinate the prospecting activity. The Survey published the methodological studies of F. Benkő (1977, 1978).

Finally we can mention the investigation of some volcanic formations for quarrying purposes (Papp et al. 1985) This activity included also the testing of several rocks such as the andesite at Hollókő, basalt at Somoskő, and basaltic tuffs in the Kemeneshát region in order to get information on their practical usability. The evaluation and/or exploration of Lower Pannonian clays and of the zone of the fine grained gravels of Pannonian age for establishing their prediction, the compilation of the prediction map of the raw-materials for the cement-industry moreover the investigation of the sulphur and gypsum occurrence at Budajenő (Jámbor 1974, 1976a, b, 1977a, 1978b, 1979, Ravasz&Solti 1980). Together with the explorations for quarryable and construction materials, investigations concerning the reclamation of some areas were carried out as well (Pálfy 1973). The completion and the further development of the rare-metals cadastre was put on the agenda, too.

In 1973 a remarkable event occurred; the annual balance of the raw-material reserves was produced by using computer techniques.

The economic-geological research got more impulse from 1979 on. The preparatory activities for the prediction of bauxite, coal, hydrocarbons and constuction materials –"stones"-- were stressed. This activity was intensified not only geologically but also by the application of computing techniques (Haas&Turczi 1987). All these programmes were accompanied by the compilation of an overview according to geographical areas (thus being of countrywide or regional character) or raw-material types (Csalagovits et al. 1983, Császár et al. 1990, H.-Pakó et al.1985, Vitális 1984, Radócz 1981b, 1985, Solti 1987, Vitális&H.-Pakó 1984, Zentay 1987).

As early as 1978 a Hydrocarbon Prediction Department was organised, followed in 1982 by a Raw-Materials Prediction Department (Radócz 1984). A special department was for prediction methodology, first of all in the field of the bauxite prediction and exploration. Later on its denomination was modified according to this activity (Department of Bauxite Geology).

In the framework of a preliminary programme laid out for the prediction of hydrocarbons (performed systematically since 1978) the hydrocarbon-geological features of the mountainous areas of Transdanubia were surveyed (Horváth et al. 1981, 1982). The molasses and Neogene volcanites were studied as well. Based on this research the hydrocarbon prediction of Northern Hungary became completed, and jointly with the experts of the OKGT (i.e. Hungarian National Oil Company, now called MOL) an overview of the state-of-knowledge of the topic was provided, too. In addition to theoretical considerations (e.g. Laczó 1982) the hydrocarbon prediction was backed also by the drilling of key-boreholes, moreover by doing their hydrocarbon-geological oriented documentation. The coal-prediction map of the region NE of Mór consisting of nine versions and that of the entire Transdanubian Central Range consisting of six versions were plotted in 1980–1981. Prediction maps of ores and alunite were compiled for the area of the Tokaj Mts; the subsequent explorations produced some positive results (Ilkeyné Perlaki 1989).

Ore-geological exploration lasting several years had been initiated (and also terminated) in the Western and Mid-Mátra Mts (Nagy, El. 1983, Baksa&Nagy, G. 1984, Nagy, G. 1988). Explorations aimed at the sulphide ores of Recsk, and at those located in the Balatonfő–Velence Mts zone were carried out (Horváth 1983, 1985, Horváth et al. 1983, Horváth& Ódor 1989). The last mentioned exploration was inspired by the example of Recsk; it was aimed at getting a correct knowledge of the features of a probable porphyry-copper type mineralization at first, but the tasks of this exploration included also the investigation of the possible existence of other sulphide-ores and non-metallic raw-materials. The ore-exploration in the Börzsöny Mts was terminated with only minor results obtained – (Csillagné Teplánszky et al. 1983, Nagy, B. 1983a, b, 1986, 1990, Vetőné Ákos 1982). Also the preliminary exploration and ore-genetical research carried on during one year periods in the Rudabánya area was terminated (Nagy, B. 1982a, Nagy, El. 1983).

The study of J. Cseh Németh (1991) on the Recsk mineralization was published by the Survey. The ore prediction for the entire area of the country, completed in 1987 represented a comprehensive summary of the ore-geological explorations of several decades. A new patch of colour in this picture was the exploration of placer deposits done in 1986–1991 by sampling sandbanks in the river beds and drilling shallow boreholes at some places (Szigetköz, Quaternary deposits of the Maros and Körös rivers, and subordinately, sedimentary rocks of the Oligocene and Miocene).

The investigations of the mineral potential of the Aggtelek–Rudabánya Mts was resumed later in the framework of the systematic mapping of the area (Grill&Szentpétery 1988, Nagy, El. 1990).

The appraisal of areas deemed prospective of Senonian coal reserves (Császár 1981, 1984a, Császár&Góczán 1988, Haas et al. 1984a) was done during the first half of the period under consideration. It was clarified quickly that the area regarded in the first place as permissive of coal was barren (Magyarpolány, Kislőd, Kolontár). This stage was followed by the exploration of the sequence containing economically important seams at Gyepükaján – the SSE margin of which had been known already by bauxite explorations. The productive parts of the coal measures were intersected by drillings in the Devecser area. Prospecting was followed by paleogeographical investigation and reconstruction relative to the extension and zonality of the coal-swamp. Similar studies were initiated–in some cases the prediction had to be revised according to their results-relative to the Liassic coal of the Mecsek region and from 1988 on in case of the Miocene lignites of Borsod county, too.

In the second half of the decade the Survey was entrusted with the exploration of Eocene coals as a consequence of qualifying the preliminary explorations in 1983 as being the competence of the state. The Survey was charged with the executing of the complete process of laying out the programmes, of managment and supervision of the exploration, as well as of the evaluation of the results obtained. The work done in the NE foreland of the Bakony Mts was successful as the seams were found in favourable hydrogeological setting. This exploration was based on foundations laid down with the participation of the Eötvös Loránd Geophysical Institute of Hungary in the sixties already. From the geological point of view the exploration done in the region of Oroszlány had success as well, but the measures of the Lencsehegy-S coal field although having big reserves of excellent quality brown (subbituminous) coal were not found exploitable because of their deep setting. Similarly the coal is lying in big depths in those areas in the N Bakony Mts (stretching between Bakonyszentkirály and Csatka villages) and fringing the Vértes Mts (at Mór and Oroszlány) which we tried to explore at recently. The Pusztamarót coal occurrence is insignificant, while the coal measures in the buried northwestern "counter-limb" of the Vértes Mts are also uneconomical due to depth, erosion and wedging-out (Gidai 1984a, b).

The aim of the explorations was modified in 1986, as the accessibility of the reserves got more emphasis. In the case of the coal this new approach required the exploration of deposits which could be exploited in open cast workings, while the requirements concerning the amount of reserves were considerably reduced: now amounts smaller by even an order of magnitude as those required earlier were taken into consideration. Several such fields had been known already; the Survey carried out the preliminary prospection of some of them, or even did more or less exploration in those areas. (Szomor, Bakonycsernye-Zsidár, Jásd–Vadalmás, Balinka, Nagyesztergár, and the already mentioned Vértessomló, where the opencast mining was in fact started, too). The Survey also participated in the exploration of the short-vived opencast mine at Szápár of Oligocene age.

Preliminary prospection of Miocene coals was carried out on a number of small fields in the counties Borsod and Nógrád in North Hungary. There a number of minor areas were put under revision by doing there some drillings or by drifting adits. These programmes lasted for several years, with only minor expenditures, however, (Dubicsány, Sajóvölgy-W, Balaton-Szilvásvárad, Szorospatak, Karancskeszi, Nógrád). Since 1986 the reserves suitable for surface mining were looked for also in these regions, while the research of areas of medium depths was not given up entirely (besides the above mentioned Karancskeszi, Szanda, Miskolc S, Járdánháza, Hevesaranyos, Sáta-Bóta, Tódebrő, Farkaslyuk, Sajóvelezd, Szuhavölgy, besides others).

Due to the deficient knowledge of some of these areas the brown coal-bearing sequence was found in surprisingly great depths, contrary to the former assumptions. In the Transdanubian Central Range the preliminary prospecting of the Berhida area was a success – although the considerable depth questioned the exploitability of the coal even here despite of the favourable hydrogeological setting. The reserve which became known at Pusztamiske was small, and was found in a somewhat bigger depth as it had been supposed.

It was tried again to find Oligocene coal in the area of Ugod by investigating an already known exposure. Concerning the lignites of Pannonian age, it was deemed expedient to produce an overview of the actual knowledge. This was followed by plotting a series of prediction maps covering the southern forelands of the Cserhát, Mátra and Bükk Mts. This series consisting of four versions was also published (Csilling et al. 1982, 1985).

In 1982–1983, overviews comprehensive of every kind of coal, were compiled. The predictions relative to Senonian and Eocene brown coals were revised and plans were formulated to produce a special coal atlas. Jointly with these activities paleogeographical research was started aiming at the reconstruction of the Senonian coal swamps. The prediction of the Liassic coal was revised. In the northern imbrica-

Table 1

The average values of the borehole-depths drilled in the period of the intensive preliminary exploration subsidized by the state budget.

Raw-material (area)	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Bauxite — Zala	273	353	500	—	—	—	—	—	—	—
Bauxite — Pilis Mts	120	235	—	—	—	—	—	—	—	—
Bauxite — Gerecse	—	110	74	152	149	150	137	84	118	—
Bauxite — NW-Bakony	—	—	172	—	—	192	180	79	95	—
Bauxite — Villány Mts	—	—	—	—	450	244	159	226	42	—
Bauxite — Diszel	—	—	—	—	90	—	—	59	71	—
Bauxite (+sinkholes) total	158	171	112	152	160	171	155	(78)	(108)	(76)
Coal-Senonian	724	831	1480	—	—	—	—	—	—	—
Coal-Vértes	—	603	512	416	376	359	175	231	81	—
Coal-Lencsehegy	—	—	645	436	631	—	758	—	—	—
Coal-Gerecse	—	—	—	88	74	172	115	—	—	50
Coal-NE Bakony	—	—	—	—	451	118	47	195	154	53
Eocene coals total	—	603	529	274	321	380	130	149	123	52
Coal-Borsod	774	218	212	394	291	101	31	34	38	30
Coal-Nógrád	597	836	613	448	347	38	36	37	—	—
Miocene coal-Bakony	—	—	—	—	496	83	—	324	—	—
Miocene coals total	—	—	—	403	322	84	33	63	38	30
Jurassic (Oligocene) coal	—	—	—	—	—	(74)	723	—	68	73
Coal total	695	602	522	316	322	104	114	114	96	52
Coal, deep	—	—	—	—	—	248	420	223	228	—
Coal, shallow	—	—	—	—	—	48	47	30	57	52
Ore+mapping	103	—	—	—	—	—	—	—	—	—
Kaolin sandstone/Kaolin	53	—	—	—	—	—	37	—	—	#
Anhydrite	171	187	—	—	—	—	—	—	—	—
Bentonite	—	—	75	43	43	21	—	27	39	34
Alunite	—	—	—	80	59	—	—	—	—	—
Alginite	—	—	—	40	41	42	—	—	—	—
Placer deposits	—	—	—	—	16	—	—	—	—	—
Phosphorite	—	—	—	—	200	—	—	—	—	—
Pyrophyllite	—	—	—	—	—	83	—	—	—	—
Total	310	298	199	224	108	106	115	87	97	53
Total without coal	210	173	112	121	48	109	116	67	97	55

= Complex kaolin-bentonite-perlite exploration (see at the bentonite)

tion zone of the Mecsek Mts some exploration was carried out by shallow drillings.

The drillings of coal exploration located SE of the Gerecse Mts supplied a lot of data concerning the extension and geological features of the kaolin-bearing sandstone. The Survey tried to register and systhematize them. The results of the perlite (Gyarmati 1982) and kaolin explorations (Kéked, Sárospatak) done in the Tokaj Mts were more important. One of the aims of the so called "sinkhole-exploration programme" commenced in the Transdanubian Central Range was that of finding kaolin deposits. Its other aim was bauxite prospecting. This programme – executed in 1989–1991– was laid out to utilize both the geological and geomorphological experience of the previous geological mapping in the mineral exploration to be carried out on eroded dolomite terrains, where the deposits of these raw-materials filling deep karstic depressions could have escaped erosion.

The exploration of alginite was carried on, along with the research concerning the possibilities of its use (Radócz 1987, Solti 1985, 1988, 1989). The exploration of basalt-bentonite, having similar conditions of occurrence was continued, too– with success at Egyházaskesző (Solti&Szabó 1985b), and with only minor results at Magyargencs and Vönöck. During the eighties bentonite-exploration was done in the Tokaj Mts, too (Kéked, Gönc). In the field of construction, road building, and ornamental stones prediction methodological studies, country-wide prediction, and practical exploration results were produced (e.g. Badinszky&Kéri 1981, Boldizsár 1981, Konda&Mészáros 1984). At the same time the elaboration of exploration and prediction maps on scale 1:100 000 of the counties was in course.

The bauxite geological activity became more varied in this period (Császár&Farkas 1984, Haas 1984, Haas et al. 1985, Jocháné Edelényi 1986, Juhász 1989, Tóth, Á. 1983, 1985). The plotting of preliminary maps for the bauxite exploration (Császár&Csereklei 1982, Haas et al. 1985, 1987, Haas&J. Edelényi 1980), and the publication of exploration results helpful for the prediction were continued (T. Gecse 1980) together with the collecting of data for the planning of surface and underground mining (Juhász 1988, Juhász&Ó. Kovács 1990). A large scale exploration activity was begun, too (Haas&Tóth 1983). The Survey started some activities in order to clarify bauxite-geological problems already in 1982-1983. By introducing into the practice the concepts derived from the analysis of the bauxite geological features in the southeastern Gerecse region, several deposits became known at Tükrös-major, Csabdi and Somlyóvár. In Zala county a complex exploration for bauxite and coal was carried on. Meanwhile, the (timely) tasks of preliminary bauxite prospecting were divided between the Survey and the industrial sector.

The activities of this kind were done, by the former, by determining the exploration programmes, by directing the work and evaluating the results obtained in the areas of Tapolca–Diszel–Vöröstó, Pusztamiske–Kislőd, in the northwestern forelands of the Bakony Mts, in the zone fringing the Gerecse Mts at the southeast, at Gerence-puszta and in the Villány Mts. The exploration programmes for the Gerence-puszta, and Pusztamiske–Kislőd areas as well as for the Csehbánya basin were developed by the BKV (i.e. Enterprise for Bauxite Prospecting and Exploration). (The aluminium industry took part in financing the exploration, but the management of the work and the evaluation of the results was entrusted to the Survey). Following the initial stage of the exploration, however, the consultative connections with the designers were maintained. The Eötvös Loránd Geophysical Institute of Hungary participated in every phase of this work. The complex, key-section like study of the most important lithological types of bauxite in also worth of mention (e.g. Bárdossy&Juhász 1991, Knauer et al. 1993). The results could be utilized in the prediction, planning and sometimes even in the preliminary phase of mine-design.

The role of geological mapping in mineral prediction and exploration programmes was reflected by their explanatory notes written also in this period. Beside the explanatory notes for the 1:20 000 scale sheets of the Bakony Mts (22 of them were published in 1979–1988) that of the 1:50 000 scale map represented a summary (Császár et al. 1990). Notwithstanding, the most of the achievements of mineral exploration were published by the Annual Report of the Survey. Other publications of the Geological Survey of Hungary and some numbers of the periodical Földtani Kutatás ("Geological Exploration") might be mentioned as well (e.g. Mészáros 1980b). It is conspicuous, however, that such studies have never been published in the Földtani Közlöny* (Bulletin of the Hungarian Geological Society) (an exception is the paper of J. Mészáros 1983b).

As mentioned above, in the second half of the decade the economical aspect of exploration, i.e that the raw-material reserves expected should be economically exploitable, got rapidly growing importance. In the majority of cases the chance for exploitability was given by the shallow setting of the deposit, and accordingly the exploration moved into these areas. In some cases the explorations was aimed at very shallow deposits which could be investigated by trenching and pitting (ore, barite, kaolin and alunite exploration in 1987, preliminary bauxite prospecting in 1989–1990). This change in the exploration activities can be seen clearly by comparing the mean depth of the boreholes drilled each year (the running metres of the coal-exploring boreholes had been left out from the calculation) (see Table 1). Until 1986 these averages had been increased considerably by the coal exploration, while later no such a difference can be seen. The entire process passed off along with the decrease of funds available for the exploration and the volume of metres to be drilled. This shrinkage turned rapid from 1989 onwards. This was the year of termination of a number of explorations in the NE Bakony Mts, in the Vértes Mts, in the SE part of the Gerecse Mts. The shallow exploration for coal in the Borsod county, and the ben-

* This was not the profile of this periodical

tonite, kaolin and perlite explorations in the Tokaj Mts were terminated as well. The results of the exploration of Middle Eocene brown coal carried out in several areas of NE Transdanubia were published in this time (Gidai 1989a, b, c, 1990 - according to him the coal is Lower Eocene). A new chapter of alginite exploration was begun by the paleoenvironmental research of the Upper Triassic sequence at Rezi village in the Keszthely Mts. The already mentioned sinkhole investigations, the "shallow" hard coal exploration and the survey of industrial limestones in Transdanubia and the geochemical ore-prospecting in the Tokaj Mts can be regarded as new explorations.

At the same time, the focal point of the Survey's activity has been moved away more and more from the mineral resources. The explorations of this kind were given up in 1992. This can be explained by two reasons: one is the increasing importance of some other branches of the geology, while the other is the fundamental change in the overall social-political structure. This latter resulted in a radical change of the engagement of the state in the geological research activity. According to the new concepts, now the Survey has the task of laying down the foundations in both scientific and informatical sense for the explorations to be done by other, financially independent organizations. From 1994 onwards this programme should be executed by the co-operation of the Geological Survey of Hungary with the Eötvös Loránd Geophysical Institute of Hungary, Hungarian Geological Survey and the Mining Bureau of Hungary.

From of its own part, the Survey began a data processing and interpretation activity, in order to promote the utilization of the mineral resources either in a system of granting concessions or in any other suitable way. Since 1991, numerous documentation packages were compiled for concessional purposes together with some informative materials of regional character (e.g. on road-construction materials, in connection with the concessions for highway construction) and a considerable number of brief notes serving as "advertisements" for mineral occurrences and perspective areas have been written as well. This work is partly of experimental character: and one or more known or supposed occurrences of every Hungarian raw-material are dealt with, save those of bauxite. Due to the special character of the topic, the documentation compiled on the geological conditions of extraction of methane from the Liassic coal seams of the Mecsek region is worth of special mention. The problems of the genesis and migration of methane were studied by the Survey already earlier (Ó. Kovács et al. 1991). In the background of all these activities there are the first steps of an appraisal of the mineral potential on regional and country-wide level, taking into consideration the possibilities of the utilization as well.

Prediction activities were continued, mainly in the field of hydrocarbon geology. They are based essentially on an integrated interpretation of the sedimentological, petrographical and organic-geochemical evidence of the area under consideration ("strategical" hydrocarbon exploration). Among the documentations completed the hydrocarbon-geological characterization of the pre-Cenozoic basement and the study on the Mid-Danubian Basin have to be mentioned. A new field of activity is the research of possibilities of the utilization of thermal energy. For the time being it is difficult to assess the importance of this source in covering some part of the total of energy demand of Hungary. It is by all means an important complementary source of energy, environment friendly and partly renewable. We did the surveying of some minor areas in connection with the compilation of the mentioned concessional "packages". The regional research on hydrothermal energy was begun in the framework of the mentioned study of the Mid-Danubian Basin.

GEOCHEMICAL RESEARCH-ACTIVITY

by I. HORVÁTH

INTRODUCTION

Since the sixties geochemical methods have been introduced at a rapidly quickening pace into every kind of geological research in the whole world. This spectacular evolution was evoked by the recent development of highly sensible analytical methods, suitable for performing mass investigations moreover by their application to geological-geochemical research. During the past decade the processing of the enormous number of analytical data became facilitated by computing techniques and programmes. Thus the age of optical spectrography of only limited use came to end; the science of geochemistry entered into a new, very promising stage in the whole world. The fundamental change in Hungary followed basic international trends with a 10–15 year of delay, but development accelerated during the past five years. Due to this transformation the last twenty-five years of the geochemical research activity of the Geological Surveyreflects changes both in the methods used and in the way of thinking.

The analytical background of geochemistry, the analitical laboratory of the Survey, has a hundred years long past, investigating the rocks, minerals and waters.

Connections have been established with a number of institutions. The research work was helped by collaborators participating in our work by doing investigations specified as follows: the Geochemical Research Laboratory of the Hungarian Academy of Sciences: electron microprobe analyses and light stable isotope investigations; the ATOMKI (i.e. Institute of Nuclear Research of the Hungarian Academy of Sciences): radiometric dating, light stable isotope investigations; József Attila University of Sciences): humic acid and water solved methane determinations moreover investigations by Rock-Eval pyrolisis; Eötvös Loránd University Faculty of Natural Sciences: testing the ammonia content of rocks; University of Horticulture; ICP trace element determinations and by ICP-MS organic matter determinations; the Training Reactor of the Budapest Technical University: investigations of rare elements by neutron-activation method; National Institute for Food Qualification; measurements carried out by gamma-spectrometry; KBFI (i.e. Central Institute for Mining Development) stable-isotope investigations and mass spectrography; MÉV (i.e. Mecsek Ore Mining Company) by determinations, U and Ra; OÉÁ (i.e. National Ore and Minerals Mining Enterprise): analyses of precious metal- and sulphide (polymetallic) ores; MÁFKI (i.e. Hungarian Oil and Gas Research Institute) by technological testing of alginite; VIKUV (i.e. Enterprise for Water Prospecting and Well Drilling) testing of the composition of gases; and the FÉMKUT (i.e. Research Institute of Metal Industry) organic carbon determinations.

During the past twenty-five years geochemistry was present in almost all fields of activity of the Geological Survey. The investigations were not limited by the borders of Hungary. Researchers of the Survey with their work done in geological expeditions abroad contributed to the knowledge of geological formations and ore deposits of Mongolia (Csongrádi&Papp 1988) and Cuba (Kovács, P. G. et al. 1991, Réti 1989, 1992 in press; Réti et al. 1990).

Often the results were not published independently but as parts of monographic publications. The completion of the process was fostered by the critically conceived summaries concerning current problems of the geochemistry by Academician M. Vogl (Földváriné Vogl 1973b, 1974, 1975, 1978, Vogl, M. 1984, Kliburszkyné Vogl 1989.)

Within this short account the geochemical activity of the past twenty-five years might hardly be presented in detail. We summarize the investigations of often overlapping character by arranging them into the following groups; rock chemistry, regional geochemistry, isotope geochemistry, hydrogeochemistry, organic geochemistry and agrogeochemistry.

ROCK CHEMISTRY

Geochemistry of magmatic rocks

Numerous papers are published on the genetics of magmatic formations and processes, discussing the results of investigations concerning the main and trace elements. These investigations have not been connected always to geological mapping.

New knowledge and important experience of interpretation methodology were gained by collecting and re-evaluating earlier analytical data of the young basalts (Jugovics 1976, Vogl 1979, 1980, Ó. Kovács 1990).

Petrographical and geochemical data concerning the geological setting of the phonolites in the Mecsek Mts were evaluated by Viczián in 1971.

The character and regional-structural setting of the Upper Cretaceous potassium bearing lamprophyric magmatism of mantle-origin, discovered during the early eighties in the Velence-Mts, were made known by investigations of the rare earths; of its carbon and oxygen isotopes and main components.

The research was extended also to the rock-forming minerals (Horváth&Ódor 1984, Dobosi&Horváth 1988, Horváth et al. 1983, 1985, 1987).

In course of the investigations concerning the North Hungarian magmatism the ophiolitic character of several terrains was pointed out – not at least by their geochemical features (Kovács&Vetőné Ákos 1983, Kozur&Réti 1986, Réti 1985a, b, 1986, 1987, 1988 a, b).

The comprehensive investigation of the intermediate volcanism of the Tokaj Mts (Gyarmati 1977) revealed the direction of magmatic evolution.

Geochemical research indicated also the originally island arc or thin continental margin type crustal position of Paleogene andesites in the Velence Hills (Darida-Tichy 1987).

Gy. Varga (1992) explained the origin of the potash-trachytes of the Mátra Mts by a potassium metasomatism of andesites.

The fundamental study of the ultrametamorphic granites occurring in the Mecsek Mts was carried out by B. Jantsky (1979) who summarized the results in his D. Sc. Ac. thesis.

The characterization of the of the Velence Hill granite considering also its metallogeny was done by I. Horváth et al. (1987, 1989). Additional data to this study can be found in a paper of B. Nagy (1972).

A rock-chemical study of the Rudabánya-rhyolite was carried out by Gy. Szakmány et al. (1989).

Rock alterations, geochemistry of mineral raw materials

The first metallogenetic map of Hungary which indicates every known ore-occurrence and indication was compiled on scale 1:500 000 by Gy. Raincsák (1993).

Carried out as part of the Börzsöny Mts exploration programme, the investigations concerning the rock-alterations and mineralizations bound to Neogene intermediate volcanites resulted in getting a clear concept about the geochemistry of the postvolcanic evolution affecting the lithological environment of the porphyry-copper mineralization (Nagy, B. 1971a, 1974, 1978, 1980, 1982b, 1983a, b, 1985, 1990; Nagy, B.&Dobosi 1984, Csillag-Teplánszky et al. 1976, Csillagné Teplánszky 1983; Balla et al. 1982, Vetőné Ákos 1982).

B. Nagy (1971b) contributed also to the knowledge of the ore-mineralization in the Mátra Mts.

The rock alteration process evolved during the Paleogene volcanism of the Velence Mts was studied in the course of the ore geological mapping of that area (Ódor et al. 1983; Daridáné Tichy et al. 1984, Darida-Tichy 1987).

Indications of rare elements occurring in the Sarmatian thermal-spring formations of the Tokaj Mts were studied by I. Vető (1971b).

The two-phased pseudohydrothermal character of the Lower Triassic stratiform ore deposits of the Carpathian Basin was recognized in the course of investigations on mineralizations bound to sedimentary formations (Csalagovits 1973a, b, c).

Contributions to the knowledge of the Rudabánya ore-mineralization were published in the papers of U. P. Fügedi (1977) and B. Nagy (1982).

Metasomatic phenomena known in the northern part of the Bükk Mts were studied by K. Böjtösné Varrók (1974).

Gy. Raincsák (1977, 1984) studied the Lower Triassic ore-indications of the Balaton Highland and determined the boundaries of prospective areas.

L. Korpás (1980) used geochemical data for dating Upper Triassic bauxite indications. The mineral composition of the Halimba-bauxites as it could be determined by calculations based on chemical data was studied by E. Jocháné Edelényi (1981). The mode of occurrence of the Mn in the bauxite along with the preconditions of concretion-forming were investigated by E. Juhász and M. Szentandrássyné Polgári (1986). By making use of geochemical data E. Dudich and A. Mindszenty (1983, 1984) compared the bauxite of the Villány Mts with those of Transylvania. The fact that the Upper Cretaceous and Eocene bauxite horizons of the Halimba deposit occurrence have different geochemical featurers was established by E. Juhász (1989). The investigation of the dia- and epigenetic evolution of bauxite facies together with the geochemical study of their main elements adapting up-to-date statistical methods was carried out by E. Juhász and L. Ó. Kovács (1990). Some problems of bauxite genesis were resolved by comparing by geochemical methods the Senonian bauxite deposit of Ajka with other Senonian deposits (Knauer et al. 1993).

The trace elements of the Lower Liassic coal measures of the Mecsek Mts together with those of the barren interbeds were investigated by I. Csalogovits and M. Víghné Fejes (1969). The berillium content of the Transdanubian browncoal deposits of Eocene age was studied by L. Ódor (1971); I. Vető was engaged in the research concerning the trace elements of Upper Pannonian lignites in 1973, Á. Jámbor and Gy. Wolf (1985) based a study concerning the geological importance of the chemical pecularities of Hungarian coals on spectroanalytical data.

Geochemistry of sedimentary rocks

The geochemical conditions of sedimentation under temperate climate were summarized by I. Vető (1971a). The geochemical conditions of the formation of mottled clays were discussed by G. Rischák (1984). New results were obtained by investigating the conditions of the recent sedimentation in the Lake Balaton. (Cserny 1987b, Cserny&Corrada 1989, Cserny et al. 1991).

By considering geochemical data A. Gheith (1981) had analysed the facies characteristics of Upper Pannonian and Pleistocene sediments intersected in the Dévaványa – drilling and came to a conclusion about the depositional environment of the sequence. In the course of detailed investigation of the Pannonian formations of the Transdanubian Central Range Á. Jámbor (1980b) studied of the main elements of argillaceous rocks. He pointed out the subordinated role of trace elements in the Pannonian sequence, and investigated the changes of salinity. G. Solti (1981) explained the genesis of the Pula geyserites using Ba and Sr data. In the course of the mineralogical – petrographical study of Miocene rocks of the E Mecsek region the data of their trace element spectra were evaluated by Ravaszné Baranyai (1973) in order to characterize the sedimentary cycles. The geochemical data of the Tengelic borehole were interpreted by J. Halmai et al. (1982); G. Chikán (1991) used also the main- and trace elements of the Cenozoic formations in the W Mecsek region to characterize these rocks. E. Dudich (1981) published new geochemical data on the Eocene of the Bakony Mts. For the comprehensive investigation of Lower Cretaceous rock samples collected in the Tatabánya region M. Földvári et al. (1973) and I. Viczián (1973) utilized the data of their elemental composition. The geochemical evaluation of the main and trace elements composition of Triassic formations and key-sections was carried out by I. Csalagovits and E. Nagy (1973), moreover by J. Haas et al. (1986; Haas, Tóthné Makk, Góczán 1988; Haas, Tóthné Makk, Oraveczné Scheffer 1988). For the characterization of the Kössen-beds geochemical data were used too, by E. Kristan-Tollmann et al. (1991). The pulverulent dolomites of the Buda Mts were geochemically characterized by B. Nagy (1979). Á. Tóth and É. T.-Gecse (1981) by re-viewing the relevant publications elaborated a model of dedolomitization. The processes were demonstrated on examples taken from the Nagyegyháza basin area.

REGIONAL GEOCHEMICAL RESEARCH

The first systematic geochemical study of the Hungarian geological formations was done in the second half of the sixties by laying out the National Programme for Exploration of Rare Metals. Investigations on every important formations of Hungary were included in this Programme. This work was executed from 1966 to 1970 by the Rare Metals Research Group formed and directed by Academician M. Vogl. The analyses made during this period have laid the basis of the National Rare Metals Database consisting of 25,000 punched cards. Conclusions drawn from the results served as theoretical base for the regional prospections of the seventies. The results of general importance were summarized by M. Földváriné Vogl (1975, 1978), while the specially oriented research activities were reported on by the members of the research group (Böjtösné Varrók, K., Csalogovits, I., Nagy, B., Ódor, L., and Vető, I.). The base level values of the Hungarian Mesozoic formations were determined by I. Csalagovits.

The first regional-unit exploration was carried out in the Börzsöny Mts by the lithogeochemical sampling of natural outcrops and artificial exposures (Nagy, B. 1971a, 1972a.) The geological and ore-geological survey performed from 1970 to 1980 was accompanied by electrochemical (Eh and Ph determinations; G. Nagy 1973) and hydrogeochemical (Nagy, B. et al. 1973) determinations only. In the anomaly-field of the SW Börzsöny Mts in some profiles the samples of shallow boreholes were tested by mass spectroscopy (Nagy, G. 1976b) together with doing "filling in" electrochemical measurements.

The "Investigation of the Darnó Structural Belt" programme (Böjtösné Varrók 1973) was initiated in the first place to predict the occurrence of ore deposits in the Aggtelek–Rudabánya, Szendrő, Uppony and Bükk Mts by using geochemical methods. In the Aggtelek–Rudabánya Mts soil and rock samples were collected on a 800 m – to 800 m grid subsequently to investigations of the channel deposits of brooks (Vető 1972). From 1971 on the survey was extended to the areas of the Szendrő, Uppony and Bükk Mts too. The metallometric map of this region was completed in 1975 on scale 1:100 000. Simultaneously with the closing of the above mentioned spacing of the sampling grid in areas considered anomalous, geological re-mapping on scale 1:25 000 was done.

The interpretation of palaeovolcanites occuring in the Rudabánya–Aggtelek Mts was accomplished by É. Vetőné Ákos (1988) upon her own data as well as previously collected ones.

The complex geological survey of the Aggtelek–Rudabánya Mts started in 1980, aimed at elucidating some basic geological problems debated for many decades. The primary objective of this project concerned structural and stratigraphical conditions, whereas soil sampling in regular network was restricted to limited areas.

The first computerized geochemical maps of the Mórágy granite block and the Mid-Mecsek areas were completed in 1977. These maps have soil- and lithogeochemical versions (Fügedi& Csalagovits 1977).

On-grid metallometric survey was carried out in the NE part of the Velence Hills in 1979-1980 covering an area of 11 sq.km where the preceding IP measurements had been permissive of mineralization. Samples of soil and rock-fragments were collected on the points of geophysical measurements on a 50 m to 100 m grid. Between Nadap and Pázmánd a deep-seated porphyry-copper mineralization may be suspected under the metasomatic rocks (Ódor et al. 1982).

The 1:50 000 scale geochemical survey of the central and western Mátra Mts was carried out between 1980-1985. (Nagy, G. et al. 1986). This mapping was completed with a minor lithogeochemical sampling performed in the Asztagkő–Üstökfő area (Csongrádi 1984). Metallometry was combined with investigations of the channel deposits of the brooks using various methods, like testing the samples of their fine fraction and the panned material.

By using modern methods of evaluation and by various filtering techniques not only the geochemical and tectonical setting of this region became more precisely known, but the detection of a number of veins and the prediction of considerable ore reserves was also managed. The mineral assemblages of the Parádfürdő and Gyöngyösoroszi mineralizations was studied by B. Nagy (1985b. 1986).

The introduction of quantitative, and very sensible analytical methods (like AAS, ICP) resulted in the sudden improvement of the quality of the field surveys, providing in this manner the solid foundations for plotting the first geochemical map of Hungary, and for the establishment of an up-to-date data base. The first step in this work was the reconnaissance type geochemical survey of the Zemplén Mts during the years 1989–1990. The sampling was carried out by using four methods simultaneously: samples were taken from the panned sediments and from the fine fraction of the channel-deposits, from the soil and from rocks. (Ó. Kovács et al. 1991, Hartikainen et al. 1992, 1993). By using this technique not only the already known mineralized areas could be contoured, but also the detection of new ones, and the better knowledge of the environment quality of the region investigated could be managed. The detailed geophysical-metallometrical survey of the Koromhegy ore-indication contoured considerable traces of hydrothermalism (Horváth et al. in press). By carrying out the detailed sampling of the channel deposits the exploration of the other areas which have been found perspective is going to be completed in 1994.

Comparing the various surveying methods used in the Mátra- and Zemplén Mts it became unambigous, that under the geographical-climatical conditions of Hungary in case of medium scale surveys the most suitable sedimentary material for the sample taking is the fine fraction of the channel-deposits, while ore-prospecting has to be based on the sampling of the A horizon of soils. At present the regional geochemical map of Hungary is being plotted in the framework of the National Geochemical Surveying Programme. This complilation which is based on the sampling of fine grained sediments of flood-plains so as each sample represents 300–400 sq.km area is attached to the joint programme of the Western European Geological Surveys and to the IGCP Project 360 "Global Geochemical Baselines". The geochemical mosaic-maps should be completed in 1996. Sample taking from channel deposits is in course in montainous areas 11,000 sq.km and covered by Prepannonian formations. Each sample represents 4 sq.km. The completion of this exploraton is foreseen for 1996. Both surveys is aimed also at a realiable understanging and characterization of the environment.

In the past few years, *environmental-geochemistry* became one of the most important research activities. Along with the collection of data on waters and rocks, also their environmental geological evaluation was begun (Ódor et al. 1992). In the geochemical surveys (of waters and rocks) which are in progress particular attention is being paid to the special environmental points of view.

ISOTOPE GEOCHEMISTRY

The Geological Survey has had no mass spectrometrical investigation facility for isotope-geochemical investigations. Such demands had to be covered by external co-operation. In one of the most important branch of our research activity, namely in the K/Ar radiometric dating, we co-operated with the ATOMKI (i.e. Institute of Nuclear Research of the Hungarian Academy of Sciences) in Debrecen. The results of this joint activity are discussed by G. Császár in the paper on stratigraphy.

Considering data published in the literature S. Rózsáné Nagydiósi proposed (1982), that the age of limestones should be determined by the U/Th method. The investigations on the C and O isotopes of the carbonates of lamprophyric and silicocarbonatitic rocks of the Velence Hills have established the mantle-origin of these rocks. (Horváth&Ódor 1984). The results of investigations of the anomalous lead-isotope content of the Transdanubian bauxites were summarized by E. Dudich et al. (1985).

T. Cserny and R. Corrada (1989) carried out the readioactive dating of the peat intersected in the Lake Balaton by bottom-drillings.

Stable light isotopes were used to determine the recharge, age and origin of deep subsurface waters (Marton&Mikó 1990, Mikó&Marton 1992).

T. Hámor and E. Hertelendi studied the early diagenetic evolution of sediments by taking as starting point the sulphur-isotope composition of sedimentary iron-sulphides (1991). Investigations concerning the enrichment of ^{13}C in the marine kerogenes of Oligocene age led to the estimation of the amount of CO_2 in the atmosphere of that time (Vető et al. 1992).

The succession of ore-forming processes in the Börzsöny Mts was established by L. Korpás and B. Lang (1991) using the method of Ar/Ar dating.

HYDROGEOCHEMISTRY

The study of the chemical composition of subsurface waters which has been part of the Survey's activity – intimately attached also to hydrogeology – independently or in the framework of the geological survey of lowlands, and having varying but always important role, ensured the country-wide overview. The state of the lowland groundwaters is presented by atlases and studies published in the period under consideration. (Rónai 1969, 1974, 1975a, b, 1978, 1980a, b, 1983, 1987a, b, Rónai et al. 1979, Rónai&Kőrössy 1983, Rónai&Szepesházy 1979, Kuti&Kőrössy 1986, 1989, 1991, Kuti et al. 1981, Boldizsár et al. 1990, 1991a, b, 1993 Scharek 1982, Kuti 1977a, b, 1979, 1989, Kaszab et al. 1982).

The explanatory notes for geological maps which contain also hydrogeochemical data relating to the area considered are too numerous be listed here.

Data on the chemistry of karstic waters were published by M. Földi (1972) I. Dér and I. Venkovits (1986, 1990).

Perhaps it is in the geochemical research of confined and thermal waters that the most far-reaching co-operation with the scientists of other institutes has been achieved (Liebe et al. 1984, Egerer et al. 1985, Tóth, Gy. 1989, 1991a, Gál&Ó. Kovács 1991, Franyó 1992). The studies accomplished in externally managed OTKA (i.e. National Scientific Research Fund) projects (Varsányi&Ó. Kovács 1993a, b, in press) resulted also in the recognition of the fact that in this field for the completion of the investigations and/or interpretations broad professional co-operation is needed. For the time being the cooperation established with the OKI (i.e. National Institute of Public Health) should it be under the management of the OTKA or independent from it – ensures that the research of mineral and thermal waters can be based on wide ranging first class quality investigations. Moreover, it promotes the study of the geological-geochemical origin of arsenic bearing confined waters (Csalagovits in press).

The salinity-history of the Pannonian sea was studied by Á. Jámbor (1978b).

ORGANIC GEOCHEMISTRY

In the geochemical utilization of data concerning the amounts, origin and maturity of organic matter roughly four fields of research, often of partly overlapping character can be outlined. Each of them is under investigation in the Survey, although with diverse intensity.

Maturity zones, reconstructions of thermal history

The recognition of the partially immatured character of the Mesozoic sequence of the Transdanubian Central Range is an important result of the seventies (Lelkes et al. 1973, Lőrincz&Vető 1976). In connection with the hydrocarbon prediction of the Transdanubian Central Range it was found probable that the top of the zone of oil-generation lies within the Triassic sequence. (Horváth et al. 1981, Vető 1988a). The Mesozoic formations of the Mecsek and Villány Mts reached maturity already during the Cretaceous (Iharosné Laczó 1980), while the organic matter of the Upper Cretaceous sequence of the Zala basin became mature during the Neogene subsidence (Iharosné Laczó&Vető 1985). The different methods of maturity estimation based on diverse considerations of the thermal-history were compared in Hungary as early as the first investigations of this kind were done in the world (Vető 1980, 1981, Vető et al. 1984, Vető&Dövényi 1986). The origin of the redeposited vitrinite which can be found aboundantly in the Pannonian Basin and the increase of maturity during the Neogene and Quarternary burial were investigated by I. Laczó and Á. Jámbor (1988a, b). The development of the maturity of organic matter in the Hungarian part of the Pannonian Basin and the metamorphism of the clay minerals were studied; the dependence of maturity on depth was determined in relation to the partial basin units. (Hámor-Vidó&Viczián 1993). The Survey performed maturity investigations also for the ÖMV (i.e. Österreichische Mineralölverwaltung AG.) and for the University of Copenhagen. In the field of organic petrography the Survey is in scientific collaboration with the BGR (i.e Bundesanstalt für Geowissenschaften und Rohstoffe-Hannover) (M. Hámor-Vidó).

Paleoenvironmental reconstrucions

The investigations of organic matter has a large spectrum of application possibilities for the paleoenvironmental reconstuction s. l., considering also the effects of becoming buried early – of anoxic marine environments (Bruknerné Wein&Szűcs 1982, Brukner-Wein et al. 1985, 1990, Hertelendi&Vető 1991, Vető&Hetényi 1991, Vető et al. in press) – of coal swamps (Brukner-Wein&Sajgó 1990, Hámor-Vidó 1992b, 1993) – of eutrophic crater lakes (Solti&Vető 1989, Brukner-Wein et al. 1991, Hetényi&Brukner-Wein 1993, Brukner-Wein&Hetényi 1993), moreover of sediments intersected during the activities of the DSDP (International Deep Sea Drilling Programme) (Brukner-Wein et al. 1985, Vető et al. in press).

Correlation of hydrocarbons and their source-rocks, migration

Thematic investigations pointed out the probability of Upper Triassic age for the source-rocks in Nagylengyel and also for those of the oil-traces known in the Pilis Mts. These are part of the Kössen-beds (Brukner-Wein&Vető 1986) or of the Mátyáshegy Limestone Formation (Wein-Brukner&Vető 1985, Vető in press). During the research begun at the end of the seventies valuable knowledge was gathered on the generation, migration and accumulation of natural gas. A minor part of the results was presented at international conferences (Szűcs et al. 1982, Gajdos et al. 1992, Vető et al. 1993). It has been pointed out, that the commencement of the thermal genesis of hydrocarbon-gases is observable the Pannonian basin between the 700 and 1,300 m depth levels. A major part of the natural gas reserves which have become known in the Tiszántúl flysch-belt were generated by the Upper Cretaceous-Paleogene flysch sequence during the formation of the Pannonian basin. The highly complex composition of the gas resulted from the mixing of the fluids arriving at different times into the reservoir. The interpretation of the thermal genesis and migration process of hydrocarbon-gases in molasse-basins is facilitated now by computerized models (Vető et al. 1990, Ó. Kovács et al. 1991).

Organic matter and human environment

The role of the organic matter in sedimentation of the Lake Balaton had been recognized in details (Bruknerné Wein 1988). It has been pointed out that deep aquifers with methane content can be found in Hungary first of all in the areas having thick Quaternary cover. Systematic measurements clarified how does the methane content of the subsurface waters change during their exploitation (Galbács et al. 1978, Galbács&Kaszab 1979, Kaszab&Galbács 1981). Thus the amount of methane entering into the atmosphere and contributing to the greenhouse effect can be estimated (Vető 1992).

AGROGEOCHEMISTRY

It follows from the geological character of the Carpathian Basin that the most important natural resource of Hungary is the soil. The processes of soil genesis, the migration and accumulation of biogene elements, the leaching of nutrients of vital importance for vegetal life: the geologically controlled evolution and agricultural importance of these conditions intrigued the Hungarian geologists since the very beginnings (Rónai 1980c, 1982). In the framework of the lowland-mapping also plotted agrogeological agrogeochemical versions were. (Rónai 1969, 1974, 1975a, b, 1978, 1980a, b, 1983b, 1987a, b, Rónai et al. 1979, Rónai&Kőrössy 1983, Rónai&Szepesházy 1979, Kuti&Kőrössy 1986, 1989, 1991, Kuti et al. 1981, Boldizsár et al. 1990, 1991a, b, 1993). Up to the early eighties the attempts of interpretation (Fügedi&Kuti 1982) were aimed at the comparison of the trace-element content of different soil horizons – with only limited success.

The research on the mobile micronutrients became feasible with the introduction of highly sensible and accurate analytical methods (Bartha et al. 1988, 1989, Kalmár 1993). Appreciating the results obtained by the method which had been elaborated for the research of agrogeological model areas (Bartha et al. 1988b) the Committee of Geotechnics and Engineering-Geology of the CBGA (Carpathian-Balkan Geological Association) put the international introduction of this method in its agenda.

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This summary was compiled with the collaboration of I. Csalagovits, U. Fügedi, L. Ódor and I. Vető.

ENVIRONMENTAL GEOLOGICAL RESEARCH

by GYÖRGY TÓTH, LÁSZLÓ KUTI, TIBOR CSERNY

INTRODUCTION
(by Gy. Tóth)

In this report we introduce mainly those research projects that study the existing and potential interaction between Man and his geological environment.

Although research has been done in the framework of many projects and other organizations in different departments, in a narrow sense it meant the hydrogeological, engineering geological and agrogeological survey, and the activity of geological nature protection.

Research generally followed the possibilities of the Survey, and adjusted itself to the tasks and resources (e.g. printing office, library, data base, laboratories, etc.). Its advantage was, that the Survey could function as a whole, and could preserve the continuous research of the basic tasks recorded in its Deed of Foundation. The fact that most of the work fulfilled the demand of "here and only here", made it possible that unnecessary research didn't dominate. Moreover, environmental research (hydro-, engineering- and agrogeological) was carried out in co-operation with other institutions (academy, universities, etc.). Environmental geological research built connections with applied organizations for the whole Survey.

However, this applied geological research only represented 10–20% of the total research of the Survey, which sometimes made co-operation with external organizations very difficult sometimes, and required significant efforts from the geologists and technicians.

We have to mention that in the first 20 of the past 25 years, research had to conform primarily to the aims and trends of the higher authorities, whereas the real social requirements were subordinate. The five-year plans and the huge national research programs didn't follow the changes of economy and environmental protection with sufficient nimbleness. During this period, some big state investments started, which had serious environmental effects (e.g. the "Eocene program", which aimed to develop coal mining in those areas where karst water meant a serious danger, the hydroelectric plant at Gabčikovo-Nagymaros, the nuclear reactor at Paks and the problem of its radioactive waste disposal). During the preparation and realization of these investments, the assessment of comprehensive evaluations made by experts from the Geological Survey were insufficiently considered. During the social conflicts connected with these state investments, the researchers of the Survey had a serious responsibility to preserve their independence and integrity.

The economic and political changes of the past 3–4 years raised further problems in the environmental geological research of the Survey. Due to the financial difficulties and the radical decrease of the staff, these branches were also reduced. However, the social requirements significantly increased at the same time. The different enterprises, institutions, educational organizations and authorities, which deal with environmental protection, and whose number rapidly increased, all demanded the environmental geological data of the Survey. The end of closed administration of data in Hungary and in the neighbouring countries makes possible their wide-spread utilization.

As a result of the worldwide upgrade of the environmental values, most of the international scientific projects study this topic. Besides the basic research, the geologists, who deal with environmental geology in the Survey have to be familiar with the new analytical and evaluation methods, like ICP–MS, GC–MS, GIS techniques.

If we analyse the environmental research of the Survey during the past few years, we can say, that due to the new project system, the different environmental geological tasks are present in most of the research branches. The "complex" geological mapping has been carried out not only on the low-land areas, but in the mountain regions, too. At the same time, most of the work of the different projects of basic research, geochemistry and raw-material prospecting are dealing with various environmental problems, like suitable sites for radioactive waste disposals, water quality problems of the water power plant at the upper reach of the Danube or the research of geothermal energy.

The Survey is gradually focusing its work to those regions, which are of environmental geological importance (Great Hungarian Plain, Szigetköz, Lake Balaton, NE Hungary).

After the above summarized general introduction, we present the results of the different topics of the past 25 years according to the publications and reports of the following colleagues:

Environmental geology s. str.: Péter Bohn, György Raincsák, Gábor Józsa, Jenő Ivancsics, György Gyuricza, Miklós Kassai, Loránd Moldvay; *Hydrogeology:* András Rónai, Lajos Szebényi, György Tóth; *Engineering geology:* Zsuzsa Raincsák–Kosáry, Tibor Cserny; *Agrogeology:* László Kuti, Tibor Zentay, András Rónai, Gábor Solti; *Geological nature protection:* Péter Bohn, Tibor Cserny, Géza Császár, László Kuti.

ENVIRONMENTAL GEOLOGICAL (S. STR.) RESEARCH
(by Gy. Tóth)

However the environmental geological research projects of the Survey were organized at different times and aspects, its principles were the followings:

– the projects should follow the basic activity of the Survey, i.e. the systematical survey of the subsurface, the pulication of the data and the possibility of their various employment, and the indifference between the various scientific and industrial branches;

– the Survey must supply public purposes (expert's opinions, preparation of laws, technical requirements), and give information to the government, scientific research and enterprises.

The history of the Geological Survey, and the events of the sixties had a fundamental effect on the development of the environmental geological tasks. During this period the geologic maps of Hungary at 1:200 000 scale and their explanation volumes were edited, rested on the firm foundation of the work of the Regional Geological Surveys since 1969, and which also promoted geologic mapping on the Great Hungarian Plain at 1:100 000 scale. Besides these two activities, attention was also paid to engineering geologic mapping, which surveyed the geological environment affected by human activity. We have to mention that L. Moldvay was the first who made methodological developments in the field of environmental geology in the Survey and applied them in Lake Balaton and Baranya Hills regions.

Lake Balaton has called our attention with an increasing eutrophication, upset of ecological equilibrium, silting up. In order to have a better knowledge of these problems, specialists of the Hungarian Geological Survey have been investigating the lake, including its catchment area, since 1981. The environment geological investigations of the lake are still in progress but are expected to be accomplished in the near future (Mihâltz 1983, Cserny 1987b, 1993, 1994, Brukner-Wein 1988, Cserny&Corrada 1989, Bodor 1987, Cserny et al., 1991, 1992).

The investigations into Lake Balaton were carried out by 33 boreholes drilled into the lake bed, by laboratory analyses, like sedimentological, geochemical tests, and by mineralogical, petrological and paleontological studies. This stage of the investigations has allowed us to have a knowledge of the most important features of the present lacustrine deposits and the specific features of carbonate muds. A continuous geophysical (seismo-acoustical) logging was performed, in a total length of 370 km. The study and evaluation of reflection logs and boreholes have allowed us to get a picture about the spatial distribution of the lacustrine deposits, the mud structure, as well as the diverse morphology and structure of the basement of Lake Balaton. By using up-to-date isotopegeochemical analyses and extending the range of paleontological analyses (palynology, diatoms, ostracods, molluscs), an outline of the geohistory of Lake Balaton and its environment, including the paleoecological and paleoclimatic conditions and the velocity of the silting up of the Lake have been given.

Because of the more and more urgent environmental protection problems, geological maps of vulnerability were edited by the Regional Geological Services at 1:100 000 scale, first in southern Transdanubia in the 2nd part of the seventies, then in the whole country. Finally the conclusive version at 1:500 000 scale was also compiled (Kassai 1988). The importance of these maps is, that they are easy to understand: "The vulnerability map is based on geological considerations and is made for planning. It functions as a traffic lamp: red is forbidden, the surface is sensitive to contamination, waste disposal is prohibited; yellow calls attention, and in green areas waste may be disposed. (The particular places are classified based on their survey)" (Kassai 1993).

Beginning with the 2nd part of the seventies, more and more plans of different level arrived at the Regional Geological Services for scientific evaluation (Józsa 1992). During this work, mainly on siting waste depositories, environmental geological aspects are more and more taken into consideration. Lately, environmental protection plays an increasing role in the establishment of (hazardous) waste depositories in the counties. Further work can develop in two directions. In the most important regions, the vulnerability maps at 1:25 000 scale, and the maps for the establishment of waste depositories at 1:10 000 scale have been carried out, and the collection of data for a complex map of prognosis at 1:100 000 scale has also started.

Until the end of 1992, maps of nine counties in five versions were ready (map of the utilizable raw-materials, map of the surface- and groundwaters, map of the hydrogeological properties, environmental geological and contamination-sensitivity map, complex geological map for utilization of the area) (Ivancsics&Raincsák 1993). Besides the geological mapping of low-land areas (Great and Little Hungarian Plains), carried out by the Regional Geological Services, and the environmental geological aspects of the engineering geological mapping, the independent Department of Environmental Geology was established in 1987 with a few employees (Bohn 1992).

The tasks of this department were:

- methodological research (environmental geological qualification of the different lithostratigraphic units);
- the establishment of rules about the environmental geological requirements during state investments (hydroelectric and atom-power stations, linear establishments);
- the establishment of rules about the environmental geological requirements at different types of waste depositories (radioactive, hazardous, not hazardous, solid, liquid);
- environmental geological research of the most endangered regions of the country.

In 1992–93, environmental geological research in the Survey was carried out in a uniform program. Both the local experience of the Regional Geological Services, and the methodological research of the Environmental Geological Department were taken into consideration when preparation of the cadastral survey of the present and former sources of contamination (waste disposal, mine tailings, industrial establishments) began (Bohn&Gyuricza 1993). The computer database of environmental contamination in Hungary (ENVIROGEODAT) has also begun to work (Tóth 1993).

The year of 1994 brought a new situation. As a consequence of the XLVIII/1993 law about mining, the Regional Geological Services primarily function as geological authorities.

Because of the drastic reduction of financial support and of the number of staff in the Geological Survey, now only the work of one project, entitled "Environmental geological survey of some important regions" has been carried out in northern Hungary (survey of potential sources of contamination in the region of sensible aquifers, edition of vulnerability maps for the planned common environmental geological research between Ukraine, Slovakia and Hungary).

In addition, we were also commissioned to do some important environmental geological research connected with radioactive waste disposal, and some aquifers (karstic areas in the Bükk and Aggtelek Mts, bank-filtered aquifer system of the Szigetköz region).

HYDROGEOLOGICAL RESEARCH
(by Gy. Tóth)

The Hydrogeological Department of the Geological Survey, which was established in 1963, and ceased in 1992, was one of the most important places for hydrogeological research in Hungary. András Rónai, who recognized the faulty decision to close the department, considered the survey of groundwaters to be one of the most important tasks of the complex geological mapping on the Great Hungarian Plain at 1:100 000 scale, which started in 1964.

The shallow bore-holes drilled during this program yielded a huge amount of data about the soil groundwater (mean water level, discharge, water quality). The 74 bore-holes at 35 sites were converted to wells, which made possible the interpretation of well-logs, and the establishment of new hydrogeological models. The data of the continuous registration since the establishment of the observation network (Csaba 1974, Rónai 1971, Tóth 1986b) are indispensable pieces of information for the water supply of the region. Due to this research, from a hydrogeological point of view, the Great Hungarian Plain became one of the best known young sedimentary basins. The atlases that introduce the results of this survey are the data base for any further environmental geological, hydrogeological, or agrogeological research, as well as for areal development.

The geological mapping on the Little Hungarian Plain, which started in 1982, was based on the complex geological survey of the Great Hungarian Plain, and also paid attention to the hydrogeological research (Síkhegyi 1984). An outstanding result was, that the hydrogeological conditions in the Szigetköz area were recorded, even before the human impact connected with Gabcikovo-Nagymaros (Tóth 1991a). The fluvial sediments, which can be considered as a hydrogeologically uniform body, were drilled and surveyed by geophysical methods, moreover registration wells at different levels were also established.

Some of the geological mapping programs (Inner Somogy–Baranya, Bükk Mts and its forelands) from the eighties paid attention to hydrogeological research, too; observation wells were established, and spring-discharge and water-quality analyses were also carried out.

The Hydrogeological Department in the Geological Survey was renewed at the beginning of the seventies, under the leadership of Lajos Szebényi. The department, and its "successor" projects have three main tasks:

(1) national hydrogeological research and its interpretation;

(2) hydrogeological research of regions;

(3) methodological research, interpretation of model areas.

In the seventies, the most important task was the research of groundwater movement in the Pannonian-Pleistocene basin areas. The complex hydrogeological research, which included the survey of the Upper Pannonian thermal waters, finished with the publication of a map, which introduced the water movement patterns of the shallow groundwaters (Szebényi 1974, Tóth 1986a).

Following this work, national hydrogeological maps were prepared at 1:500 000 scale – the "Hydrogeological map of Hungary" (Siposs&Tóth 1989) and "Map of mineral and thermal waters" (Tóth 1989)

The program of "Hydrogeochemical survey of Hungary" started in 1982. The aim was to sample and analyze all the groundwaters of the country, and to determine the genesis of the various components. During the first phase of this work, the so called "medium zone of currents" were analyzed, which is the most important deep-origin supply for drinking water, together with the waters descending from the catchment areas in the mountains. The results were published in the Hydrogeochemical Atlas at 1: 1 000 000 scale in 1985 in co-operation with Miskolc University (Tóth et al. 1985). During the second phase, from 1985 to 1990 deep-origin waters, connected with hydrocarbons, and thermal waters were surveyed. In the third phase (from 1990), we investigated the shallow groundwaters and some model areas (e.g. research of waters with nitrate content in Szabolcs-Szatmár, the bank-filtered aquifer system in the Szigetköz region, the contaminated karst water at Balaton–Berhida, the groundwater at Dombóvár, the karst water system at Hévíz-Nyirád, the arsenic-content waters in the southern part of the Duna–Tisza interfluve; Gál&Ó. Kovács 1991).

In eastern Hungary, isotope hydrogeological analyses were carried out, in addition to the hydrogeochemical investigations (Marton&Mikó 1989).

Now there is a separate project for hydrogeochemical investigations in the Geological Survey. Its activity is presented in the geochemical report by Horváth, I.

The huge amount of the different hydrogeological data necessitated the establishment of a computer data base. The INWESP system contains the most important data of the deep wells, their supplementary hydrogeochemical data, and the time sequences of the wells of the observation network established by the Geological Survey (Tóth 1982).

The Hydrogeological Department started the supplementary hydrogeological mapping on the mountain areas in the seventies. During this work we analyzed the water movement patterns. The hydrogeological map at 1:150 000 scale of Borsod county and its surroundings was published in 1978 (Deák&Szlabóczky). In 1983 the hydrogeological atlas of the western part of North Hungary was issued (Horváth&Tóth 1984). The plan of the informatic system of the Transdanubian Central Range, which was issued in 1985 by T. Böcker and Gy. Tóth, was based on the conclusions of these two atlases. The hydrogeological research of the karst waters in the Transdanubian Central Range (1993–1996) has considered the results of the above mentioned projects, and its aim is the establishment of a more precise model for karst water rehabilitation. The geological-tectonic model, which is necessary for this work, is provided by the huge amount of data, which accumulated in the Geological Survey during the geological mapping on the Great Hungarian Plain and other raw-material prospecting.

The observation network of the Geological Survey is composed of the wells established during geological mapping of the mountain and low-land areas, and the key-bore holes, which were transformed later. Some wells have data sequences as long as 30 years. Although most wells were drilled to study a certain hydrogeological problem, regular and reliable registration has made them important parts of a mean-water-level registering network in the country, and they regularly supply data in this function, too. For most of the wells, there is a regional registration with different instruments, in the past few years even in digital form. The most important "element" of registration is a reliable person. This work has been carried out by István Venkovits, Zoltán Kuchen and László Csaba during the past three decades. In the past few years the system was completed by the registration in the Bükk Mts during geological mapping (the project leader was Géza Nagy until 1993).

The wells register the further situations: multi-level observation of the groundwaters in basin areas, the natural infiltration through the river-bank aquifer in the Little Hungarian Plain, cold- and thermal karst waters, shallow alluvial aquifers in the mountains, groundwater wells in aquiclude hilly areas.

The results have been published periodically (Rónai 1982d, Kuchen et al. 1991, Nagy&Tóth 1991). Now we are interpreting the data of the wells in the Duna–Tisza Interfluve together with the results of the Basin Analysis project, and establishing a new hydrogeological model of the area (Rotár-Szalkai, Á.). The geological model, which was prepared for the national hydrogeological model at the end of the eighties, has been also completed (Tóth et al. 1987).

The hydrogeological evaluation of the different lithostratigraphic formations in the eighties was an important task. During this work, hydrogeological parameters and the areal distribution of the most important Cretaceous, Eocene, Oligocene and Miocene formations were described (Siposs 1987, Lorbererné Szentes 1987). Other methodological research also has been carried out on the interpretation of change in the mean water level (Csaba 1977, Tóth 1986b, Venkovits 1990). An experiment tried to use the chemical composition of the water as a geothermometer (Tóth 1991b). After study of Recent sediments, the hydrogeological atlas of the loose, porous sediments was published in 1982 by Tóth&Vermes.

ENGINEERING GEOLOGICAL RESEARCH
(by Gy. Tóth)

The Geological Survey started engineering geological mapping in the Balaton Highland at the end of the sixties. Its first result was the atlas of the Tihany peninsula, which was issued in 1969 for the centennial of the Survey. Based on the results of the Tihany model area and other engineering geological mapping programs in Hungary and abroad, the Central Office of Geology published the principles of engineering geological mapping at 1:10 000 scale, which determined the uniform methods of mapping. This regulated engineering geological mapping during subsequent years in Hungary.

Between 1970 and 1978 the engineering geological maps at 1:10 000 scale of the Balaton suburbs were published. During this period, 37 atlases were edited, each of them containing 10-18 different maps. Besides the obligatory maps of documentation, geology, geomorphology, hydrogeology, hydrochemistry, construction and synthesis, other versions were also compiled about certain regions (Raincsák Gy.-né 1993).

The engineering geological mapping of Budapest at 1:10 000 scale started in 1969, with the aim of establishing the multitudinous construction work in the capital. The Balaton and Budapest metropolitan areas were represented on 37+28 maps at 1:10 000 scale. The methods of mapping and map editing were the same for the two areas.

In 1978 all the previous data were integrated at 1:20 000 scale for both areas. Between 1981 and 1985 those people edited the maps and carried out the printing preparations, who took part in the mapping itself. A 4-version summary map about the Budapest metropolitan area was also edited at 1:40 000 scale. The same map of the Balaton area was issued at 1:50 000 scale. The volume of these maps is characterized by additional documentation of 20,000 pages. The Geological Survey co-operated with FTV (i.e. Geodesical and Soil Mechanics Co) on the Balaton area, and with FTV, the Geographical Institute and the Institute of Geodesy and Geophysics of the Academy, Eötvös Loránd University and Budapest Technical University on the Budapest area (Raincsákné Kosáry 1993; Raincsákné Kosáry&Cserny 1984).

In the engineering geological mapping of the big cities, the Geological Survey took part in the work at Pécs, Salgótarján and Szeged. At Pécs, where the Survey made the geological versions at 1:10 000 scale on 12 pages, the mapping started in 1976. Summaries were edited at 1:20 000 and 1:25 000 scales.

After a 10-year mapping and editorial effort, the engineering geological maps of Salgótarján were published in 1982, three of them at 1:10 000 scale, and six at 1:20 000 scale, together with the explanation volumes.

The engineering geological mapping at Szeged was carried out between 1980 and 1985, in the central parts at 1:10 000 scale, in the surroundings of the city at 1:25 000 scale. Finally an atlas was published with four maps at 1:10 000 scale and one at 1:20 000 scale with an explanation and the documentation

The engineering geological mapping of the Balaton suburban area at 1:50 000 scale started in 1981. As a result of this work, we can answer any engineering geological, agrogeological, or environmental geological questions on the shore. The atlas of the Balaton suburban area at 1:100 000 scale, with 6 maps, also contains the results of the actual geological survey on the bottom of the lake (Chikán&Cserny 1993).

The huge amount of data generated during engineering geological mapping all over the country necessitated the establishment of a computer data base.

The National Engineering Geological Data Base (OMAB) was founded in 1986. By 1994 the data of the mapping of Budapest had been recorded, and data from the Balaton area have been continuously entered (40% is ready). During this period the neighbouring areas of the Danube had great importance. That's why OMAB has been developed with the data of the river banks 100 km above and below Budapest. Besides this work, a complex map-series also has been carried out at 1:25 000 and 1:50 000 scales. Its aim is the engineering geological establishment of water supply and plans of arrangement, and the indication of the possible sites of communal waste disposal.

Engineering geological evaluation of the different formations has been performed since 1981. The engineering geological characterization of all the solid rock formations will have been finished by the end of 1994.

AGROGEOLOGICAL RESEARCHES
(by L. Kuti)

The former Agrogeological Department parted from the Geological Survey on the 5^{th} of September 1948, and was renamed the Soil Science Department, but that didn't mean the end of agrogeological research. Specialists who had been working on low-land areas carried out geological research for agriculture, so naturally they continued to provide data during the survey.

The 20 year-long program of geological mapping on the Great Hungarian Plain, which was lead by András Rónai, started in 1964, and it planned an agrogeological survey, too. The maps, which showed the $CaCO_3$ content and permeability of the surface and near-surface sediments, presented the rock-soil interaction at the same time, which supported later agrogeological research (Rónai 1982c).

The beginning of the seventies brought important changes in agrogeological research. At this time the amelioration plans for the agriculture required more and more data, which could be provided only by geological research. At the same time environmental protection required natural materials for amelioration; their survey was also the task of geologists. The Regional

Geological Services were established at that time; their task, among others, was the agrogeological survey of specific regions (Zentay 1980).

The increased requirements, and the fact that agrogeological research started in different departments of the Survey, made some kind of checking necessary. For this reason, an expert from the Central Office of Geology organized a meeting, where all those scientists who had carried out any agrogeological research in the past, took part. The first lectures were given by András Rónai and Tibor Zentay, and the final conclusion of the meeting was, that the different opinions about agrogeology are very far from each other.

Some people wished to pursue classical agrogeological research, i.e. the geological aspects of soil surveying, which frightened the soil scientists, of course, because they were afraid of competition.

Some other geologists thought that agrogeology need not deal only with the soil, because it had its specialists. According to their opinion, the most important task of agrogeology was to analyze the rock-soil interaction, because only this method could provide new information. This instigated the new waves of agrogeological research that culminated in the doctoral thesis of László Kuti in 1977b. Agrogeological research in the Geological Survey follows his new ideas, and studies the integrated processes of the soil-rock-groundwater system.

Besides these two trends, the third group thought the survey and prospecting of the natural amelioration raw-materials to be the most important task of agrogeology. Alginite, a special kind of oil shale, which was discovered by the geologists of the Survey, was an important result during this work. Gábor Solti did most of his research connected with the agricultural utilization of alginite, and other natural amelioration raw-materials. The geologists at the Regional Geological Services also did a lot of work, when they summarized the local amelioration raw-materials.

Geological mapping on the Little Hungarian Plain, which started at the beginning of the eighties, also planned agrogeological mapping, complemented by genetic soil maps edited by soil scientists. The map of factors of infertility was a new version. These maps were mainly edited by István Marsi (1987).

During the engineering geological mapping in the Balaton suburban area, Péter Farkas studied the geological reasons of erosion, and their representation on maps. He established the method of prognosis and representation of possible erosion on maps. Later, as an employee of the Agrogeological Department, he compiled the map of erosion danger zones in Hungary at 1:500 000 scale (Farkas 1989).

At the same time, the geologists who took part in the geological mapping on the Great Hungarian Plain, started to edit agrogeological maps, to establish uniform keys, and to reevaluate the data of geological mapping according to agrogeological aspects (Kuti 1990). Research was expanded to the analyses of trace elements in the soil-rock-groundwater system. The survey of some model areas has also started. Together with chemists and geochemists, the BFK method based on complex study of soil-groundwater-rock system was set up, which later regulated the survey of model areas (Bartha et al. 1987).

In the seventies and eighties, the center of agrogeological research was in the Regional Geological Service at Szeged, where mainly amelioration research had been carried out under the leadership of Tibor Zentay, together with many other scientists from different universities and other institutions.

Due to the changes in agricultural geological research, the Agrogeological Department was reestablished in 1986. Its task was the agrogeological survey of Hungary, which was carried out under the leadership of László Kuti. The research started according to his ideas, and continues even today.

The aim of the program, which lasts from 1996 to 2005, is the production of agrogeological maps of Hungary at 1:100 000 scale in 6-9 versions, depending on the geological-morphological properties of the area. It follows geological mapping, partly reevaluates its data, and also makes new outcrops in those areas, where previous surveying wasn't sufficient. During this work, agrogeological maps of the southern part of the Great Hungarian Plain and the Tiszántúl, and the geological-agrogeological survey of the Sajó valley and the southern part of the Hernád valley, have been carried out. The completion of the latter is our recent task.

During the survey of model areas, a dense network of shallow drillings (max. 10 meters of penetration depth) exposes a certain area, which has been selected according to different aspects (geology, soil science, agriculture, forestry, environmental and nature protection), and it is studied in detail according to the BFK rules. We assign the agrogeological regularities based on the detailed comprehensive analyses of all the data. Until now, 20 model areas were studied in Hungary, in some areas control research has been carried out a few years after the survey. This research can support a further monitoring system for complex environmental survey.

An important task of agrogeological research is the study of the possible interactions between amelioration materials and the soil-rock-groundwater system (e.g. infiltration of trace elements into the rocks).

The program emphasizes the importance of some geophysical methods, which may inform agrogeological research.

The centennial of agrogeologic researches was celebrated on the 5th of December 1991, together with the Hungarian Geological Society. The meeting started with the presentation of Pál Stefanovits, who began his scientific research 50 years earlier, in the Soil Department of the Geological Survey. All those geologists of the Survey who had ever dealt with agrogeology made presentations; they showed the whole spectrum of research to the crowded assembly.

Many publications in scientific and other journals, and presentations at different conferences document the agrogeological research of the Geological Survey.

GEOLOGICAL NATURE PROTECTION (by T. Cserny)

The activity of the Geological Survey connected with nature protection includes the survey of surface and subsurface formations, publication of the results, and their maintenance and dissemination.

The aim of the survey of the geological objects to be protected has been developing gradually during the past 25 years. It was connected with other types of research until it became a separate project in 1993 (Császár 1992b, Cserny 1994).

The program of geological key-sections started in 1980 in the frame of the complex research program of the natural sources of energy in Hungary. During the 10 years of this program, all the rock formations that take part in the geological buildup of Hungary were exposed and studied in outcrops or bore-holes. The results were documented in a uniform way. Altogether 265 surface outcrops were studied; the documentation for 169 of them was issued between 1982 and 1990 in three languages (Hungarian, English and Russian). The key boreholes of great depth were also studied in detail, and the results were published. From the 600 bore-holes, documentation was issued for 236 (Haas 1987c). Most of the key sections and the boreholes are protected; the Survey controls some of them. We have to emphasize further:

(1) The outcrop at Ipolytarnóc, which is also a candidate for the World Heritage, has been protected since 1954. Complex scientific research started there in 1970. We also took part in establishing a museum (the financial support was provided by the Office of Nature Protection, and the museum opened in 1985) (Kordos 1990a).

(2) An occurrence of *Hominoidea* in a former quarry at Rudabánya was exposed in 1967, and it became protected in 1977. The 10 million-year-old bone and skeleton remnants of *Rudapithecus hungaricus* and *Anapithecus hernyaki* (anthropoid apes) were discovered in paludal sediments. Besides these bones, this outcrop contains the richest continental fauna and flora of that age in the Carpathian Basin (ostracods, molluscs). Many international expeditions have surveyed this area, which also belongs to the Survey, during the past years (Kordos 1990b).

(3) The protected area at Tata-Kálváriadomb is on a high level, even by European standards. It became a protected area in 1958, and contains many types of rocks and fossils. The Survey has developed it continuously during the past years. A museum was founded in 1992. Now we can visit an entire Mesozoic sequence, a prehistoric chert mine, and a museum that shows the different rocks and raw-materials of Hungary along with old mining instruments in a beautiful park of 4 hectares (Fülöp 1984).

(4) The administration and publicity of some famous protected areas (Mogyorósdomb at Sümeg (Haas 1987c), Csárdahegy at Úrkút, Darvastó at Nyirád) (Kecskeméti&Vörös 1987) have been handled by the Geological Survey since 1979, under the supervision of the Office of Nature Protection. Besides the geological sites in the former manganese mine at Úrkút (palaeokarst, limestone and manganese formations, different structures), old mining instruments are also displayed. The former opencast bauxite mine at Darvastó has similar geological and mining interests; it became a protected area in 1971. The Mesozoic sequence and archeological site at Sümeg-Mogyorósdomb became a pro-

tected area in 1976. A geological educational center was established in this interesting area in 1975 (Jocháné Edelényi 1988b. Field-work geology courses for university students and postgraduate environmental geological courses were organized between 1978 and 1991 with the help of the researchers of the Survey. Since 1992 these courses have been ceased because of lack of needed expence.

The core-stores at Rákóczi-telep in northern Hungary, at Szépvizér in northern Transdanubia and at Pécs-Vasas in southern Transdanubia preserve the documents of the bore-holes. The development of these establishments intensified after 1979. A new store was built in Szolnok in 1981, and they were all enlarged continuously until 1990. After 1993 their position is more and more unstable because of the shortage of their budget.

Geological nature protection is extremely important in the research of those areas (national parks, other protected areas) that haven't been affected yet by human activity. The different departments of the Survey and the Regional Geological Services have carried out multifaceted research in the national parks at Hortobágy, Kiskunság (Molnár&Kuti 1978a, b), Fertő Lake, on the Balaton Highland (Tapolca- and Kál basins, Tihany peninsula) and in other protected areas (e.g. Buda Mts (Bedő 1992), Szigetköz, Dráva Valley). We studied many quarries as key-sections (e.g. Szabó Sand quarry at Várpalota, palaeokarst at Darvastó in Nyirád, chert mine at Sümeg), which later became protected areas. The complex environmental geological survey of the Kál basin, which is a protected area, is being conducted with special analyses and mapping that record the so called "zero stage".

Together with the Office of Nature Protection, the Survey participates in the establishment of educational pathways all over the country. Some descriptions have been carried out in the Kál basin, and we continue our work on the Balaton Highland.

The more than 3,000 caves of Hungary are also protected, some one hundred of them are under serious protection because of their unique dripstone and crystal forms. Scientific research there is conducted by the Institute of Cave Sciences. Some geological key-sections were described in the Baradla cave at Jósvafő (Piros et al. 1989).

The regional complex prognosis of Hungary, which started in 1981, also took into account the aspects of nature protection. During this program, geological mapping was carried out at 1:100 000 scale, which summarizes the environmental condition of the country in 5 versions. An outstanding value of these atlases is, that they show both the possibilities of utilization of certain areas and the interests of nature protection.

LABORATORIES AND ANALYTICAL ACTIVITY

by MÁRIA FÖLDVÁRI, RÓBERT HORVÁTH

INTRODUCTION

In our days the level and the efficiency of research in the field of earth sciences can be guaranteed by the increase of the role of analytical and synthesizing activities. One of the decisive elements is the proportion of application of laboratory methods, their technical level and the expertise in their application.

In the Hungarian Geological Survey the germs of laboratory activity developed already in the eighties of the past century. At the time of the centennial period a děpartment with numerous experts provided the background for geological research. First-generation equipment suitable for en mass investigations were available (emission spectrograph, spectrophotometer, DTA device and derivatograph, X-ray diffractometer etc.).

The development of the past 25 years was affected by numerous factors:

– the use of laboratory methods in geological exploration has been increasing on a world scale as a result of the increase of depth of knowledge and of the complexity of research;

– accelerated development has been going on in laboratory instrumentation and, particularly during the past decade, in the field of automatization and computerization;

– the emphasis from mapping, stratigraphy and key-section studies has been shifted to mineral exploration and further, in the past few years, to applied geology and environmental geology. At the beginning of the period concerned research in mountinuous areas, later the study of deep boreholes, nowadays the field survey have been the most important fields of our activity. As a result, the structure of laboratory work should have been changed as well.

While these factors affected positively the development of laboratory methods, the possibilities of improvement were impeded mainly by financial, to lesser extent by mental obstacles. Nevertheless, the methodological work carried out during this period has had decisive role in the fact that in spite of the lack of instrumental investments and decreasing staff number the quantity of analyses could be considerably increased in certain fields, while in others it could be maintained. Data processing and interpreting activities have gained also greater significance.

TECHNICAL DEVELOPMENT

To purchase instruments from budgetary sources always less money was available than needed. As a result, our laboratory equipment has become unbalanced and remarkable backwardness has risen as compared both to the international and to the national level. Some favourable turn occurred in the late eighties when it became possible to purchase instruments with the money obtained at national and international competitions. Simultaneously, sectoral instrumental centres were founded in Hungary aiming at the effective coordination of the development or different institutes and the mutual utilization of analytical capacities. In the framework of the Geological Instrument Centre founded in 1987 seven member institutes could harmonize their ideas about instrument development. The Centre is a member of the National Scientific Measurement and Instrument Network. The concepts of development of the Hungarian Geological Survey were affected by its own tasks on one hand and by the division of tasks within the Instrument Centre on the other:

– among the tasks of the Hungarian Geological Survey the applied geological research was emphasized, such as environmental geology and the geochemical environmental and raw-material aspects;

– the focus of exploration was shifted to the basin areas. The Survey tried to develop interconnected analytical systems, e.g. element analysis, organic geochemistry, phase analysis;

– the basic principle of development within the Instrument Centre was as follows: the great instruments providing basic data and suitable to en mass analyses to satisfy different geological demands have to be installed in the Survey, while the smaller university or academic laboratories will carry out special analyses.

Taking into account this principle, the Survey competed for geochemical and sedimentological developments (unfortunately, the latter has remained unsuccessful so far). The main stages of instrument purchase mostly by the Survey are summarized in Table 1.

It can be seen from these data that during this long period some instruments had to be replaced due to the physical and moral amortization. Some instruments could be renewed by developing computer connection, that partly control the instruments, partly promote the recording and interpretation of data (reflectance measurement, thermal analysis, X-ray diffractometry etc.).

Parallel to purchasing these instruments, however, the level of the preparatory work could not be maintained. The microscopes have become aged, too. At the same time, the supply with personal computers proved to be important since these make easier the everyday activity and provide new possibilities in the fields of data processing and interpretation. Nevertheless, the recent strong measures of staff number reduction caused severe problems in utilizing the instrument park on the required level.

To treat more than 10,000 samples a year György Peiker elaborated a sample receiving and registering system in the late seventies that has been working satisfactorily up to the present day.

PARTICIPATION IN THE RESEARCH

The main activity of the researchers working in the laboratories is to carry out routine analyses for the colleagues in the Survey or of external customers. In addition to this data-supplying they take part in two kinds of research and development activity. They deal with the development of their own investigation methods. Since 1972 the descriptions of the applied and developed methods are published by the Institute in the series of "Methodological Papers". (Földváriné Vogl et al. 1972, Tolnay et al. 1973, Ikrényi et al. 1983, Tóthné Makk 1985, Földvári 1986a, b, Viczián 1986, Rischák 1986, Lelkesné Felvári 1989, Parténsimilar Lechner 1989). The so-called research laboratories take actively part in the solution of geological problems with processing and interpreting the data. To characterize the last 25 years, the following achievements can be pointed out from different fields.

Chemical analytics

At the time of the centenary the chemist colleagues of great theoretical knowledge and of precise practical labour used mostly the traditional wet-chemical analytical methods (gravimetry, complexometry etc.). This was the time when the emission spectrographic laboratory was in its glory among the similar laboratories of Hungary that could perform en mass trace element analyses at the technical level of that time. Special procedures were elaborated to determine different element groups. These works are related first of all to the name of Péter Zentay. With the classical spectrographic procedures a great number of analyses could be performed. This is why they provided the data of numerous metallometric and geochemical surveys. The installation of a Soviet-made quantometer resulted in a considerable increase of capacity. This has produced thousands of analyses for the metallometric survey of the Börzsöny Mts. It was operated between 1976 and 1981. Subsequently to the up-to-date and more accurate trace element analytical methods the need for classical spectrographic analyses drastically dropped. Nevertheless, this method is used even nowadays as informative analysis. In case of the spectrophotometer that was also operated at the time of the centenary different methods were elaborated to determine trace elements and micro-components. Due to the world-wide development of instrumental analysis and to the capacity demands of metallometric and geochemical surveys requiring high sample numbers these methods were

Table 1

The main stages of instrument purchase in the Hungarian Geological Survey

Instrument	Year of purchase	Price (MHUF)	Purchaser
Quantometer	1974	3,0	HGS
Infrared spectrophotometer MOM	1975	0,13	HGS
Scanning electron microscope	1976	2,5	HGS
Square-wave polarograph	1976	0,15	HGS
AAS-spectrophotometer	1977	0,6	HGS
UV-spectrophotometer	1977	0,4	HGS
Infrared spectrophotometer Zeiss	1977	0,65	HGS
Gas chromatograph	1977	0,63	HGS
Gas titrimeter	1977	0,3	HGS
MOM-spectrophotometer	1978	0,15	HGS
AAS/spectrophotometer	1979	0,4	HGS
Rock cutting machine	1979	0,14	HGS
Automatic polishing machine	1979	0,75	HGS
Q-derivatograph	1979	0,8	HGS
Flame photometer	1979	0,15	HGS
AAS-spectrophotometer	1980	1,2	HGS
X-ray diffractometer renovation	1980	5,0	HGS
Thermal demagnetizer	1981	0,5	HGS
AC demagnetizer	1983	0,8	HGS
Cryogenic magnetometer	1984	3,0	HGS—ELGI*
MOM-spectrophotometer	1985	0,2	HGS
Derivatograph-c	1988	2,5	OTKA**
Gas chromatograph	1989	1,4	HGS
ASS-spectrophotometer	1989	1,7	HGS
ICP	1990	7,6	OTKA
ICP-MS	1991	40,0	PHARE
X-ray computer modernization	1991	0,6	HGS
Susceptibility meter	1992	0,4	US-Hungarian Joint Fund
Graphite furnace to AAS	1993	2,9	OTKA
Ion chromatograph	1993	2,7	OTKA
Microwave rock desintegrater	1993	2,5	OTKA
N/C/S analyser	1993	4,1	OTKA
Polychromator to ICP	1993	6,4	OTKA
Fourier transform infrared spectrophotometer, Perkin Elmer	1993	4,0	HGS
Derivatograph, IBM computerization	1993	0,5	HGS

* Eötvös Loránd Geophysical Institute of Hungary

** OTKA (i.e. National Scientific Research Fund)

gradually replaced by more up-to-date instrumental analytical procedures since the late seventies. The classical water analytical methods were gradually replaced by instrumental analyses. Most of the publications reflect the adaptation of instrumental analyses to the actual tasks of geological exploration (in the field of environmental geochemistry the measurement of toxic elements, in the field of hydrogeochemistry the elements affecting water quality, in that of raw-material prospection the determination of indicator elements etc.) first of all in the atomic absoption, ICP-AES and ICP-MS analyses (Ikrényi 1980, 1987, Bartha&Fügedi 1981, Ikrényi&Bartha 1982a, b, Bartha&Fodor 1987, Jarvis et al. in press). The recently purchased polychromator may increase the analytical velocity the sequential ICP-device; the microwawe instruments provide sample preparation of good efficiency and required purity; the ion chromatograph operates in the field of anion determination of water samples more sensitively than the methods applied so far and providing the possibility of determining other anions as well. As a result of these developments the chemical laboratory of the Hungarian Geological Survey has become one of the best equipped and modern laboratories of elemental analysis in Hungary.

Investigation of organic matter

At the beginning of the period studied only less modern techniques were available, mainly the procedure suitable to estimate the maturity was lacking. Due to the new demands of the oil and gas industry and to the new tasks of the Survey in the field of basic research, further development has become indispensable. Due to financial restrictions as a first step this problem was solved by the novel use of available instruments.

To estimate the maturity of organic matter Földvári (1973) elaborated a new derivatographic method. Based on the experiences of study-tours in abroad (SNPA, Pau, France; VNIGRI, Leningrad, Soviet Union) H. Lőrincz&Vető, I. (1976) adapted the method of estimation of maturity on the basis of the colour of palynomorphs (conservation index). Vető (1977) introduced a rapid method to estimate the quantity and quality of bitumens on the basis of their fuorescence. The analytical basis of hydrocarbon prediction of the Transdanubian Central Range were developed by this kind of development initiated by study tours and carried out only in the "grey matter".

In the middle of the seventies, with the aid of the purchased new instruments the measurement of maturity on the basis of vitrinite reflectance as well as the IR and GC analyses of the organic matter were started (Szűcs&Bruknerné Wein 1982).

The papers by Laczó (1982, 1984), Bruknerné Wein&Vető (1981), Wein-Brukner et al. (1985) dealt with the interpretation of the first analytical data. To satisfy the needs of alginite exploration in the Survey the derivatographic method of organic matter investigation was modified (Barna 1981).

At the end of the seventies we tried to extend the analytical cooperation (organic carbon content SzKFI, i.e. Hungarian Hydrocarbon Institute; József Attila University, Szeged; disperse hydrocarbon gas content VIKUV, i.e. Enterprise for Water Prospecting and Well Drilling). Upon the request of the oil and gas industry a complex method was elaborated to identify the organic additives used for drilling muds (Bruknerné Wein 1987).

Adaptations, instrument purchase and the extension of analytical cooperation allowed to perform the analyses required for the hydrocarbon prediction the Northern Mid-Mountains, and for the evaluation of the generation/migration aspects of 20 ultradeep exploratory wells of the oil industry and of 25 key drillings of the Hungarian Geological Survey.

The extension of analytical cooperation was continued (Rock-Eval pyrolysis, József Attila University, Department of Mineralogy-Geochemistry, Szeged; stable C-isotope analyses, ATOMKI, i.e. Institute of Nuclear Research of the Hungarian Academy of Sciences, Debrecen). Papers written by Brukner-Wein et al. (1990), Brukner-Wein&Sajgó (1990), Hertelendi&Vető (1991) are examples of the interpreted publication of the results.

In the last years the normal and excited (UV) lights were used for parallely for organic petrographic purposes. Our Survey is the only one in Europe where parallel microlithotype and maceral analyses are carried out and the vitrinite reflectance data go directly into the data bank from the measuring microscope (Hámor-Vidó). It proved to be successful to purchase an IR spectrometer and a CNS analyser from the OTKA budget that are promising in the research of environmental geochemistry and hydrocarbon exploration. The latter instrument was adapted to geological samples.

Co-operation was initiated with OKI (i.e. National Institute for Public Health) and with the Laboratory for Geochemical Research of the Hungarian Academy of Sciences.

Instrumental mineralogical investigations

Except IR spectrography, all methods were available at the time of centenary in the laboratories of the Survey. In spite of this fact, however, the past 25 years have fundamentally changed the utilization possibilities of the methods.

In the **thermoanalytical laboratory** the systematization of reaction types characteristic of certain minerals was carried out and their regularities were studied. This allowed that in addition to the usual finger-print method (based on comparison) also the characteristics of minerals based on the electron negativity law of the reactions could be identified (Földvári 1987). The thermogravimetric curves of the derivatograph allowed the quantitative determination of minerals on the basis of their stoichiometric reactions (Földvári et al. 1986). Measurement possibilities were refined by the introduction of the quasi–isothermal–quasi–isobaric measurement technique (Földvári et al. 1988, Földvári 1991a), and the separation of the overlapping thermal reactions can be performed by the thermo-gastitrimer analyzing the gases removed during heating (Vargáné Barna 1983). The derivatograph-c device assures the possibility of measuring the second derivatives and the reaction kinetic parameters (Földvári 1990). For the calculation of the quantitative measurements, appropriate software was developed in the laboratory (Földvári&Rozs 1991).

In the **X-ray laboratory** the diffractometer and spectrograph purchased in 1960 were renewed in 1980. Since that time no X-ray fluorescence analyses have been carried out in our laboratory. The diffractometer was modernized by a computer control and data processing unit in 1991.

In this case too, the elaboration of quantitative analysis was the most significant improvement. The problems of factors determining the size of reflections (Rischák&Viczián 1974), the determination of (corundum) factors of minerals (e.g. Szemereyné Szemethy 1976) were dealt with. It was an important step to elaborate the determination of amorphous phases in addition to the crystalline ones (Rischák 1989). In the laboratory a software was developed to perform the complete quantitative evaluation. His method was based on the measurement of the characteristic reflection(s) intensity and the reflection width of the minerals. The purchase of evaluating program developed by I. Sajó in the X-ray laboratory of the ALUTERV-FKI (i.e. Aluminium Research and Planning Institute) provided us with a tool of quantitative determination based on an other principle and with the first databasis containing X-ray diffractometric data. Based on the joint experiences this program has been considerably improved. Since that time further data bases have been purchased.

Developments carried out separately in the two laboratories have been later interwoven and turned towards the complex phase analysis in order to use the information gained from different methods for the possibly most accurate determinations (Földvári&Farkas 1985). At that time the infrared spectrograph was also used in the mineralogical investigations that could be completed in this manner with the information concerning the lattice characteristics.

The overwhelming majority of the laboratory's activity involved the routine-like phase analyses exemlified by those performed in the framework of the explorations in the Velence Hills, Sárospatak, Balaton Highland, bauxite and alginite exploration, the processing of key-sections and other drill holes (Daridáné Tichy et al. 1984, Ilkeyné Perlaki 1989, Ilkeyné et al. 1993, Cserny et al. 1992, Földvári 1991b, Solti 1981, 1988 etc.).

Other fields of research have to be mentioned, too: single crystals (Farkas 1975), crystal structures, e.g. aluminite (Farkas&Kürthyné Komlóssy 1981), bastnaesite (Farkas et al. 1985), kutnahorite (Farkas et al. 1988a, b), crystallinity determinations (Földvári&Kocsárdy 1984, Földvári&Kovács-Pálffy 1993), investigation of clay and mixed layer minerals (Viczián 1977, 1981, 1987) diagenesis research (Viczián 1974, Árkai&Viczián 1975).

Sedimentology

Most of the routine sedimentological, soil mechanical and petrophysical methods have remained essentially unchanged, disregarding some modifications increasing accuracy and efficiency. Home made developments served to improve the analyses: in heavy mineral separation the traditional separation with bromoform was helped by the freezing method; in addition to the Köhn grain size analysis sedimentometric separation was also introduced allowing the relatively rapid analysis of the grain size range below 0.002 mm; a CO_2 registrating manometer was developed to study the carbonate content of the sediments (Rischák 1982). The determination of the minerals in thin section by colouring was introduced also in this period. Although analyses have been carried out with the traditional methods, calculations from measurement data, tabulation and graphic display are now performed with computer technique (e.g. Lantos&T. Kovács 1985 etc.). In the field of gravel studies Molnár&Vermes (1989) tried to improve the routine analyses.

Heavy minerals

With the aid of traditional routine micromineralogical investigations the sedimentary cycles and transport directions were traced in exploratory wells of the Great Hungarian Plain and in the Balaton Highland (Gedeonné Rajeczky 1971, Elek 1985, Sallay&Thamóné Bozsó 1988, Thamóné Bozsó 1991). Remarkable number of micromineralogical analyses was performed by Gyurica (1971) in the eighties in the framework of placer exploration. T. Gecse (1982) dealt with the micromineralogical analysis of bauxites.

Mineralogy

Some trends of mineralogical analyses were mentioned above, in the part dealing with instrumental analysis; the studies concerning mineralogical descriptions of different metalliferous regions of Hungary: Börzsöny Mts, Rudabánya, Gyöngyösoroszi, Velence Hills, Szabadbattyán, Parádfürdő, Recsk have to be mentioned here (Nagy, B. 1978, 1982a, b, 1983a, b, 1985, 1986, 1990, Fügedi et al. 1991). New mineral occurrences were also described: cinnabarite, metacinnabarite, sulfur, aluminite and basaluminite, "mauritzite", diadochite, markasite, copiapite and rhomboclase, gorceixite etc. (Nagy, B.&Pelikán 1975, Ravasz 1978, Tóth et al. 1982, Kákay-Szabó 1983, Földvári&Nagy 1985, Viczián et al. 1986, Szentpétery et al. 1991). It is to be mentioned that fluid inclusion studies were initiated also in the Hungarian Geological Survey (Vetőné Ákos 1977, 1980, 1982). Hámor, T. 1988) dealt with the mineralogical-genetic problems of sedimentary pyrites. The methodological studies of U-table measurement possibilities of plagioclases are also worthy of mention (Örkényiné Bondor 1990, 1991).

Petrological Researches

Sedimentary rocks

Based on thin section microfacies analyses of carbonate rocks the Hungarian Triassic (Szabó et al. 1979, Budai et al. 1993), the Cretaceous (Lelkes 1985, 1990), the Miocene (Lelkes&Müller 1984, Lelkes 1992, Lelkes in press), the Cuban Cenozoic (Lelkes 1988a, Gyalog&Lelkes 1990) the Recent regions from actual-geological aspects (Lelkes 1986, 1987, 1988b) as well as several key-sections were studied.

The mineralogical-petrographical investigation of the Miocene in the Mecsek Mts was a far-reaching work (Ravaszné Baranyai 1973).

Other sediment-petrographic investigations were carried out on bauxites (Dudich&Mindszenty 1984, Tóth&T. Gecse 1981, Juhász&Ó. Kovács 1990).

The problems of mineral composition and classification of clastic sediments were treated by Zentay (1982), Gerei&Zentai (1991).

Metamorphic rocks

The results of research on metamorphites described in the paper on basic research were based on thorough petrological investigations. References cited there have to be complemented here with some petrological studies (Szepesházy 1975, Ravaszné Baranyai&Viczián 1976, Lelkesné Felvári 1971, 1978, 1989).

Igneous petrology

No independent work on igneous petrology was included in the plans of the Survey. However, in relation with the solution of other tasks remarkable results were achieved also in the field of magmatites. L. Jugovics dealt with the chemistry of Hungarian basalts (1976). Based on the chemical analyses found in his bequest further mathematical statistical studies were done (Vogl 1979, 1980). With the aid of computer processing similar studies were performed by Kovács&Ó. Kovács (1990). Viczián (1971) studied petrologically the phonolite of the Mecsek Mts. The carbonatite rocks of the Velence Hills were recognized by Horváth et al. (1983).

Both grinding-polishing and cutting machines were purchased in this period but all are worn out by now. In addition to traditional thin sections, thin sections for coal-petrological studies, surface sections for reflect measurements, ore sections and different preparates have been prepared.

Other techniques

Scanning electron microscopy

The application of SEM was initiated in the Institute by paleontologists and they have used it in full measure. In the past decade radiolarians and condonts were also investigated beside the traditional micropaleontological studies. The results are presented in papers of this book dealing with basic research and stratigraphy. At the same time but to a smaller extent the SEM was used also in the field of petrology (Juhász 1986, Hámor&Kovács 1991) and sedimentology (Rischák 1988, 1989).

Paleomagnetic research

The first magnetostratigraphic measurements on a Hungarian borehole were initiated by the Survey. The measurements themselves were made in Canada (Rónai&Szemethy 1979). The Hungarian Geological Survey established its paleomagnetic laboratory in 1985, put into operation in 1986. This laboratory is unique in Central Europe and concerning its instruments and processing methods it is of world standard.

The main activity concerned the magnetostratigraphic survey of the Tertiary, mainly Neogene, key-sections on the basis of polarity changes of the geomagnetic field. The results are presented in the chapter on stratigraphic research. To study the short-term geomagnetic phenomena the Laboratory won the grant of the US-Hungarian Joint Fund for three years, in 1991.

Researches related to the radiometric dating

The laboratories of the Survey have no facilities for isotopic analyses. Only the geological checking and interpretation of the measurements carried out in the isotope laboratory of ATOMKI (i.e. Institute of Nuclear Research of the Hungarian Academy of Sciences) in Debrecen were done by the staff of the Survey. In the course of these works the Mesozoic igneous rocks (Árva-Sós et al. 1987), the basalts from Transdanubia (Balogh, Kad. et al. 1982), the Miocene volcanites (Balogh, Kad.&Rakovits 1976, Hámor et al. 1980), the Tertiary formations of North Hungary (Hámor et al. 1978), as well as the andesite of Komló (Árváné Sós&Ravasz 1986) were investigated. Measurements were carried out on alunitized rocks (Rakovits et al. 1981), methodological studies made on the possibilities of dating with glauconites (Földvári&Balogh, Kad. 1984) and on the theoretical problems of absolute geochronology (Vogl 1976).

COLLECTIONS

MÁRTA CSONGRÁDI, ELIZABETH ERDÉLYI, LÁSZLÓ KORDOS

THE MUSEUM OF THE HUNGARIAN GEOLOGICAL SURVEY
(by L. Kordos)

The Museum of the Hungarian Geological Survey was founded in 1868, preceding by one year the foundation of the Survey itself. At present it is the greatest state-owned professional collection: its inventory comprised 128,988 items on 31st December 1993 (Figs. 1 and 2).

The first hundred years of the Museum's history were summarized in 1969 by A. Tasnádi Kubacska the Head of Museum in that time (Fülöp&Tasnádi Kubacska 1969).

1969–1981: The Golden Age of the Museum

Arrangements for the Centenary Celebrations went together with a complete reorganization of the collections and exhibitions of the Survey. In accordance with the national legislation on museums a new "Operational Rules of the Museum Department" were elaborated already in 1966. This regulation is in force even today. The Museum is specified in it as a professional public collection of country-wide competence, managed by the Hungarian Geological Survey. The Museum's activity is directly supervised by the minister of Education in agreement with the

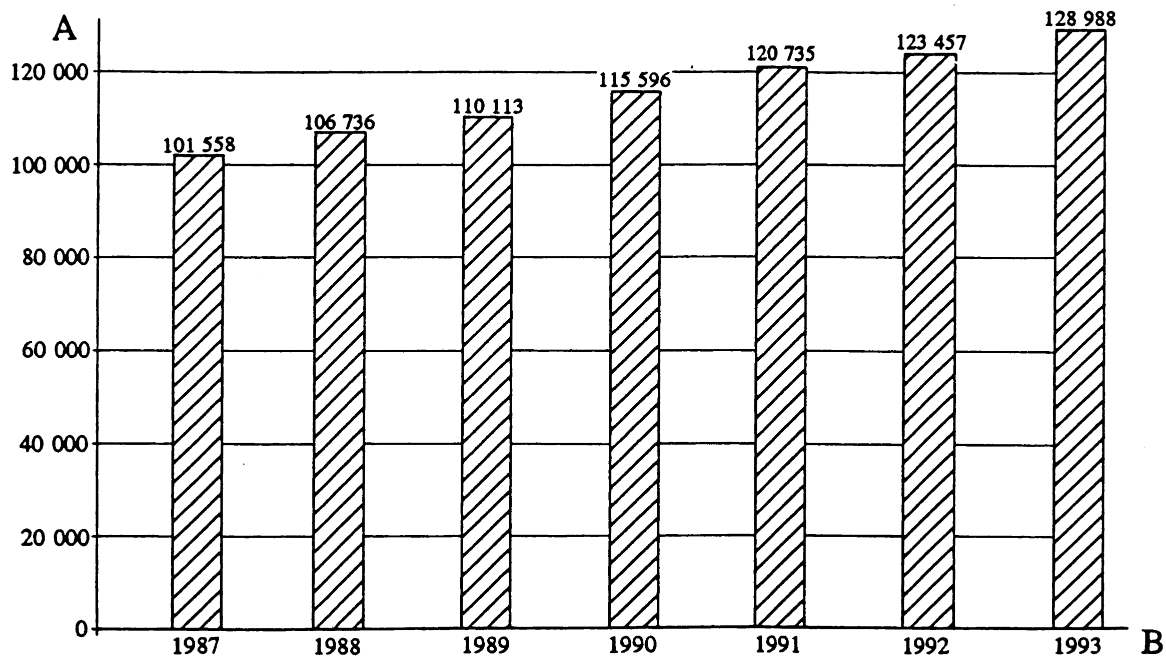

Fig. 1. Increase of the inventorized stock of the Museum (1987–1993)
A: Number of inventorized pieces, B: Year

sues. In the "Operational Rules" a new structure section was set up dividing the collection into the following: Stratigraphy (consisting of 13 units), Echinodermata, Paleovertebrata, Paleobotany, Type-specimen collection, Mineralogy, Petrography, Deposits of ores and minerals, and surveying sample collection. The original inventories of the collections, except the Paleoverebrata having been lost, a new, large-scaled registering of the stock was needed. The inventory of the present stock is the result of the work done during the past twenty-five years. In 1967 the objects were placed in 370 newly acquired uniform, double-door oak storage cabinets filling two wings of the second floor in the main building of the Survey. The reorganization went along with a substantial change of the ideas on the Museum's task and role. The pre-war public exhibition was terminated, and substituted by a new one arranged in showcases placed in the corridors and in the assembly hall of the Survey. In these documents of the Survey's history, and characteristic samples of the geological formations and mineral deposits of Hungary are exhibited. At the same time the objects which according to the views of that time could serve the purposes of science popularization and education were ceded to various state museums. The space thus gained was utilized for the development of the standard collections of documentative samples resulting from the geological mapping. Simultaneously with the restructuring carried out in the late sixties the staff of the Museum was developed, too. Its number varied between 25–37 in that time. A specialized researcher and his/her assistants were in charge of practically every section of the collection.

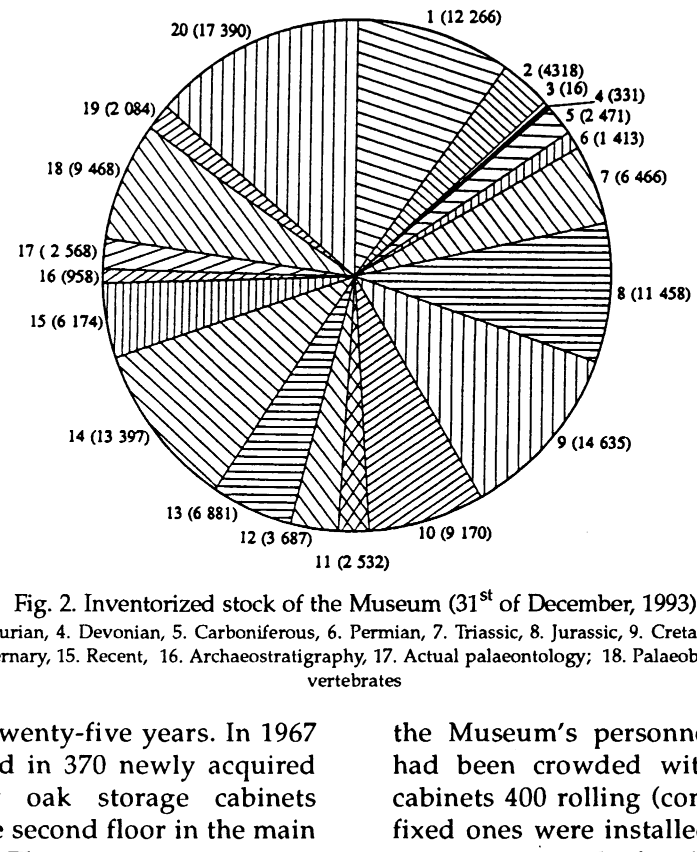

Fig. 2. Inventorized stock of the Museum (31st of December, 1993)
1. Mineralogy, 2. Petrology, 3. Silurian, 4. Devonian, 5. Carboniferous, 6. Permian, 7. Triassic, 8. Jurassic, 9. Cretaceous, 10. Eocene, 11. Miocene, 12. Sarmatian, 13. Pliocene, 14. Quaternary, 15. Recent, 16. Archaeostratigraphy, 17. Actual palaeontology; 18. Palaeobotany, 19. Echinoderms, 20. Fossil vertebrates

1981–1987: The birth of the modern Museum

The complete re-building of the Museum which was completed in 1981 aimed at the solution of the insufficiency of space available for the Museum's personnel. In the space which had been crowded with the wooden storage cabinets 400 rolling (compact) cabinets and 204 fixed ones were installed by using light-weight structures, mainly for the storage of the collections. Due to the smaller storage capacity of the new cabinets the collection had to be divided between the Survey's main building in Budapest and the core depositories established in the countryside. The stock of Hungarian origin was left at the headquarters, while the other objects together with the old storage cabinets were transferred to premises in Szépvízér, Rákóczi-telep and Pécs-Vasas. Due to the new systematization of the material the former registers became obsolete, and it was only after some years that the new catalogue became usable. During the re-arrangement of the collections a metallic mezzanine structure was built into the Museum, yielding new space mainly for the researchers of the Paleontological Department, who also deposited a considerable part of their samples in the new storage cabinets of the collection. The entire rear part of the former space of the Museum, which had connected the two wings of the floor occupied by the collections was separated from it and given to the National Geological Database. In the present arrangement of the Museum's space the reduced number of research associates and their auxiliary personnel have modern and clean working places at their disposal. In the rebuilt rear building of the Survey a central preparation workshop has been installed.

1987–1993: The Museum is enlarged by core-depositories

In July 1987 the four big depositories of drill-cores (Rákóczi-telep, Szépvízér, Pécs-Vasas, Szolnok) which had been managed locally were placed under the competence of the Museum. The Museum's staff were on the increase anew, in order to cope with the growing tasks. The combined number of researchers and their assistants reached peak with 37. The documentative and informative value of the collection and the services of this kind were on the increase. At the beginning of the nineties more and more mining and drilling enterprises were liquidated. As the last chance to save the invaluable material of their huge sample collections piled up earlier, they had to be taken over by the Survey. At the time being approximately 75% of the total of cores recovered from boreholes drilled in Hungary is kept by the Survey. Due to the number of transfers, the unsuitable methods of sampling as well as the obsolete storage conditions of the cores of the deep boreholes is becoming progressively worse and worse. Their preservation is highly questionable because of financial problems. That's why the secure storage of about 400,000 metres of cores originating from 14,000 deep drillings in 90,000 boxes is still an unsolved problem. In the same period the catalogization, study and preparation of the "traditional" stock of the collection were carried on. The increased international demands could be satisfied mainly by copies of the originals. New parts were added to the collection, such as the Silurian material, the archaeostratigraphical and actuopaleontological collections. The number of thematic sections reached the figure of 22. Also the completion of the "Catalogue of the Collection of Hungarian Geological Survey" printed in the Survey's own printing shop is a result of this period, too. In the five volumes of this series the entire catalogized stock of the collection is grouped by counties, municipal units, and by some other viewpoints.

1993: Establishment of computer-based recording

The first computer of the Museum was acquired in 1992. It was put into operation by using the ARIADNE collection recording programme in 1993. During one year 10,364 items of the inventory (8% of the entire stock) were fed into the computer. Now, not only the traditional cards can be printed by the computer but, the first time in the Survey's history, the informative interconnecting of the different sections of the collection has been achieved by the computer programmes, too; improving in this manner the information services. In 1993 the collection of clay samples and pottery-technological samples of classical value (consisting of 708 pieces) was recovered from the Museum of Applied Arts, to which it had been ceded. The Collection of the History of Science earlier managed by the Library was merged with Museum's collections on 1st January 1994. At the same time the staff of the Museum were reduced from 26 to 6 (4 researchers and 2 technicians). The sample preparing activity ceased. No auxiliary personnel has been left in the depositories of drill-cores. In this new situation the tasks and aims of the Museum's staff had to be changed essentially. The safeguarding of the collections listed in the inventory and the perfect data-supply gained new emphasis.

During the past twenty-five years the researchers of the Museum published 15 to 30 professional papers in each year, they enriched the Museum by their collecting actions done personally, took part in co-operation whithin and out of the Survey and also with international scientific organizations, they contributed to the education and science popularization.

THE NATIONAL GEOLOGICAL DATABASE
(by E. Erdélyi)

The National Database was established officially on 15th January 1952. This is the time of the foundation of the Department of Archives organized in the Survey on purpose to collect the data and documents of raw-material exploration, to registrate them, to carry out reserve estimations and to prepare expert's opinions. During the past years the importance of these tasks changed, as the emphasis was shifted; the denomination of the department changed together with its position in the organization of the Survey. During its history this department had names as: Economic-geological Archives – Geological Archives – Department of Archives – National Geological Database, and finally, since the 1st January 1994, National Geological and Geophysical Database which belongs actually to the Information Centre of the Hungarian Geological Service.

The systematic collection and registration of geological data have been regarded during the whole history of the Survey as the eminent task of this department. Regarding the water exploratory drillings this activity was backed up as early as 1903 when a ministerial decree made compulsory the supply of data for the Hungarian Geological Survey (Oswaldné Bárány 1989). Thus the formal foundation of the Archives created a stable, organized framework for an activity which had been done through decades.

The data supply for the Archives was regulated by various instructions and rules promulgated in different times. The steady, assiduous work of the staff of the Archives, however, contributed to not a lesser degree to the growth of the stock of data and documents. Following the establishment of the Department of Archives, Sándor Vitális put the works, expertises and documents comprising several hundreds of items, accumulated by his family during many decades, at the Survey's disposal. This collection is still one of the most valuable parts of the Database.

At present 1,878 such manuscript reports can

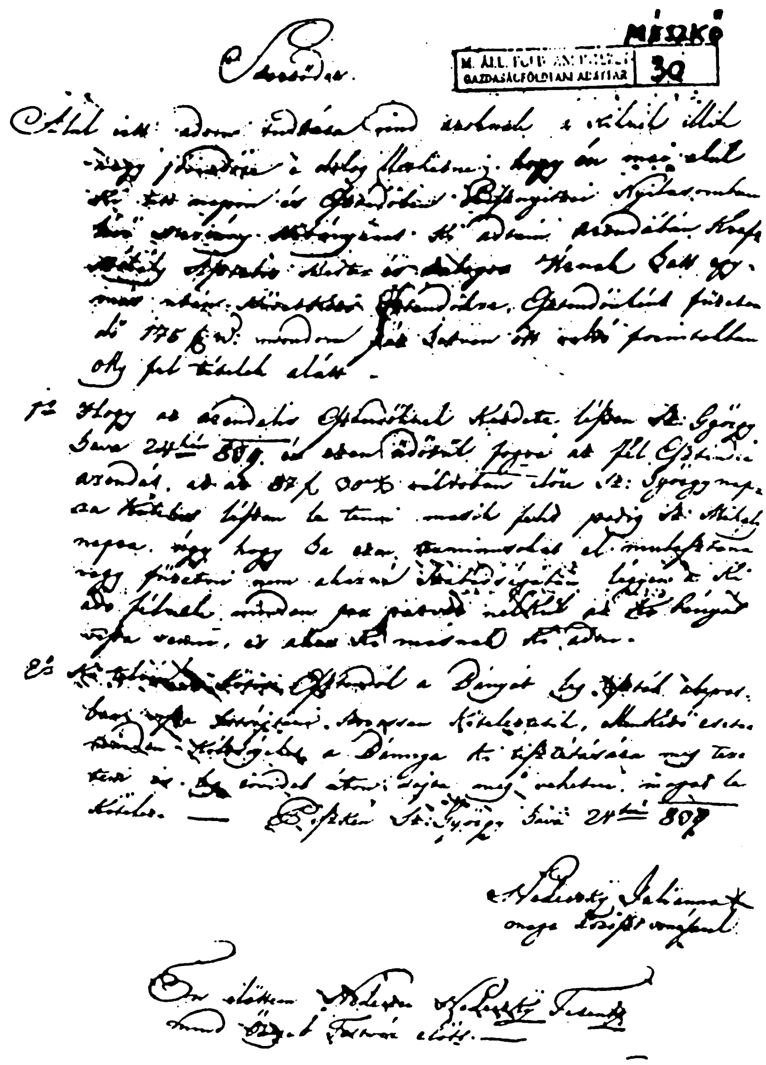

Fig. 3. The oldest document of the Database

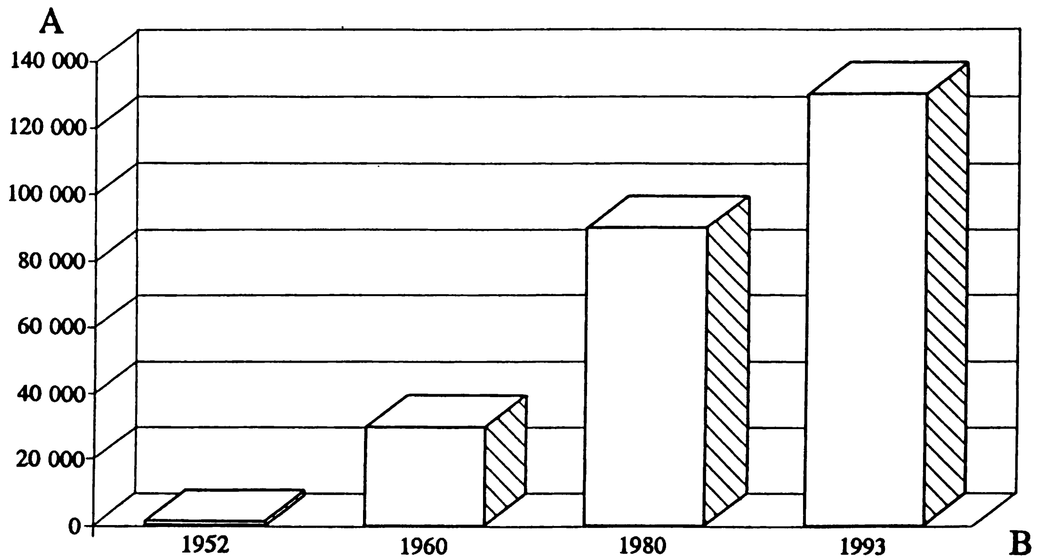

Fig. 4. Increase of the stock of the Database (1952–1993)
A: Number of documents, B: Year

be found in the Database which had been compiled prior to the foundation of the Archives. 1,050 documents were incorporated into the the Archives at its foundation, the oldest one is the "Mészkő 30" report (Fig. 3) written in 1839, while 828 documents were acquired later (Erdélyi 1992). The stock grew continuously and swiftly (Fig. 4). At the time being 33,000 manuscript reports and expert's opinions, 80,000 drilling documentations and more than 20,000 original drawings (such as maps, profiles etc.) can be found in the Database.

The traditional system of recording the documents was organized according to the main types of documents: reports (25 percent), borehole documents (61 percent) drawings (14 percent) (Fig. 5). The "Cadastre of Drillings" serving the registration of exploratory boreholes can be regarded as an independent data-collection, since it stores the basic administrative, technical and geological data of several tens of thousands of drillings, the complete documentation of which can not be found in

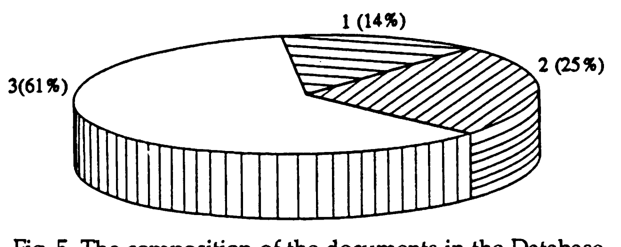

Fig. 5. The composition of the documents in the Database
1. Figures, 2. Reports in manuscripts, experts'opinions, 3. Documentations of drillings

the Database. This inconsistency is due to the not infrequent changes of the instructions and regulations relative to the data-supply: in some periods the entire drilling documentation, in others only the basic data had to be supplied by organizations carrying out geological explorations.

According to our present knowledge the Database contains the detailed documentation of two-thirds of the drillings penetrated in Hungary. It is being completed at a level of ever growing rate.

The register and the different documentations reflect of course the knowledge and scientific opinion of that time. This has to be considered, when we use the data of an older document.

The system of recording developed step by step. The classification of documents done originally according to raw-material types turned out to be unpractical. The method of recording used at present was elaborated in 1959; it was designed fundamentally for doing the retrieval of the data and documents according to author, to geographical location and subject (Szebényi 1959, 1964). The use of computers for recording was initiated in 1988. Further development led to the completion of the computerized database for reports in 1993. Regular services can be obtained from the database of drillings as well.

Besides the data-recording and evaluations done according to the timely demands of state authorities, systematic recording has been carried out, too. As one of the important results of this work the serial publication of the volumes entitled as "Prospecting Geological Exploration" at first, then renamed as "Central Geological Exploration", and finally as "Basic Drilling Data of Hungary" (Bohn 1967, Kiss 1983) have to be mentioned. Since 1989 the data published previously in the aforesaid series are entered directly into the database.

In 1983, the second phase of analytical registering was begun by plotting the maps of exploration coverage, and by compiling maps showing the extension and boundaries of surveyed areas and the tracing of the geological profiles. The maps of these series show the geographical situation of areas explored by drillings, or the coverage by geological maps included into the unpublished reports or expert's opinions, moreover the trace lines of geological profiles on scale 1:100 000 (Vitális 1987). In 1993 the computerized recording of the completed maps based on GIS (Geographical Information System) was begun with all the inevitable difficulties of transition from the traditional manual methods to the uniform computerized data processing excluding any kind of subjective views.

The systematization of water prospecting drillings was begun in 1985; at present this work is going to be completed. Resulting from the checking, comparation and completion of the data and documents, the Database has an unparalleled collection of documentation on water prospecting drillings (Oswaldné Bárány 1985).

The information supply for a broad scale of institutions had a gradual evolution, but by becoming operative it helped effectively the collection of data. By the success of the "concept of reciprocity" the supply of the data required by legal instructions gained practical importance for the supplier, too (Mrs. G. Erdélyi).

Statistics on the attendance of the Database, although a bit incomplete, are available from 1970 onwards (Fig. 6). A rather-changing degree of the demands is shown by them. The relatively small number of visitors, or the decreasing demand for the services as it is reflected by the figures may be caused likewise by the severity of the state regulations of data protection in certain periods, as by the temporary closing of the Archives due to rebuilding or removal of the material stored. At the time being the Database is open to the public. The predominant part of stock qualified as being "of common interest". The services of the Database are helped to a great degree by the computerized databases mentioned above.

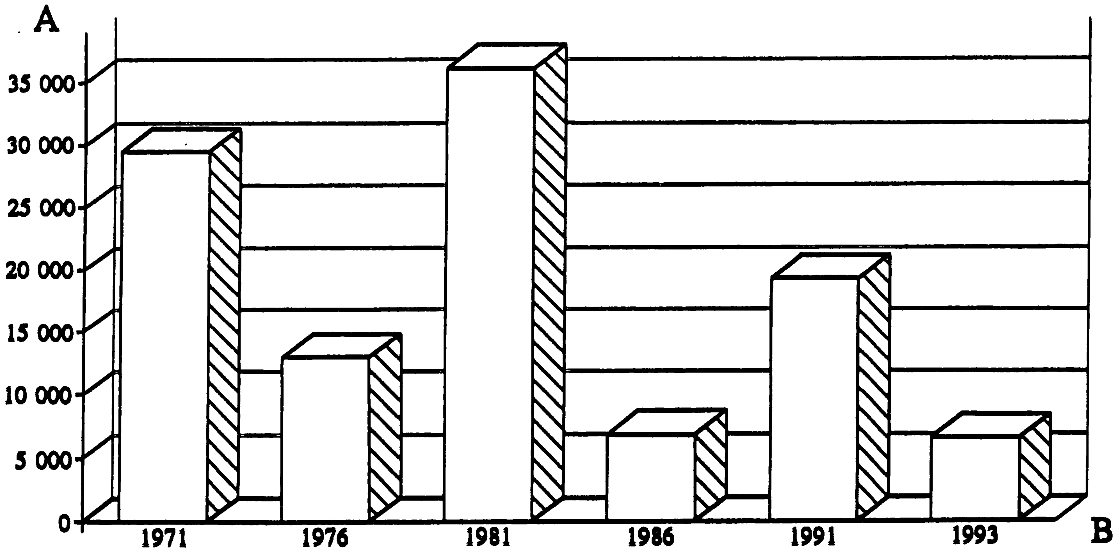

Fig. 6. The number of the lended documents (1971–1993)
A: Number of the documents, B: Year

The technical conditions of the activity in the Archives were generally sufficient during its history. It moved to the present premises on the second floor of the Survey's main building in 1982 (Nagy, I. 1984). In the instrumentation helping the work of the research staff the PENTAKTA made microfilm devices had eminent role during approximately 15 years (1977–92). The stock of the Database was enriched considerably by the documentations microfilmed in the framework of agreements reached with several enterprises. Huge amounts of such data could be included into the stock which, due to problems of various copying difficulties, lack of information supply etc., had been missing up to that time (Fördős&Varga 1986).

The instrumentation of the Microfilm Laboratory which had become obsolete had to be dismantled in 1992, but in the same year the Survey acquired the CANOFILE 250 type optical archivation system in order to replace it. The system has been put in operation, facilitating thus the steady completion of the Database.

The changes which took place during the past few years brought along a new, somewhat sad task imposing extraordinary responsibility on the staff of the Database; namely that of saving the geological data of the former state enterprises being now liquidated or privatized. Within the framework of this project the databases of the above mentioned companies have been revised in general terms. Detailed revision has been accomplished in some places with the results stored in computer. Data missing in the Database have been recorded by making copies or by archiving with the CANOFILE machine. Furthermore, the recording of scientific data of the Nógrád Coal Mines, the copy of the central database of MAT (i.e. Hungarian Aluminium Trust), and the recording of the database of the OÉÁV (i.e. Hungarian Mining Company of Ore- and Mineral Resources) in Budapest have also been finished. The recording of other databases is under preparation. We intend to carry out this duty in cooperation with the legal successors of the enterprices concerned by taking into consideration as far as possible their professional interests in a manner, however, that the data should be managed and safeguarded with responsibility everywhere and all the time. Each piece of information produced during the geological exploration in the past or at present gained by our predecessors or contemporaries should be saved for us and our successors.

THE NATIONAL GEOLOGICAL LIBRARY
(by M. Csongrádi)

The foundation of the Survey's Library and its hundred years history were described by I. Kaplayné Schey in the volume edited on the occasion of the Survey's Centenary Celebrations (1969). Some years later Á. Kiss summarized the events of the period lasting to 1987, illustrating them by statistical data (Kiss 1989).

The fundamental task of the Library is to collect printed documents on the geological and related fields of research to incorporate these into the stock; to safeguard, record, and make them available to the public.

Thanks to the size and composition of its

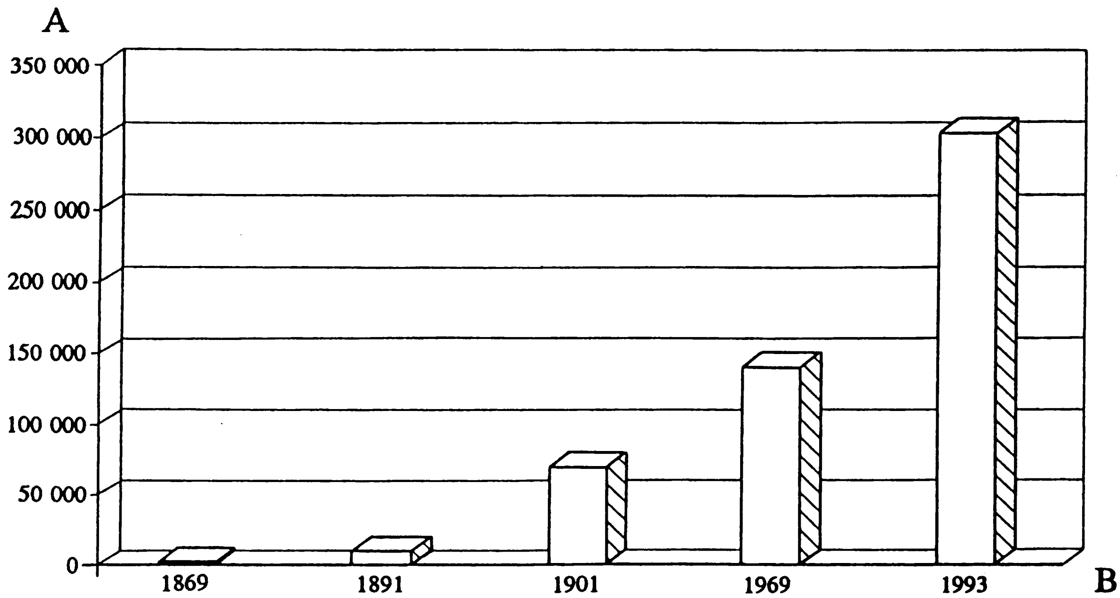

Fig. 7. Increase of the stock of the Library (1869–1993)
A: Number of stocked pieces, B: Year

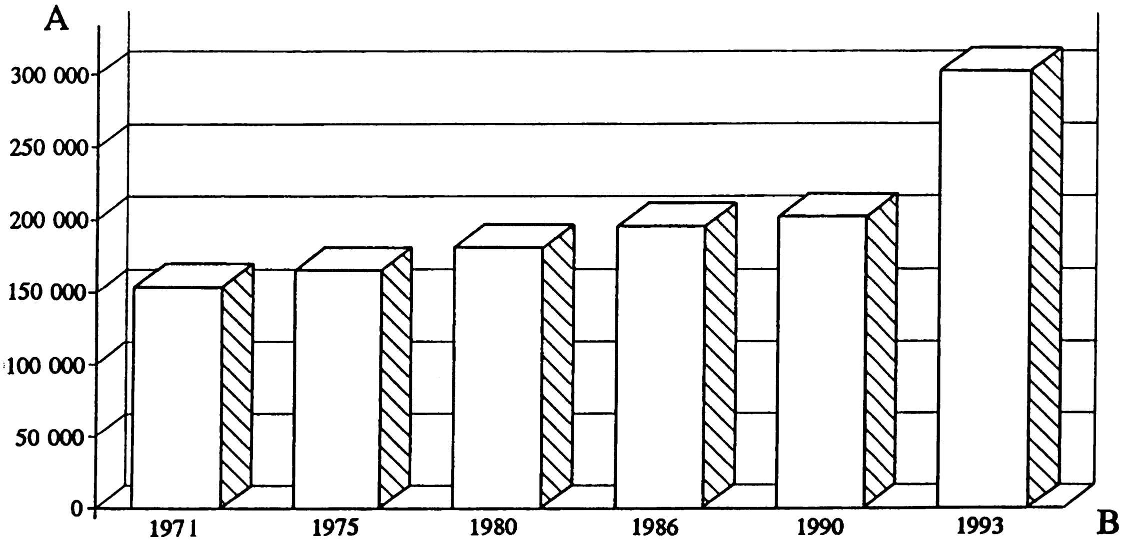

Fig. 8. Change of the stock of the Library (1971–1993)
A: Number of stocked pieces, B: Year

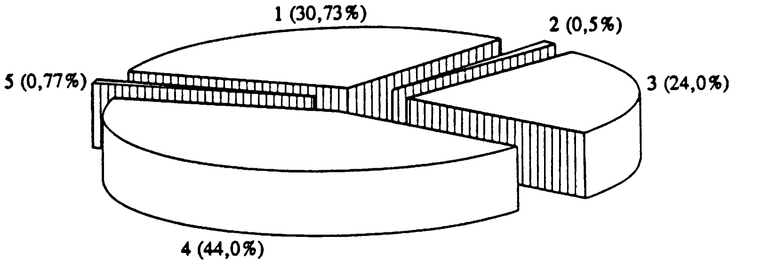

Fig. 9. Recent stock of the Library
1. Maps, 2. Other, 3. Books, 4. Journals, 5. Manuscripts

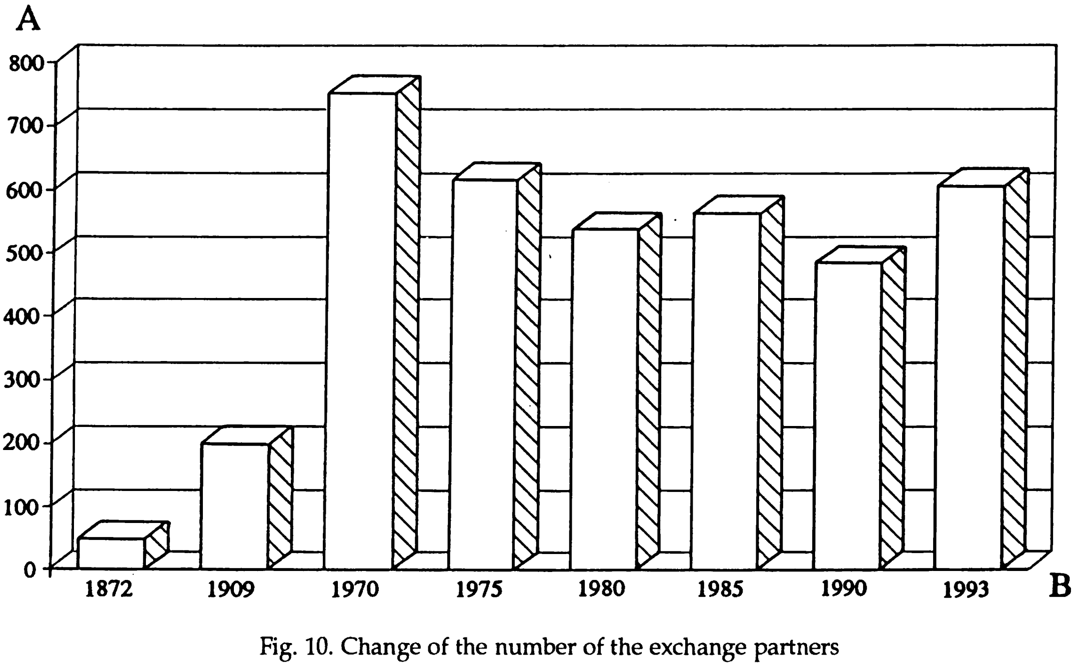

Fig. 10. Change of the number of the exchange partners
A: Number of the exchange partners, B: Year

stock, the level of the registering and the thematic analysis of the collected documents, as well as the quality of the services performed, the Library of the Survey has been registered by the Libraries Act promulgated in 1976 in the list of professional libraries of nation wide competence.

The Library is open to the public. The readers include specialists of various institutes and enterprises of both scientific and industrial character, research associates, staff members and students of universities, and even secondary school pupils. The Library had more than 105,000 visitors during the past twenty-five years. More than one million volumes were brought out from the stores and nearly 110 thousand volumes were lent.
Today there are 302,000 library units in the stock of the Library, consisting of catalogized books, maps, legacies, manuscripts, translations and microfilms. The growth of the Library's holding from the foundation of the Survey until 1993 is shown on Fig. 7.

The unbroken increase of the stock between 1971 and 1993 is illustrated by Fig. 8.

The Map Depository was merged with the Library at the beginning of 1992. The outstanding figure in the growth of the stock at that time is due to this measure of restructuring. The composition of the stock is characterized by the numerical superiority of the periodicals which are the quickest sources of information and by the considerable amount of maps (Fig. 9).

Manuscripts, translations, and microfilms together with the CD-ROM database of non-traditional informative systems are registered as "miscellaneous".

The exchange of periodicals, books and conference proceedings for the Survey's own publications has been the most important contribution to the growth of the Library's stock since its foundation. Thus not only a good survey of the world's geological literature has been obtained, but publications which could have not been acquired by commercial way have been incorporated into the stock of the Library, too. The Centenary of the Survey affected favourably our external connections. At present we have 611 active partners in 78 countries of the world (Fig. 10). Since the Centenary in 1969 approximately 54,000 volumes of Annual Reports and Yearbooks, Geologica Hungarica and occasional publications, maps and explanatory notes have been sent to our partners, from New Zealand to Iceland.

We took important material in our inventory received as donation from other institutions, presented by our readers. Often deceased geologists bequeathed their own collections to the Library, too. Some names to remember: A. Földváry, B. Jantsky, A. Rónai, T. Szalai.

The budget for the development of the library has not increased during the past few years, moreover, inflation and increasing prices caused the drastical decrease of the number of journals. In our files 667 current periodicals are registered. Out of them, however, only 47 are subscribed, while 620 are received by exchange.

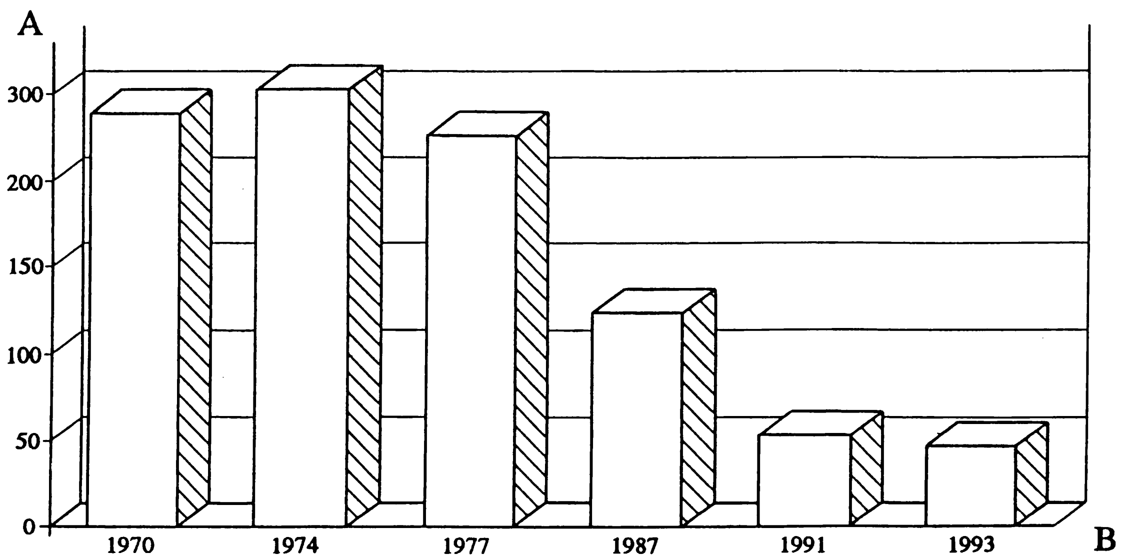

Fig. 11. Journals from abroad, ordered by the Library (1970–1993)
A: Different journals, B: Year

At present the number of foreign periodicals subscribed is only the one fifth of that in 1974 (Fig. 11). These shortcomings are compensated by registering the periodicals which can be found in other libraries collecting geological publications as well. Over more than 600 periodicals received by 13 libraries are registered. This list is available as working material both in xerocopied and computerized versions. Due to the restricted financial resources the number of purchased professional books and manuals is regrettably small.

The manysided evaluation of the stock regarding its thematic composition is manifested in the continuously updated catalogues: those of books, occasional publications, translations, publications of scientific congresses, moreover those of the Survey's own publication are available. Thematic inquiries can be done by the UDC, or by the key-word catalogue.

Besides the referative periodicals the informative data retrieval from the geological literature published abroad is facilitated by the GEOREF CD-ROM database developed by the U.S. Geological Survey, which includes 1,3 million records and is updated every two months.

According to the will of T. Szalai his donation was utilized for the modernisation, the technical development of the Library. The first computer hardware was acquired in 1989. The list of the periodicals subscribed by other libraries collecting geological publications, too; moreover that of the periodicals available in the Library of the Survey and its exchange collections were completed by using this computer.

Today all the technical conditions are given to implement computerized data processing by the introduction of the TINLIB complete library-system which we had purchased at the end of 1993. On the xerox machines, bought by obtaining the aid of the Soros foundation in 1986 and 1993 we made 320,000 copies until the end of 1993 hitherto.

The most important task of the future should be the creation of a "virtual library" by finding the adequate proportions of supplying printed materials and electronical information (Bossers 1993).

We have compiled the bibliography of the approximately 1,500 textual publications published during the past 125 years, and that of the map-sheets edited from 1957 to 1985 (see in the References as Szöveges kiadványok 1993 and Kiadott térképek 1985).

These are indispensable in the supply of information, in establishing relations of exchange and also for commercializing the publications of the Survey.

The catalogized stock have already filled up the storage rooms designed by Ö. Lechner. Since 1980/81 we have been keeping 474 periodicals in external premises. The problems of storage are increased by the incorporation of the stocks of the libraries abolished in the course of reshaping the system of geological institutions in Hungary.

The enthusiastic and professional work of the librarians and the keepers of the Map Depository ensure the unbroken development of the Library in the spirit of the best traditions, and the safekeeping of our collection, preserving its big scientific-historical value for the posterity.

PUBLISHING ACTIVITY

by **KÁROLY BREZSNYÁNSZKY**

One of the basic tasks of the Survey is to publish its results and to issue maps and other publications. The geological maps, the different geological scientific periodicals and monographs are essential to understand the geology of Hungary, and in this way, they are part of our national heritage.

PUBLICATION OF MAPS

The maps issued during the past 25 years had various subjects and scales. They are introduced in the text according to their decreasing scale.

Map series

Detailed geological mapping at 1:10 000, 1:20 000 and 1:25 000 scales started in the Mátra, Mecsek, Bakony and Tokaj Mts, and in the Dorog Basin, in the sixties, which were the most important areas for raw-material prospecting. The geological maps of the mountain areas were edited on the basis of those maps, which contained all the field-work data and documentation, and which were also published. The maps also had explanatory notes. The maps of 1:10 000 and 1:25 000 scales were secret, according to the law at that time, which highly restricted their accessibility. The different geological mapping projects mostly finished in the sixties, but the publication of the maps and volumes of explanations continued through the subsequent decades.

Besides the geologic maps of the Dorog Basin at 1:10 000 scale, the primary maps that contained the original field-work observations were also issued. Of the 15 map sections covering the area, 7 pages were issued during this period. The program of publication finished in 1973.

The program of publication of geological mapping at 1:10 000 scale in the Mecsek Mts finished in 1976, with the issue of the last 14 pages. Besides these maps, which had a final geological, as well as an original field-work observation version, the 3rd version of the Cserkút and Pécs NW maps, which were the most important areas of uranium prospecting, also recorded the locations of research establishments (drillings, etc.).

The results of geological mapping in the Mátra Mts at 1:10 000 scale were issued on 19 pages, 12 of which were published after 1969. The program of publication finished in 1979. Certain sections had two versions: a geological and an observational one.

The geological maps of the Bakony Mts were published at 1:20 000 scale to avoid the problems of secret maps. The first page, as a specimen copy, came out in 1969. Since that time, 25 sections were issued, but the program of publication hasn't finished yet. Certain maps had geological and observational versions, but in the regions of intensive raw-material prospecting, a separate map recorded drilling sites, too. Uncovered geological maps, without the Quaternary sediments, were also published.

The publication of 11 maps from the 1:25 000-scale geological map series of the Tokaj Mts spread across to the seventies. The program of publication finished in 1977. Certain maps had a geological and an observational version, but in some cases these were drawn together.

Maps of different subjects and scales

After the completion of detailed geological mapping, there was a claim to regional summaries, i.e. the publication of maps of the different mountain areas. The geological maps of the Dorog Basin (1981), eastern Mecsek (1982) and western Mecsek Mts (1984) were published at 1:25 000 scale. The geological map of the Keszthely Mts at 1:20 000 scale (1979), the 4 tectonic maps at 1:25 000 scale of the Buda Mts (1977), and the 2 maps at 1:200 000 scale of the areal extent and facies distribution of the Oligocene–Lower Miocene formations in the Transdanubian Central Range (1981) were published as appendices of monographs. The uncovered geological map of the Aggtelek–Rudabánya Mts at 1:25 000 scale summarizes the excellent results of a new style of geologic mapping (1988).

Summary maps at 1:50 000 scale were published for the Mátra (1974) and Tokaj Mts (1976), and for the Nógrád–Cserhát area (1976). Covered (1985) and uncovered (1990) geological maps of the Bakony Mts were also issued at this scale.

The prognosis maps for the further prospecting of certain raw-materials were based on the huge amount of stratigraphic, facies and tectonic data accumulated during geologic mapping. After publication of the general bauxite-geology map of the Transdanubian Central Range at 1:100 000 scale (1978) and the special maps connected with certain stratigraphical levels at 1:200 000 scale (1980 and 1982), the combined map with the synthesized data of the underlying and covering beds will be issued at 1:100 000 scale (in press). The geological map of the lignite area of Cserhát–Mátra–Bükkalja was published at 1:200 000 scale in 4 versions (1982).

Many versions of engineering geological maps for regional planning, utilization of areas, environmental geology, etc. were published for some cities: Eger, 1:10 000 (1978), Miskolc, 1:12 500 (1979), Veszprém, 1:25 000 (1979), Salgótarján, different scales (1981), Budapest, 1:40 000 (1984), suburban areas of the Balaton, 1:50 000 (1985).

Parallel with the detailed geological mapping in the mountain areas and its publication, the maps of 1:200 000 scale, which were edited according to uniform guiding principles of the former Comecon countries, have been published continuously since the beginning of the sixties. Except for the pages of Budapest and Veszprém, all these maps were secret, as it was ordered at that time. Certain maps had geological and economic-geological versions. According to the available data, further special maps (hydrogeology: mean water level, hydrogeochemistry of the groundwater; engineering geology) also came out. Of the 25 pages covering the territory of Hungary, 11 sections were published in the seventies, mainly about the lowland areas. The program of publication finished in 1977, but the last page of Sopron never came out. The maps and their volumes of explanations, even accounting for the lack of Sopron, are one of the most important summaries of the geology of Hungary.

Atlases

To present the complex geological knowledge of a specific area, the Survey often chose the form of an atlas in the past two decades. These atlases are not only collections of maps, but also contain a comprehensive explanation in Hungarian, or in a foreign language, and are encyclopaedic treatments of a certain area.

The Survey published the "Atlas of deep drillings in Hungary between 1963 and 1975" in 1981. The scale of the maps is 1:150 000.

The "Neogene Palaeogeographic Atlas of Middle- and East Europe" was a result of an international cooperation, and was issued by the Survey in 1988. The main maps at 1:3 000 000 scale present the Neogene paleogeography of the whole area in 7 different time-sections, and also have supplementary maps at 1:7 000 000 scale.

From the second part of the sixties, the Survey carried out a great program of geological mapping and publishing on the Great Hungarian Plain. The main goal of geological mapping of low-land areas is to support agriculture, utilization of areas, water supply and environmental protection. The results of the complex geological mapping are presented on maps of 1:200 000 scale, in 19 versions, with an explanatory text in atlases. From 1969 until the present day, 16 atlases were issued, which means a 50% completion of the planned program of publications.

Geological mapping with the above mentioned aims started on the other low-land area of the country, on the Little Hungarian Plain. The results of the field-work observations were complemented by remote-sensing and geophysical data, and the final versions were edited by computer. The maps at 1:100 000 and

1:200 000 scale are published in forms of atlases with explanatory texts in Hungarian and English attached. From 1990 until today, 4 maps from the planned 13 have appeared.

The gigantic research work of the Survey, which has lasted for more than 20 years from the beginning of the sixties, made it possible to create different large-scale geological syntheses. This synthesizing work was also timely due to the general development of geology. The reevaluation of the stratigraphic range of the different formations, and the new structural model of Hungary, based on plate-tectonic considerations, were the bases of the syntheses. The geological build-up of the country is presented in an atlas containing maps at 1:500 000 scale, certain pages even have a volume of explanation.

The first page, the geological map of Hungary, was published in 1984. Further maps show the Pre-Cenozoic basement (1987), the pattern of Cenozoic formations from below (1990), the structural build-up (1990), the metallogenesis (1993), the seismic survey of the country (1990), the distribution and thickness of certain Pannonian formations in 4 versions (1987), the soil groundwater-movement patterns (1986), the hydrogeology (1989), the prognosis for construction raw-materials in 3 versions (1988), the engineering geology (1986) and sensitivity to contamination (1988) of the surface formations, and finally the cadastral survey of the waste disposal sites. Further pages of the atlas are still awaiting publication.

OTHER PUBLICATIONS

Periodicals of the Survey

The scientific periodicals of the Geological Survey have great traditions, and play an important role in the Hungarian geological literature. The Annual Report and the Annals were founded more than 100 years ago. Two series of Geologica Hungarica started in the first decades of this century.

The Annual Report of the Hungarian Geological Survey publishes scientific papers, in addition to the report of the director. The journal is in Hungarian with summaries in foreign languages (English, German, Russian). The report about the activity of the Survey has been published in a separate volume from 1991. Both the activity report, and the scientific papers have been published in English since that time.

The Annals of the Hungarian Geological Survey publishes longer studies and monographs in Hungarian and/or in a foreign language. During the past 25 years, 22 volumes were issued. Most of them discussed the geology of specific areas where geologic mapping had been carried out.

Geologica Hungarica has two series: Series Geologica and Series Palaeontologica. This volume has a big size, and it is also suitable for publishing high-quality photos. A volume generally contains one study or monograph in Hungarian and/or in a foreign language in that series, which is appropriate to its subject. 9 volumes of Series Geologica, and 16 volumes of Series Palaeontologica were published in the past 25 years.

The above mentioned periodicals of the Survey are national ones, although they sometimes also are published in a foreign language. Most of the published papers discuss the geology of Hungary, and the authors, with some exceptions, are working in the Survey.

Explanations of the maps

The biggest part of the publication of the Survey are the explanations of the maps, both in the number of volumes and in the number of copies. The programs of publication of geological maps at different scales all had the aim of issuing explanatory texts, too. The simultaneous publication of the maps and their explanations wasn't successful in all cases. Some explanations have never been finished.

During this period, 86 volumes of explanations were issued in the following distribution (we indicate the date of publication of the last volume in brackets): Dorog basin, 4 pieces (1974); Mecsek Mts, 10 pieces (1979); Mátra Mts, 14 pieces (1979); Bakony Mts, 23 pieces (1988); Tokaj Mts, 8 pieces (1978); series of geological maps of Hungary at 1:200 000 scale, 11 pieces (1981); series of geological maps of Hungary at 1:500 000 scale, 3 pieces (1991). Another 3 individual volumes have come out as explanations of different regional maps.

Occasional publications

Methodological Papers and Special Papers belong to this group. The Survey started both series in 1972. Methodological Papers has had 13 volumes until today. Its main goal is to introduce the results of development of the different methods of investigation. The publication of Special Papers was necessary because of the enlarged international partnerships of the Survey. It announces the different results of the geologists of the Survey during their work abroad. Until now, 8 volumes have been published.

Other different volumes of various subjects and lengths also belong to this group. We have 28 volumes, which were all issued during the past 25 years.

Publication of Information

Volumes of "Long-Term Geological Research", which started in 1963, and was later renamed "Central Geological Research", then "Basic Data of the Deep Drillings in Hungary" belong to this group. The volumes annually present the coordinates and the most important geologic data of deep drilling. The volumes were issued every year until 1988. From 1981 to 1988, parallel with the above-mentioned volumes, regional summaries were also published (the so-called Retrospective Series). Altogether 7 volumes summarize the data of deep drilling in Transdanubia, in northern Hungary and on the Great Hungarian Plain.

Another important series of information is the "Catalogue of Key-Sections and Key-Boreholes". Between 1985 and 1991, 166 booklets were issued, which were connected with the "Programme of Key-sections of Hungary". Each booklet presents a specific lithostratigraphic formation. They are the basic documents of the re-evaluated stratigraphic ranges. Those papers that present the geology of some foreign countries, which are rich in different raw-materials, also belong to this group; 15 volumes were published between 1982 and 1988. In the framework of Comecon Geoinform cooperation, 21 booklets were published between 1981 and 1989 in Hungarian and in Russian, mainly about raw-material prospecting.

Publications of Meetings

Publications of conferences and excursion guidebooks belong to this group. We issued 20 different volumes altogether. The most important ones were the publications of RCMNS 8th Congress in 1985. In 1975 and 1979, international postgraduate courses in engineering geology were organized in Budapest, which were also supported by UNESCO. The English and the Hungarian volumes of the courses, altogether 55 pieces, were issued by the Survey.

The Hungarian Geological Survey carried out significant publishing activity during the past 25 years. Lists compiled by the National Geological Library contain the detailed bibliography of the above-mentioned, or cited, maps and other publications, which are available for everybody, including: "Maps, issued by the Hungarian Geological Survey between 1957 and 1993", and "Publications of the Hungarian Geological Survey between 1869 and 1993". As a consequence of the decreased staff in the Survey, due to the transformation of the system of geological institutions, the publishing activity will also decrease. In 1993 we had to liquidate the traditional printing of maps in the Survey, and also had to discontinue our own printing office with all its advantages. However, we try to seize the opportunity of these disadvantages, and modernize the still existing production of publications.

DIRECTORS OF THE HUNGARIAN GEOLOGICAL SURVEY

JÓZSEF HÁLA

JÓZSEF FÜLÖP

He was born on the 20th January 1927 in Bük. He finished the secondary school at Sopron in the school of commerce. Between 1946 and 1948 he was teacher candidate specializing in geography and economics at the Pázmány Péter University but changed specialization and graduated as geologist in 1952. For two years he worked as assistent at the Department of Geology of the University. In 1954 he was appointed Chief of Department for Material Testing in the the Hungarian Geological Survey and later to Geological Adviser to the Secretariat of the Cabinet. Since 1st September 1956 he was Deputy Director, between 1959 and 1969 the Director of the Hungarian Geological Survey. In 1963–64 he was also Director of the Eötvös Loránd Geophysical Institute of Hungary. Since 1st October 1968 he was as President of the Central Office of Geology in everyday contact with the Survey. Between 1984 and 1990 he worked in the Survey as research professor in part-time employment. Since 1970 he was full professor of the Eötvös University, between 1984 and 1990 Rector of the University and since 1971 up to his death of 13th April 1994 the Head of the Research Team of the Geological Department of the Hungarian Academy of Sciences.

His professional work was focused first mainly on stratigraphy, more precisely that on the Mesozoic, especially the Cretaceous type regions of Hungary. He comprehended his results in the monographical works "Cretaceous formations of the Gerecse Mountains" (Geologica Hungarica Ser. Geol. Tom. 11. 1958), "Lower Cretaceous (Berriasian-Aptian) formations of the Bakony Mountains" (Geologica Hungarica Ser. Geol. Tom. 13. 1964), "Cretaceous formations of the Villány Mountains" (Geologica Hungarica Ser. Geol. Tom. 15. 1966), and "The Mesozoic basement blocks of the Tata basin (Geologica Hungarica Ser. Geol. Tom. 16. 1975). His intention for life-long activity was to create the handbook "The Geology of Hungary". This series of monographs with key-sections which was prepared for decades is both exploring and synthesizing work with the critical evaluation of the complete referenced literature and with the finishing touch of superb editorial work. The series was planned to consist of 8 volumes with the aid of outstanding experts of Earth sciences, but because of the early death of the author only four volumes were published ("History of mineral raw materials in Hungary", Technical Press, 1984, "Introduction into the geology of Hungary", Academic Press, 1989, "Geology of Hungary, Paleozoic I, Hungarian

Geological Survey, 1989, "Geology of Hungary, Paleozoic II, Academic Press, 1984). He published his results in stratigraphy, science history, paleoarcheology and geological nature conservation in wide circles. In his activity in science politics have to be specially mentioned preparation of the national long-term research plan (1961), papers on the tasks and research concepts of the Survey, publications on the guidelines of the Survey and exploration of natural resources of Hungary and the first open reports on the mineral resources of Hungary combined with their economic evaluation.

The appreciation of his scientific results have been honoured by the following awards and qualifications: Candidate (1957), Academic Doctor (1962), Corresponding Member (1967) and Full Member (1976) of the Academy of Sciences, Szabó József Memorial Medal of the Hungarian Geological Society (1969), Hantken Miksa Memorial Medal (1981), Corresponding Member of the Geologische Bundesanstalt Wien (1975), Corresponding Member of the Austrian Academy of Sciences (1980), as well as Honorary Member of the Association of Hungarian Geophysicists (1971), of the Hungarian Geological Society (1981), of the Hungarian Geographical Society (1981), of the Austrian Geological Society (1980) and of the Bulgarian Geological Society (1981). For his outstanding work in the field of geological research he was awarded the Order of Eminent Worker of Geological Research (1957), by the State Prize (1983) for his efforts in the field of raw-material prospection, and by Pro Natura Prize for his results in geological nature conservation (1976).

His activity as director is characterized by the initiation of modern geological research in Hungary fitted to the requirements of our modern age: he established units for geological mapping, geological material testing and geological documentation forming the base of the organization of the Survey. He regarded as the most important elements of the Survey's activity: detailed geological mapping in sections supported by man-made exposures and geophysical measurements, complex mass-analytical work, construction of several thematic maps distinguishing between observed data and interpretation, with legend and monograph supplements. He initiated, and for the most part materialized, the detailed geological mapping of the Mecsek and Bakony Mts, of the Dorog Basin, of the Mátra and Tokaj Mts and, as a revision, that of the Great Hungarian Plain. In addition to the promotion of regional monographs, he also initiated national mineral resource prediction work, geochemical rare-earth element exploration and engineering geological mapping (1968). The institution of report sessions initiated by him aimed at the wide dissemination of the research results of the Survey. His name is hall-marked the modernization of stratigraphy in Hungary, by the introduction of lithostratigraphic formation system, the establishment of geological nature conservation areas of Tata and Sümeg and the development of the system of geological key-sections of Hungary. He played an important role in developing and performing the tasks of public and higher education as well as in raising the professional standard of the Survey.

In the course of his directorship he represented the whole of the Hungarian geological community as Chairman of the IUGS Mediterranean Mesozoic Committee (1960–1968), Chairman of the Stratigraphic Committee of Hungary (1970–1991), Chairman of the Geological Scientific Committee of the Department of Earth and Mining Sciences of the Hungarian Academy of Sciences (1985–1991), as Editor in Chief of the Acta Geologica Hungarica (1985–1994) and as Vice-President and elected Presidential Member of the Hungarian Academy of Sciences (1977–1980). He renewed the international relations of the Survey by organizing the International Mesozoic Conference in 1959 by the centenary celebration of the Survey and related 6 international meetings in 1969 as well as by the bilateral Austrian–Hungarian geological co-operation agreement in 1968.

JÓZSEF KONDA

He was born on the 21st October 1929 in Budapest where he also finished elementary and secondary schools. Between 1951 and 1955 he studied geology in the Eötvös University. In his first employment, in the Hungarian Geological Survey he worked as an assistant researcher with the Engineering Geological Group. From March 1956 to April 1957 he worked as geologist at the Tokod Drilling Co., and from April 1957 to September 1959 at the Pécs Uranium Ore Mining Co. From September 1959 to October 1961 he was a fellow of the Hungarian Academy of Sciences. From 1st October 1961 to 1st January 1970 he was Deputy Director, from 1st January 1970 to 30th March 1979 Director of the Hungarian Geological Survey, from the 31st March 1979 to 30th December 1990 until his retirement he was Scientific Advisor of the Survey. From 1st September 1976 he is Associate Professor at the Eötvös Loránd University.

His professional activity has been related to the exploration of the Dorog–Esztergom brown coal exploration, to the exploration of the uranium deposits of the western Mecsek Mts and to the geological exploration of the Bakony Mts ("Sediment-geological investigation of Jurassic formations of the Bakony Mountains", Annual Report of the Hungarian Geological Survey, Vol. L. No.2, 1970). The appreciation of his scientific work was honoured by the candidate degree (1967). For his merits in raw-material prospection he was awarded the order of Eminent Worker of Geological Exploration (1965), and he received decorations by the Goverment twice (1966, 1969)

His work as director was characterized by the activities to assure the continuity of work and to develop the Survey's activity responding to the social and economic demands. During his leadership the field of activity of the Survey expanded. His concept had the following guidelines:

– to asses areas potentional for mineral prospection and to compile the inventory of proven reserves;

– to provide the geological base for planning of regional settlements, road, railroad and hydrological constructions of national scale;

– to complete the programs started in 1958;

– to extend the regional geological mapping of geographical units (in addition to the acceleration of mapping in the Bakony Mts) over the fields of the Vértes and Gerecse Mts and Zagyva-trench and to the whole of the northern Transdanubian Central Range, as well as

– to perform the engineering geological mapping started at Budapest.

His results of practical importance were: coal resource prediction in the Mecsek Mts, the recognition of the brown coal deposit of Lencse-hegy in the Dorog Basin, the discovery of the deep-seated Recsk copper deposit in the Mátra Mts, the discovery of the oil shale deposits of Pula, Várkesző and Gérce in the Balaton Highland. On the initiation of the Central Office of Geology he established the organization of Regional Geological Services within the frame of the Survey (1971–1974) in order to perform tasks of a geological administrative authority. The Regional Geological Services also took the task to prepare predictive maps for building materials, maps of pollution vulnaribility and maps of surface-movement hazards.

He organized an international conference in 1976 in order to promote the international contacts of Hungarian hydrogeologists and to demonstrate their results to the international public. He also organized an International Postgraduate Engineering Geological Course (1975, 1979) supported by the UNESCO. The Survey joined the Information System of BRGM (Orléans) during his directorship.

GÉZA HÁMOR

He was born on the 3rd June 1934 in Kecskemét. Already at the time of his studies in the secondary school (1951–1952) he worked as seasonal labourer at drillings of the Survey in the exploration of the Great Hungarian Plain. From 1951 he studied geology at the Eötvös Loránd University and in 1954–56 he was part-time worker in the Sediment-Petrographic Laboratory of the Survey. Subsequently to graduation, from the 1st October 1956 he worked in the Survey, first as assistant, later as scientific assistant, researcher, senior researcher and scientific adviser upto 29th December 1991. He was fellow of the Hungarian Academy of Sciences between 1960 and 1963. From 1964 he was Head of Division for Mapping in the Survey, from 1974 Deputy Director and from 29th March 1979 to 30th June 1991 Director. On 1st June 1976 he was nominated full professor at the Technical University for Heavy Industry at Miskolc. In 1988 he has been invited as Professor and Head of Department for Regional Geology at the Eötvös Loránd University.

His professional activities have concentrated on the following fields: geological mapping in the eastern Mecsek, Börzsöny Mts and in the Nógrád–Cserhát region, Neogene stratigraphy, paleogeographic reconstruction and geologic-paleogeographic map construction. His work record includes 46 geological maps of various kinds and 34 map legends, the monographs "The Miocene of the eastern Mecsek Mts (Annual of the Hungarian Geological Survey, Vol. LIII 1970) and "Geological setting of the Nógrád–Cserhát exploration area" (Geologica Hungarica Ser. Geol. Tom. 22, 1985), basic Neogene stratigraphic studies ("Chronostratigraphie und Neostratotypen, Miozän der Zentralen Paratethys, Bd. III. M2 Ottnangian" Bratislava, 1973, "Bd. VI. M4 Badenien" Bratislava, 1978, Annual of the Hungarian Geological Survey Vol LXX. 1987, Acta Geologica Hungarica 27/1–2, 1984), the manual of quantitative methods of paleogeographic and facies analysis (Special papers No. 2 Budapest, 1983) and the map of "Neogene Paleogeographic Atlas of Central and Eastern Europe" (Hungarian Geological Survey, Budapest, 1988). In addition, he published papers on methodology of geological mapping, application of aerial photo interpretation in geological mapping, development of the K/Ar based geochronological scale in Hungary and magnetostratigraphic investigation of Neogene key-sections.

The appreciation of his scientific achievements are Candidate (1967) and Academic Doctor (1987) degrees, academic prizes (1976, 1986), the Koch Antal Memorial Medal of the Hungarian Geological Society (1972), Corresponding Membership of the Geologische Bundesanstalt Wien (1985), Honorary Membership of the Polish Geological Society (1986) the Honorary Membership of the Hungarian Geological Society (1994). For his results in the field of raw-material exploration he was awarded by the Order of Eminent Worker of Geological Exploration (1958) and State Honour (1985). His education work was appreciated at the Mining Faculty of the Miskolc University by the memorial medal Pro Facultate Rerum Metallicarum (1994).

His work as leader and director involved several important elements such as to raise basin research to due level corresponding to its importance in the geological composition of the country, to raise the profile of basic research in the Survey, to improve prediction research and to the increase publishing activity. His main results in these fields are: the publication of maps and monographs on preliminary exploration phases, the production of a series of maps in geographic units and mineral-resource prediction maps, the initiation of publishing the "Geological Atlas of Hungary" with publishing the first 19 varieties to assure the participation of the Survey in the international map publication programs. Regarding the basin aeras, the geological model of Hungary has been highly improved, the national key-section network and lithostratigraphic formation system developed and with his assistance the first four volumes of the series entitled "Geology of Hungary" were published. Under his guidance the profile of the Survey in applied geological research has been raised and, as a fundamental method, the map and basic data system for integrated regional predictive works were developed.

He improved considerably the national and international relations of the Survey. His work in this field was aided by his professional-public functions: he was Secretary, Secretary-General, Vice-President and President of the Hungarian Geological Society between 1961 and 1991, up to 1991 the Consultative Member of the Xth Department of the Hungarian Academy of Sciences, up to 1993 Chairman of the Hungarian National Committee of IUGS, Vice-Chairman of RCMNS and Chairman of its VIIIth (Budapest) Congress, between 1982 and 1991 head of the project of Research Development Program No.3 of the IUGS. Currently he is member of the Hungarian IUGS National Committee and of the Hungarian IGCP National Committee, President of the Subcommittee for Miocene, Stratigraphic Committee of the Hungarian Academy of Science and member of the Editorial Board of Acta Geologica Hungarica.

GÁBOR GAÁL

He was born on 28th October 1938 in Nyitra. He finished the elementary and secondary school in Budapest. Prior to final examination he left Hungary and set for the final examination in the Hungarian Secondary School of Innsbruck, Austria in 1957. From 1957 to 1963 he studied geology, paleontology and petrography at the University of Vienna supplemented by studying physics and mathematics (1964). He graduated in Austria,

where he earned the PhD by his paper "Geologie des Rosskogelgebietes W Mürzzuschlag" written on the metamorphic rocks and structure of a Styrian region of the Eastern Alps.

Between December 1963 and June 1964, as geological trainee in the Indian Geological Survey he performed geological mapping in Bihar State of East India. Since 1964 Finland has become his permanent residence where he worked already since 1961 in the summers as geological assistant. In the initial phase of his professional career he gained practice in base metal exploration as employee of the Outokumpu Oy. He lectured structural geology and tectonics as a docent in the Oulu University, Department for Geology and Mineralogy since 1970. In June 1973 the Ore Geological Committee of North Finland, nominated by the Ministry for Industry and Commerce of Finland appointed him to Chief of Research of a large scientific exploration program. In order to perform this work, the Outokumpu Oy provisionally relocated him. Subsequently to the completion of the work he worked one year more at the company.

In April 1978 he was appointed Associate Professor for Structural Geology and Precambrian Geology at the Helsinki University. In addition to lectures he has taken part in the works of international scientific projects and organizations, e.g. in the IGCP Projects entitled "Precambrian Metallogeny" and, "Standards for Computer Applications in Mineral Resource Studies" and as Corresponding Member of the Tectonic Commission of the IUGS. Parallel with these works he took part in field trips and field excursions of conferences in Austria, Cyprus, Greenland, Kenya, Mexico, Namibia, South Africa, Spain and in the Soviet Union.

From January 1982 to May 1983 he stayed in Brazil where as invited professor to the Federal Univeristy of Bahia he lectured structural geology, tectonics and metallogeny, as well as functioned as consultant at various mining and exploration companies (DOCEGEO, CBPM, Caraiba Metais S.S.). In July 1983 he was employed by the Geological Survey of Finland as Chief Geologist where he founded the Mineral Resource Prediction Unit. Subsequently, he was Chief Geologist for International Relations. Since that time his research activity on international scale has considerably increased: between 1985 and 1992 he was the Chairman of the IUGS-Commission for Storage, Retrieval and Processing of Geological Data (COGEODATA) , between 1986 and 1991 Co-Leader and Leader of IGCP Project No.247 entitled "Precambrian ore deposits and tectonics". He was member, Vice-President and since 1992 President of the IUGS/UNESCO Deposit Modelling Program. He has been member of two working groups of the International Lithosphere Program and since 1992 of the International Scientific Board of the International Geological Correlation Program (IGCP). He was Vice-President (1986) then President (1987) of the Finnish Geological Society.

Between 1983 and 1991 he actively took part in the organization of several international meetings, further he participated in congresses, symposia and field trips in Brazil, Canada, China, Hungary, India, Sweden and Tanzania. He took also part in the evaluation of two development projects in Nicaragua (together with the Swedish SAREC aid institution). From the 1st January to the 1st May 1991 he functioned as visiting professor at the Western Australia University at Perth.

Since the 1st July 1991 he has been the Director of the Hungarian Geological Survey.

IRODALOM — REFERENCES

MAGYARÁZAT

Az irodalomjegyzék sikeres használatához az alábbi magyarázatokat fűzöm. Mivel a kötet két nyelven jelenik meg, minden címet idegen nyelven (elsősorban angolul) is szerepeltetünk:

— ha a magyar nyelvű cím után az idegen nyelvű cím nincs zárójelben, akkor az írás teljes terjedelmében megjelent idegen nyelven;

— ha az idegen nyelvű cím zárójelben van és a cím előtt „Abstract" jelölést használunk, akkor a cikk szövege magyar nyelvű, de tartalmaz idegen nyelvű abstractot vagy rezümét;

— ha az idegen nyelvű cím zárójelben van, akkor a mű teljes szövege magyar nyelvű, a zárójelben szereplő cím csak címfordítás.

A rövidítéseket az irodalomjegyzék után található lista tartalmazza.

PIROS OLGA
az irodalomjegyzék összeállítója

EXPLANATION

The following remarks are to facilitate the use of the list of References. As the volume is published in two languages, the titles of the references are given also translated — first of all in English:

— if the translated title following the Hungarian one is not in brackets the full text of the reference is published also in a foreign language;

— if the translated title put into brackets, and the Hungarian title is preceded by the word "Abstract", an abstract in foreign language is attached to the Hungarian text of the reference;

— if the translated title is into brackets, the full text of the reference is in Hungarian, only its title has been translated.

The abbreviations used are listed after the list of References.

PIROS, OLGA
compilator of the list of references

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RÖVIDÍTÉSEK — ABBREVATIONS

Acta Biol., Acta Univ. = Acta Biologica. Acta Universitatis Szegediensis

Acta Botan. Hung. = Acta Botanica Hungarica

Acta Chim. Hung. = Acta Chimica Hungarica

Acta Geod. Geoph. Mont. Acad. Sci. Hung. = Acta Geodaetica, Geophysice et Montanistica Academiae Scientiarum Hungaricae

Acta Geogr. Acad. Geol. et Meteorol. Debrecina = Acta Geographica Academiae Geologica et Meterologica Debrecina

Acta Geol. Acad. Sci. Hung. = Acta Geologica Academiae Scientiarum Hungaricae

Acta Geol. Hung. = Acta Geologica Hungarica

Acta Min. Petr. = Acta Mineralogica, Petrographica

Adv. Space Res. = Advances Space Research

Ált. Földt. Szemle = Általános Földtani Szemle

Akad. Kiadó = Akadémiai Kiadó

Analitica Chim. Acta = Analitica Chimica Acta

Ann. Geol. Pays. Hellen., Hors ser. = Annales Géologiques des Pays Helléniques

Ann. Hist. Nat. Mus. Nat. Hung. = Annales Historico Naturales Musei Nationalis Hungarici

Ann. Inst. Geol. Publ. Hung. = Annales Instituti Geologici Publici Hungarici

Ann. Univ. Sci. R. Eötvös sect. Geol. = Annales Universitates Scientiarum Budapestiensis de Rolando Eötvös Nominatae sectio Geologie

A Balaton tud. tan. eredm. = A Balaton tudományos tanulmányozásának eredményei

Bány. Koh. Lap., Bány. = Bányászati és Kohászati Lapok, Bányászat

Besz. a Földt. Int. Vitaüléseinek Munkálatairól = Beszámoló a Magyar (Királyi) Állami Földtani Intézet Vitaüléseinek Munkálatairól

Bull. lab. de Geol., Géogr., Phys. etc. = Bulletin des Laboratoires de Geologie, Géographique, Physique etc.

Cret. Res. = Cretaceous Research

Disc. Paleont. = Discusion Paleontology

Earth Evol. Sci. = Earth Evolution Science

Environm. Geol. = Environmental Geology

Eötvös L. Geof. Int. Évi Jel. = Eötvös Loránd Geofizikai Intézet Évi Jelentése

Értek. a term. tud. köréből = Értekezések a Természettudományok köréből

Földr. Ért. = Földrajzi Értesítő

Földt. Int. alk. kiadv. = Magyar (Királyi) Állami Földtani Intézet alkalmi kiadványai

Földt. Int. kiadv. = Magyar (Királyi) Állami Földtani Intézet kiadványai
Földt. Int. Évi Jel. = Magyar (Királyi) Állami Földtani Intézet Évi Jelentése
Földt. Int. Évk. = Magyar (Királyi) Állami Földtani Intézet Évkönyve
Földt. Int. gyak. kiadv. = Magyar (Királyi) Állami Földtani Intézet gyakorlati kiadványai
Földt. Int. Adattár = Magyar (Királyi) Állami Földtani Intézet Adattára
Földt. Int. Irattára = Magyar (Királyi) Állami Földtani Intézet Irattára
Földt. Int. Módsz. Közlem. = Magyar Állami Földtani Intézet Módszertani Közlemények
Földt. Int. Spec. Papers = Magyar Állami Földtani Intézet Special Papers
Földt. Közl. = Földtani Közlöny
Földt. Kut. = Földtani Kutatás
Fragm. Miner. Pal. = Fragmenta Mineralogica et Paleontologica
Gen. Geol. Rev. = General Geological Revue
Geodyn. = Géodynamique
Geof. Közl. = Geofizikai Közlemények
Geol. Bull. = Geological Bulletin
Geol. Palont. Mitt. = Geologisch—Palontologische Mitteilungen
Geol. Hung. = Geologica Hungarica
Geol. Hung. ser. Geol. = Geologica Hungarica series Geologica
Geol. Hung. ser. Pal. = Geologica Hungarica series Paleontologica
Geol. Rdsch. = Geologische Rundschau
Geol. Res. = Geological Resarch
Geol. Soc. spec. Papers = Geological Society special Papers
Geol. Zbornik, Geol. Carp. = Geologicky Zbornik, Geologica Carpathica
Geophys. Trans. = Geophysical Transaction
Hung. Geol. Soc. = Hungarian Geological Society
Intern. Nannoplankton Assoc. Newsletter = International Nannoplankton Association Newsletter
Jahrbuch d. k. k. Geol. R.-A. Wien = Jahrbuch der kaiserlich—königlichen Geologischen Reichsanstalt
Jugosl. Ak. Wiss. Künste, Serb. Ak. Wiss. Künste = Jugoslavische Academie Wissenschaftliche Künste, Serbische Akademische Wissenschaftliche Künste
KFH = Központi Földtani Hivatal
Kir. Magy. Term.tud. Társ. = Királyi Magyar Természettudományi Társulat
Közp. Bány. Fejl. Int. Közlem. = Központi Bányászati Fejlesztési Intézet Közleméyei
MÁFI = Magyar Állami Földtani Intézet
Magy. Tájak Földtani Leírása = Magyar Tájak Földtani Leírása
Math. Nat. W. Berichte aus Ungarn = Matematische und Naturwissenschaftliche Berichte aus Ungarn
Mem. Sci. Padova = Memorie Scienze Padova
MGSZ = Magyar Geológiai Szolgálat
Miner. Slov. = Mineralia Slovaca
Mitteil. a. d. Jahrb. = Mitteilungen aus dem Jahrbuch der Königlich Ungarische Geologischen Anstalt
Mitteil. d. Geol. Geselsch. Wien = Mitteilungen der Geologischen Gesellschaft in Wien
MTA Földrajztud. Kut. Int. = Magyar Tudományos Akadémia Földrajztudományi Kutató Intézet
MTA Földt. Bány. Tudom. Oszt. Közlem. = Magyar Tudományos Akadémia Földtani és Bányászati Tudományos Osztály Közleményei
MTA X. Oszt. Közlem. = Magyar Tudományos Akadémia X. Osztályának Közleményei
N. Jb. Geol. Paläont., Abh. = Neues Jahrbuch für Geologie und Palontologie
Org. Geochem. = Organic Geochemistry
Ősl. Viták = Őslénytani Viták
Phys. Chem. Earth = Physics and Chemistry of the Earth
Proceed. Intern. Symp. = Proceedings of the International Symposion
Rel. Ann. Inst. Geol Publ. Hung. = Relationes Annuae Instituti Geologici Publici Hungarici
Schriftenr. Erdwiss. Komm. Östrr. Akad. Wiss. = Schriftenreiche der Erdwissenschaftlichen Komissionen, Österreichische Academie der Wissenschaften
Sitz. b. k. Akad. Wiss. Wien, Math. Nat. w. Klasse = Sitzungberichte der kaiserlichen Akademie der Wissenschaften Mathematisch—Naturwissenschaftliche Classe
Zeitschr. Geol. Wiss. = Zeitschrift für Geologische Wissenschaften
Zeitschrift. Angew. Geol. = Zeitschrift für Angewandte Geologie
Zool. Bull. = Zoological Bulletin

CONTENTS

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