GUIDELINES FOR ENGINEERING-GEOLOGICAL MAPPING ON THE SCALE OF 1:10 000

(Methods of the engineering-geological survey developed by the Hungarian Geological Institute)

Compiled by

PÉTER GUÓTH

SPECIAL PAPERS

INVESTIGATIONS IN FOREIGN COUNTRIES: METHODS AND APPLICATIONS

BUDAPEST, 1974/2

Criticism and suggestions made by

Mrs. P. FODOR, M. Sc.

Translated by

S. VÉGH, D. Sc.

Translation revised by

E. DUDICH, D. Sc.

Technical Editor

D. SIMONYI

Responsible Editor

J. KONDA, D. Sc.
Director
of the Hungarian Geological Institute

PREFACE

The systematic engineering-geological activity started in Hungary as early as the beginning of the '900s. Small-scale engineering-geological maps useful in regional urban planning were issued from 1960 within the Map Series of Hungary on the scale of 1:200 000. The Szolnok Atlas, resulted by the geological mapping of the Great Hungarian Plain (1:100 000) and published by the centenary of the Hungarian Geological Institute, 1969, also includes some engineering-geological map variants. Engineering-geological surveying on the scale of 1:10 000, according to quadrangles, was initiated in the urbanistically first-listed Lake Balaton Region (1964) and, subsequently, in the Budapest Region (1967), finally in the surroundings of Eger and Miskolc (1968). In the above-mentioned regions the survey programme has been developed in co-operation of the Hungarian Geological Institute with the Company for Geodesy and Soil Mechanics, Department for Geology of the Budapest Technical University, Department for Geology and Soil Sciences of the University for Heavy Industries at Miskolc, including some other institutions kept in line by us. For the development of this activity carried out at public expense, the need arose to lay down fundamentals as far as uniformity in drawing techniques, properly chosen nomenclature and legend are concerned. This was aimed at by a brochure entitled „Directives for engineering-geological survey and map plotting on the scale of 1:10 000", issued as a manuscript by the Central Office of Geology, edited by

MRS. PIROSKA FODOR

and compiled by

DR. GYÖRGY GABOS, DR. GÉZA HÁMOR, DR. JÓZSEF JUHÁSZ, DR. ÁRPÁD KÉZDI, DR. JÓZSEF KONDA, DR. PÉTER REMÉNYI, DR. ANDRÁS RÓNAI, DR. GYULA SCHEUER, DR. JENŐ SZILÁRD and DR. IMRE SZILVÁGYI.

The present work has enabled minor modifications and additions to be made to the original text by PÉTER GUÓTH, *Research Associate, upon experiences gathered by the Hungarian Geological Institute.*

JÓZSEF KONDA, D. Sc.
Director

INTRODUCTION

Fundamental principles and aims

1. The engineering-geological map constitutes a geological basis for engineering; it forecasts forthcoming changes and movements in the rocks after their origin, moreover material and geological position at the present time had competently been studied.

2. Engineering geology will hereby provide the general planning of building development with every geological detail necessary for breaking down the large-scale plan and for making decision in the question of the need of complementary works that could be emerged therefrom.

3. An engineering-geological map series is supposed to be provided with every data on geomorphological, geological, tectonical, hydrogeological, hydrochemical, petrophysical and economic-geological features observable in the field, which are to be put on map by standardized remarks and should be indicative of a depth determined previously by housing requirements.

4. The engineering-geological map should be used, in the first place, for purposes of the regional and urban planning. They would be, however, informative for investment estimates needed by industrial or housing estates to be erected on the area surveyed. On the other hand, they must not be used for particular design works, in place of specific soil-mechanical case studies that could be required on the spot.

5. The maps show details according to the scale used.

6. Engineering-geological maps on the scale of 1:10 000 are plotted upon geological maps with related observations on the same or more detailed scale.

PRELIMINARIES

1. Previous collecting and processing of data

All valuable documents concerning the survey area, are to be gathered in the following order:

a) Topographic maps with scales from 1:2000 to 1:25 000 and aerial photo maps scaled from 1:10 000 to 1:25 000.

b) Maps on subject, drafted or printed, independently from their informative value at the present time, are to be collected. Subjects are as follows: geology, geophysics, geomorphology, hydrology, registration of historic buildings and monuments etc.

c) Data of laboratory tests made on rocks recovered or cropping out at the surface of the survey area.

d) Official reports or expertises on the area that could be informative for the survey planned.

e) Informations on terrain corrections, housing projects and development programmes planned by the local authorities or in scope of the national economic planification.

f) Every kind of literature, published or stored as manuscript, in which the survey area is concerned.

g) Sporadic data i.e. every kind of information proceeding from a widespread orientation, which might have importance if not at present but in the future.

Previous data collecting would take place by visiting institutes, universities, companies, trusts, institutes and objects of water management together with their authorities, mines, building companies etc. Material gathered should carefully be listed and prepared for its forthcoming use and even, if possible, its reference number marked on a key map (Annex 1). Thereby retrieval of data will be fast and simple.

2. Valuation on data collected

Every datum and document acquired during any kind of preliminary work would serve as auxiliary material which comes in handy when elaborating an adequate operating strategy for the survey planned. On this basis, the following preliminary maps should be drafted:

– Geological map showing every kind of lithological, stratigraphic and structure-geological detail offered by former surveys and aerophotography;

– Geomorphology;
– Hydrogeology;
– Areal distribution of technical objects.

Going on step by step, a sketch on the itinerary planned and lining up of problems to be solved, are in turn. The „scope of problems" will encircle the following subjects: stratigraphy, petrography, lithofaciology, small-scale and large-scale tectonics, hydrogeology and engineering as being analysed in their characteristics inasmuch they are problematical, followed by setting up, at least, outlines for their future solution.

3. Previous reconnaissance in the field

This is a previous walk all over the survey area with the goal of checking in the field all data that had previously been collected by office work.

4. Operating strategy

On the line of making use of maps mentioned under 2, a suitable recovery programme would be elaborated. Since the purpose and scale of the survey are given, parameters of the recovery spacing will depend on terrain characteristics together with the defining geological features.

As it has been experienced on the southern shore of Lake Balaton, where outcrops are rare, at the most two mechanical or hand-drills per square km would do for an engineering-geological recovery programme to be carried out satisfactorily there. On the northern shore, however, there are much more outcrops, exposures and observation data from before, so that number of the new recovery points could consequently be reduced to 50 per cent as compared with the former.

As early as the recovery programme is finished, a programme for instrumental testing should be set up. In this scope every kind of instrumental testing on the spot (soil mechanics, well-logging, special geophysics and rock mechanics, geodesy etc.) as well as geohydrological examinations and laboratory tests and analyses in the whole, are concerned.

FIELD SURVEY

1. Mapping in the field

As basic concept it is considered essential for the mappers to have the ability to check up, to the best of the requirable sphere of experience, all data observable in the field. Observations will subsequently be marked on the map clearly and unambiguously in order to make it most informative for the selected topics as well as geology, structural geology, engineering-geology, geohydrology and geomorphology. Among others, the following data always are to be recorded in the field notebook:

– Full name of observer;

– Date;

– Place of observation as localized and numbered, its dimension with height above sea level and character (outcrop, cut, pitting or trenching; cave-in water etc.).

The field notebook should contain sketches on any convenient scale showing every outcrop or exposure in which two or more rock types could be recorded. Survey documentation must not be lacking with good quality photographs on the subject. Localities of observation should identically be numbered in the field book and on the map.

a) Fundamental observations to be recorded:

- Name of the rock upon geological classification;
- Colour of the rock;
- Texture;
- Grain size;
- Sorting;
- Origin, shape and state of retention of the grains;
- Type and quantitative proportion of the cement;
- Porosity;
- Hardness, fracture or cleavage;
- Grade of preservation (non-altered, weathered, fissured etc.);
- Bedding and other structure elements (thickness by 0,1 metre of accuracy);
- Genetic features;
- Supplementary recording: position of the rock, phenomena observable on bedding planes, types of banding, continuity and breaks in sedimentation, exogenetic effects as well as water saturation, leaching, frost-thaw etc.;
- Age of the rock (chronostratigraphic unit) if determinable in the field.

b) Basic data for structural geology:

- Strike and dip readings;
- Orientation analysis of joints, description of the filling materials in cracks;
- Strike, dip and offset of the faults, materials spacing between fault surfaces;
- Other structure elements (e.g. folding);

c) Requisite data directly for engineering:

- Valuation of fissuring;
- Phenomena of alterations in the rocks;
- Location of sediments in which forthcoming slides are prevised;
- Relative bond strength and stability of the slopes;
- Porosity observable megascopically (forecast of ground subsidences);
- Workability of the rocks (detailed upon work expenditure);
- Eluvial phenomena (rain furrow, loess hole etc.);
- Springs and swallow holes;
- Surface movements (ground flow, landslide, landfall: characterized by their origin, form and dimension; areas of such movements proved and/or forecasted are to be distinguished on the map;
- Karstic phenomena;
- Replenishment thicker than 1 metre (material used, thickness);
- Zones planned to be divided into housing districts;
- Generalizations on building damages;
- Damages in buildings caused by ground subsidences;
- Building damages by ground-water uplifts;
- Ground-water accumulated in cellars;
- Well-out of ground-water by foundations;
- Seismic movements as damaging factor, largeness i.e. intensity and sphere;
- Defects appeared in linear objects;
- Site and depth of any construction or shafting cut deeply into ground;
- Detection and measuring of caves in the surface or subsurface cavernous rocks; undermined zones;
- Special foundations;
- Bulkheads;
- Land drainage;
- Pollution centres and directions;
- etc.

d) Hydrological and hydrogeological observations in general:

- Definition of the aquifers;
- Dug wells;
- Springs;
- Data administered by exploratory drills or productive wells;
- Surface waters;
- Observation on water table fluctuations;
- Flavouring the waters sampled;

– Additionals: flood level, inland waters, water-management works, zones lacking runoff, water catchment areas, irrigated zones, ground-water flow in saturated zones etc.

e) Geomorphological observations to be principal:

– Role of (various) parent rock(s) in soil formation;
– Zones of soil erosion;
– Other types of the erosive effects;
– Categories, grade of exposure and shadow effects of the natural slopes surveyed;
– Gravitational rubble flows in general;
– Watersheds;
– Accumulation of rubble at slope sides (side rubble), thickness measured;
– Data on the local crosional base;
– The action of erosion upon surface morphology;
– Full characterization of terraces;
– Morphology of valley cuts.

2. Sampling

Every rock type observed either on the surface or in boreholes should be sampled accordingly to the following aims to be attained:

– A documentary rock collection should be at disposal;

– The outstanding characterization and classification of the rocks must be based on due laboratory tests and analyses.

Sample collecting intervals are determined by various factors such as
– Areal distribution i.e. frequency of outcrops and exposures;
– Characteristics of the geological setting of the survey area.

3. Drilling

In order to avoid defectiveness in recording rock sequences from boreholes, drills are carried out with full core sampling. Description of samples from boreholes must be done from the top downwards with the following data included:

– Number of the bed distinguished;
– Depth interval referred;
– Thickness of the bed;
– Grade of efficiency in recovering cores (core recovery percentage);
– Petrographic description as detailed above (1–a: „Fundamental observations to be recorded"), which includes, in separate column, the stratigraphic age of the rock.

Sampling from boreholes is also to be done according to the points of view mentioned above (see 2). Untrimmed cores for special laboratory tests should hermetically be wrapped up. Sample collecting intervals, in general, they are of 2 m but actually must be adapted for changes observable in lithological features within the rock sequence penetrated.

Hydrogeological data from boreholes should carefully be recorded.

4. Handwork recovery in general

In the course of the field surveying exposures by trenching and pitting are made and checked up in order to attain the following aims: preparation of outcrops, road cuts and geological section tracks for observation and sampling; recovery of consolidated rocks covered immediately by soil; cleaning up of stratigraphic boundaries and structure elements.

5. Examination and measurement in the field

Water output determination. It is carried out in completed boreholes. In the first place, the hole should be flushed out with clean water. After bailing out the water from the hole and under the very condition that it had resisted to the mechanical and hydrodynamic effects provoked, water recharge level in the hole would be measured every hour or every half an hour as long as hydrostatic level could be registered. If borehole had fallen in, due to unsuited treatment or whatever circumstances, no hydrogeological observation and water sampling would be made therein.

Observation well network. In order to put in function a prolonged observation on ground-water fluctuation, one or two boreholes and even dug wells out of use, set within quadrangles chosen to be surveyed, are turned to hydrogeological observation well(s) and checked up every fortnight.

Geophysical observation. Well-outlined problems will be solved by surface geophysical methods as well as gravitational, earth-magnetic, moreover small-depth geoelectric and seismic ones. In well logging, electric and radioactive methods are used.

* * *

At the moment of having completed the field works, the following documents are ready to access:

- Field survey notebooks;
- Field notebooks for borehole descriptions;
- List of rock samples collected;
- Outcrop maps as drafted in the field;
- List of water samples collected;
- Photodocumentation;
- Documents of measurement carried out in the field.

LABORATORY TESTING AND ITS DOCUMENTATION

With respect to the function and purposes of the engineering-geological mapping concerned, the following laboratory tests and analyses are dealt with:

Consolidated rocks:

– Complete or partial chemical analyses;
– Determination of specific and volume weights;
– Hardness and resistance to rupture;
– Spectral analysis;
– Examination on polished and thin sections;
– Determination of mineral components;
– Mineralogical determinations in general;
– Microstructural evaluations;
– Micro- and macropaleontological examination;
– Statistical evaluation of paleontological features.

Loose sediments:

– Granulometry;
– Specific weight, volume weight;
– Yield point, twisting limit, plasticity index, shrinkage limit, porosity, water saturation;
– Organic materials content;
– Calcium carbonate content (Scheibler method);
– Micromineralogy (heavy and light minerals);
– Identification of clay minerals (DTA, DTG);
– Petrochemistry;
– Grain roundness of the clastic rocks;
– Permeability;
– pH measurements;
– Micro- and macropaleontological treatment;
– Statistical evaluation of paleontological features;
– Shearing experiment, triaxial test, resistance to unilateral pressure;
– Hydrochemical analyses.

It seems obvious that laboratory tests to be executed are properly selected in accordance with the actual rock peculiarities. Necessary though this task of choice is, it must be approached with caution to ensure that the authentic and outstanding identification of the rocks, including the adequate determination of their areal extension, is not jeopardized.

Principal aims to be attained by means of laboratory testing could be grouped as follows:

– Detailed and overall characterization of principal rock types, sequences and of main geological sections on the basis of specific and generalizable geological characteristics;

– Factual and objective interpretation on natural phenomena observable in the field;

– Data collecting aimed at statistical evaluations carried out in order to pick out essential and general facts therefrom.

Results of the laboratory tests and analyses are registered on printed blanks. Computerization of data processing has recently been initiated.

* * *

Importance though of laboratory testing might be emphasized, this activity itself could by no means provide us with all facilities to develop an exhaustive geological and engineering-geological evaluation on rocks that build up the survey area. It would be based on a thorough study of the genesis of rocks and their behaviour experienced under natural and experimental conditions, from every requisite point of view, supported by a mine of knowledge of facial, structural, chemical and mineralogical properties of the rocks to be shown on the engineering-geological map.

MAP PLOTTING

The engineering-geological map, properly speaking a collection of maps on relevant subjects, it contains the following map varieties:

– Observation maps (geology, hydrogeology, well-sitting, field technical conditions);

– Geomorphological maps (applied geomorphology, slope categories, slope exposure, morphological shadow effects);

– Geological maps (surface and subsurface maps, geophysical map);

– Hydrogeological maps (relative and absolute depth i.e. height of the ground-water table, permeability of the aquifer, hydrochemical map with diagrams, agressive chemistry of the ground-water, overlook on water supply possibilities);

– Engineering-geological maps s.s. (foundation contitions);

– Complementary maps (economic geology, seismicity, environmental i.e. sanitary engineering, housing economy etc.);

– Synoptic maps.

Adjacent materials:

– Explanations (explanatory brochures) to the maps;

– Store of data that had been used when plotting the maps.

Principles to be kept in view when plotting the maps:

– Fundamentally, every map is to be plotted on the scale of 1:10 000. Exceptions would be made in case of emergency or special necessity. It means, on the one hand, that any smaller scale (1:25 000–1:50 000) would be used due to scarcity of data proceeding from the survey programme executed but thereafter found to be poor in yielding informations enough to plot a map on the scale of 1:10 000 as it is required. On the other hand, there are subjects (e.g. seismic effects, morphological shadow) that might need no such a detailed delineation. Finally, importance of any subject together with an overnumber of data collected thereabouts, it might lead to the necessity of plotting maps, completely or partially, on a larger scale (1:5000–1:1000);

– Marks and colours on the maps mostly are used in accordance with the Hungarian i.e. international practice adopted;

– Any grading in depth or other natural parameters to be shown on the map must be indicated by using shades of the rainbow colour-scale (blue–green–yellow–orange–red);

– Statistical evaluations shown on map will be illustrative by means of a distinctive use of marks different in their typographic shape and size, moreover of colours and hachure;

– Uniformity in data interpretation must throughoutly be ensured.

There are, or could be, some deviations as far as, for instance, petrographic nomenclature is concerned from different points of view. According to what the Central Office of Geology requests, geological practice in Hungary has adopted to classify clastic rocks upon cummulative distribution curves plotted on weight percentage data yielded by grain size measurements. Predominant grain size category, in terms of the scale used, will name the rock and an attributive second name will also be added. The latter comes from the name of the secondary grain size fraction, quantity of which, however, must exceed the 20 per cent of the total weight computed. Rock names upon soil-mechanical nomenclature (in accordance with the Hungarian Standard) will subsequently be added in brackets.

Nevertheless, some differences between geological and engineering-geological maps would be envisaged with respect to diverse classification of the more cohesive i.e. clayey sediments as being qualified also by their plasticity index and yield point specified that are of major importance in engineering. Plasticity index, for example, of the „silt" grain size category changes from 0 up to 30 that means, at the most, four soil-mechanical categories to be distinguished therein. In consequence, a rock formation which is shown uniformly as „silt" on the geological map, it might be cut into four categories to be plotted expediently on the engineering-geological map variant.

Any misunderstanding due to this problem seemed to be surmounted, at least for a while, by making a „dualistic" i.e. parallel use of geological and engineering-geological rock names on every type of the map series. Useful though it is both to geologists and engineers, a future improvement is expected in this respect.

Each map sheet contains the following textual and graphic informations:

– Surveyor's name;
– Starting and finishing date of the survey;
– Plotter's name;
– Finishing date of map plotting;
– Geological sections, stratigraphic column, auxiliary maps and extracts from the map;
– Map explanations (legend).

1. Observation map

Observation map is to be informative of every data acquired previously and during field survey, namely:

– Sites of outcrops and exposures;
– Exploration shafts, pits and trenches;
– Location of boreholes;
– Geological structure elements;
– Survey traverses with points of observation;

– Localities of economic-geological observation;
– Spots of serial field measurements done;
– Localities of recollected and referred sporadic observations.

As for the so-called *„Map of technical conditions in the field"*, it is considered as an engineering-geological map but, really, it constitutes part of the observation map series. Damages of buildings and other technical objects (e.g. pipes) provoked by ground movements, ground-water fluctuations or by undermining, are shown on the map together with location of cellars, underground caves and replenished areas. Replenishment could be effectuated by terrain corrections and mining activity, too; its thickness is shown by shades of colour on the map. Main rock constituents used for replenishment, if determinable, should be marked by letters and, referring to their classification, divided into three main categories:

– Natural, unorganic materials (e.g. rock gravel);
– Products of fuel burning (ashes, slag);
– Waste materials (of industrial origin or from housekeeping).

Marks are shown by Annex 1.

As it must be clear from that aforesaid, number of the observation map types depends on abundance in acquired data to be plotted on map. As for the simplest and very rare case, a single observation map might be enough but commonly we need, at least, two maps:

– Geological observation map (outcrops and recovery etc.);
– Map of hydrogeological and technical conditions in the survey area.

Increased abundance in data would require more variants to be elaborated. In such cases outcrops and drilling localities i.e. hydrogeology and technical conditions might be shown on separate map sheets as plotted, at the very most, on four independent ones.

2. Geological map variants

By a completed geological map the following graphic informations should be comprised:

– Stratigraphic boundaries;
– Stratigraphic age and facies of the rocks (colour and symbol with index);
– Petrographic features (hachure);
– Structure elements;
– Geological section lines marked;
– Geological observations in general.

Course of map plotting:

– Definition and areal delimitation of stratigraphic or lithological units as it could be based on data yielded by outcrops and exposures;

– Airphoto-interpretation which focusses attention on tectonic processes;

– Drafting of auxiliary geological sections which encourage a rigorously systematic approach to accuracy in map plotting;

– Plotting of geological profiles on the basic scale used for the map, across sequences highly characteristic of the survey area's geological setting;

– Plotting of a chronostratigraphic column (exaggerations in scale permitted);

– Additional auxiliary sections drafted in order to attain the final accuracy in map plotting.

Age of the sedimentary rocks is shown by distinguishable *colours* i.e. shades of colour (see Annex 2). *Petrographic units* are indicated by kinds of hachure with graphic distinctions therein as far as loose or consolidated sediments, igneous or metamorphic rocks are to be marked, and giving place to possible mark combinations to show, if necessary, any significant gradation in rock characteristics (see Annex 3). The *geological index* (symbol) is an adequate letter/number combination indicative of *stratigraphic, petrographic* and *faciological* features shown by the concerned geological formation. Capital and small letters in alphabetical order of the Latin ABC and small letters of the Greek alphabet together with Arabic numerals are used to make a symbolic rock definition in accordance with international prescriptions. Altogether, taking into account symbols and numerals shown by Annex No 2, 3, 4, 5 and 6, we may now take an example:

$$ {}^{sp}_{f}Q_{p4} , $$

where it would be clear upon Legends mentioned above that occurrence of a Quaternary (Q), more closely Upper Pleistocene (p4) fluviatile (f) sandy pebble (sp) is to be dealt with. All the formula will be marked on its due place on the map just as put in the actual Legend, too.

Every geological map is accompanied by *geological section(s),* showing the most important, characteristic and structurally most complicated parts of the area. Accordingly, their legend is identical with that of the map. Vertical exaggeration is permitted with corresponding dip angle corrections.

Lithological column. As a rule, it is plotted on a larger scale than the map itself. It should comprise all stratigraphic and lithofacial units distinguished on the map. Colouring and hachure should be identical with those of the map. On the right side, short description and thickness data, while on the left one, indices datation and denomination of the units are given. Sedimentation gaps and unconformities should be indicated.

Geological map variants. (It is obvious that not all variants are plotted in every case.)

a) *Surface geological map.* This geological map variety shows every geological formation observable on the surface with the admissible lack of the Holocene cover unless its thickness surpasses 1,5 metre.

b) *Subsurface geological map.* It shows, in general, formations that lie immediately under the Holocene–Quaternary ones. Its extension to depth is limited in 20 m measured from surface. It is desirable to use depth isolines because levels of the optimum load capacity to lay building foundations are to be indicated here.

c) *Geological basement' map.* On the basis of data from geophysical survey and boreholes, maps on any suitable scale on datum horizons of the geological development would be plotted (buried geological surfaces of the Pannonian, Neogene, Mesozoic and Paleozoic complexes).

3. Geomorphological maps

Morphogeological investigations are carried out parallel with other field studies devoted to petrography, geology and geodynamics. Thus development of the surface morphology will be traced back to prevailing petrographic composition and geological structure (including neotectonics) of the concerning region and, moreover, phenomena of surface dynamics (erosional effects, ground slides etc.) could adequately be surveyed even as forecasted thereupon.

The geomorphological map should frame the following subjects:

– Characterization of surface morphology (small-, medium- and large-sized forms of the terrain), laying particular emphasis on morphogenetic factors and general contitions of the stability of surface for the time being;

– Categorization of slopes with regard to the actual state of stability of the hill-sides. Areas of old i.e. stabilized or new surface movements observed and/or foreseen, are to be outlined;

– Grade of exposure and shadow effects as they manifest themselves by loss of insolation expressed in percentage conferred with astronomical considerations.

There are, in the whole, three variants of geomorphological map to be plotted:

– Applied geomorphology;
– Slope exposure and morphological shadow effects;
– Slope categories.

Despite the exigency laid down to make the first drafting of these maps on the scale of 1:10 000, it has been deemed expedient to complete and publish them on other suitable scale. Applied geomorphological conditions together with slope categories should always be presented and, eventually, plotted at the most on the scale of 1:25 000. Microclimatic circumstances, grade of slope exposure and topographic shadow effects should be put on map for mountainous regions only and on any handy scale.

4. Hydrogeological map variants

The following subjects are to be dealt with here:

– Surface water hydrogeology and hydrology;
– Ground-water table measurement;
– Permeability conditions in subsurface aquifers;
– Qualitative characteristics of water resources.

It is a principle to keep in view requirements of engineering geology. Water supply possibility as being no direct task for engineering geology, it will be mapped and recorded schematically.

Discussion:

a) *Relative depth and absolute height of the ground-water table* are shown on separate maps. Contours of the absolute height are, commonly, scaled by 5 m but isobaths might be chosen upon necessity (e.g. 0,5–1–2–4–6–9–12–15–20 m). Main direction and intensity (in percentage) of the ground-water flow even as other relevant data are also observed and recorded. It is necessary to set, at least, one observation well within each quadrangle to carry out formation-pressure measurements. Data of a long-term ground-water observation are not at our disposal about the beginning of map plotting thus observations correspond to a relatively small interval of time of any survey effectuated. Ground-water measurement, accordingly, will be carefully dated and compared with maximum/minimum levels that had ever been determined and, furthermore, will be checked up retroactively when taking adventage of a long-term and systematic ground-water observation activity planned as forthcoming. The free ground-water regime thereby could subsequently be defined and, later, supplemented.

b) *Permeability of the aquifers* will also be shown on map according to its areal distribution and by colour shades as being grouped in four categories:

– Aquifers of high transmissibility to water flow (gravel, boulders, sandy pebble beds, pebbly sand);	up to 10^{-4} mps
– Aquifers of good transmissibility (sand, pebbles with silty cement);	10^{-5}–10^{-6} mps
– Aquifers of middling transmissibility (silt, loess, side rubble);	10^{-7}–10^{-8} mps
– Practically impervious layers (clay, marl).	less than 10^{-9} mps

In not every case is needed this map type.

These three map variants could expediently be drawn together and their data recorded on a sole map. In such a case contours and isobaths belonging to different subjects will be coloured diversely. Rainbow colours will show any change in class of the relative and absolute level determined for the vertical position of the ground-water table if every map variant could separately be plotted.

c) *Hydrochemical map.* Hydrochemistry is shown as follows:

– Every chemical analysis will be represented by its proper circle diagram drawn on the map as centred at the same point where the sampling had been taken in the field;

– The circle diagram is put together with another drawing which shows the weight percentage of materials solved in the water sampled and analysed, by due graphic illustration of proportions measured up starting from the centre;

– The four chief cations are shown by four separate triangles which start from equally-sized circle segments of the right-hand side semicircle. Areas of the triangles are proportional to cation equivalence;

– The four chief anions are shown in a similar way in the left-hand side semicircle;

– For easy reading every cation and anion will preserve the same place in all diagrams;

– Plotting the diagram: circles corresponding to the total weight of dissolved salts would be drawn upon nomogram reading. Equivalent weight of each ion is also shown by making use of nomograms plotted upon circle size categories. Size of the circles and triangles would also be determined by using nomograms and data from table readings.

Chemical type of the waters is distinguishably expressed by the diagrams even if they are in black line print only. Nevertheless, triangles when coloured could be much more illustrative.

d) *Map of the agressive waters.* Water types are categorized on the map after their sulphate content as follows:

0– 400	milligram per litre
400–1000	"
1000–2000	"
2000–4000	"
4000–	"

Areas of the presence of carbonic acid in the ground-water, as much as it could be harmful to concrete (more than 10 mg per litre), moreover zones characterizable by an excess in chloride ions (more than 500 mg/lit.), are delimited. This map will show hardness of water by isogram lines. The water hardness is given in German degrees. Categories to be figured:

0– 10	German degrees
10– 20	"
20– 40	"
40–100	"
100–	"

Alcalinity of water by coloured patches:

0–10	Degrees of alcalinity
10–15	"
15–20	"
20–25	"
25–	"

The latter map types could also be drawn together.

e) *Hydrogeological map of mountainous regions.* Hydrogeological survey in mountainous regions generally is restricted to checking springs. They are classified accordingly to their geological character (slope-, detrital cone-, crack spring etc.). Springs may also be divided into permanently acting and intermittently acting, ascending-type or descending-type ones which equally can yield normal or mineral water of normal or higher temperature. These qualifications are given on the map by different symbols completed with letters, marks for chemical features and numerals referring to temperature (see Annex 1).

Hydrogeological marks in the whole are shown by Annex No 8 and 9.

5. Engineering-geological map variants

There are assumed to be recorded the following observations:

- Geological formations important on the engineering-geological viewponts;
- Formation boundaries;
- Petrophysical and foundation settlement factors;
- Zones unfavourable to housing;
- Observation data.

Our engineering-geological maps refer, substantially, to foundation conditions of four subsequent levels in depth. First of them (down to 1,5 m) corresponds, properly speaking, to the surface conditions and shows, together with the others (of 3,5, 5,5 and 10,0 m respectwely), relevant petrographic features of the rocks (e.g. grain size, plasticity index) beside making perceptible other important peculiarities as well as state characteristics and load capacity. Areas where ground-water table overlaps the foundation levels, are carefully delimited, moreover significant data from laboratory testing made upon undisturbed rock samples, are spotted. Ground movements and other surface phenomena are shown on the shallow-level map (1,5 m) only. Beside the common marks owned by geological formations mapped, hachure with increasing density is used to demonstrate any classifiable growing in plasticity. Load'capacity of the rocks is shown by colours (see Annex 10). An attempt has recently been made to use also hachure for geological age of the rocks to be given.

6. Economic-geological map variant

This variant shows mineral resources, mines, data on mineral raw materials estimation and particulars on mining operation, respectively.

Locations of mineral raw materials for various industrial purposes are to be recorded on the map: materials for producing concrete, mortar, road pavement, building wrapping, cement (clay, limestone), metallurgical additive agent (dolomite) and others. Extension, thickness (dimensions in space) and qualification of the mineral resources should duly be given together with their underground position measured up and related to the surface and to any kind of subsurface water table (see Annex 11).

Since the subsurface water resources are of primary importance for livelihood, thus the principal bored wells or well groups should appear on the economic-geological map. It is the very same with mineral and, possibly, medicinal water springs as well as with any wells that yield simple thermal water or that one of sanitary importance. Springs are recorded by their conventional mark (Annex 1) with degrees of water temperature and chemical type symbol to be added. As for the wells, size of the symbol varies parallel with any classifiable change in specific water output.

This map variant might be, if permitted by informations, independent but it generally is plotted together with the so-called „synoptic map".

7. Synoptic map

Records to be framed:

- Field unit boundaries;
- Conditions harmful to any housing;
- Areas declared or proposed to be forbidden for any housing;
- Zones of optimum building conditions.

Every important communication held by the previously treated map variants including data proceeding from field measurements and laboratory tests should be incorporated by the synoptic map. More precisely, relevant informations for field engineering are put together here in an utmostly distinctive form, discarding unnecessary details.

In the first place, the morphological units are separated as patches drawn by stronger lines and with Latin capitals written therein. Within these spots the geologically viz. petrographically homogeneous parts are similarly distinguished and signed by small letters of the Latin ABC. Stratigraphic column for each of such geological units is given in Explanations. Finally zones of different building conditions are also defined.

First of all, areas considered to have no perspective in building plans are marked for disuse. Motives chosen for it would be as follows: ground movements in action, too steep slopes, replenishment thicker than 10 m, layers of organic materials rooted as deep as 10 m and more beneath, near-surface caves of previsible falling-in, undercaved or cavernous areas. All these zones are painted by dark grey colour and marked so that the symbol should be indicative of the existing danger.

On the second hand, zones of unfavourable conditions that could be improved upon extra costs or by selecting special building foundations for the difficulties to be come over, are in turn. As to the matter, here the following conditions could be dealt with: presence of inland waters, undermined zones, ground movements coming into action, discompactions in loess or clayey underground, sulphate content in ground waters exceeding 4000 mg/lit., replenishment thinner than 10 m, layers of organic materials rooted within 10 m of depth etc. These zones should distinctively be raised as light-grey coloured and hachured patches doing it in accordance with the type of danger that exists.

In the third place, zones that seem good for housing are subdivided into three additional categories on the basis of their load-bearing capacity measured immediately at the surface, as it is

- Very favourable to housing $\delta_a > 5$ kp/cm^2
- Favourable to housing $\delta_a = 2{-}5$ kp/cm^2
- Regular to housing $\delta_a = 1{-}2$ kp/cm^2

Conventional marks are shown by Annex 12.

8. Maps on building economy

These variants will be destined to areas of utmost importance with regard to building development of the Balaton Lake Region. Estimation of building economy could be based on the technique used for the time being to lay foundations that is to say the „strip foundation type" in Hungary. Beside the financial requirements given by load-bearing capacity of the rocks that occur at the surface, additional costs from other natural properties are taken into account, too.

One-, four- and ten-storey buildings would have their economical parameters shown on separate maps accordingly to assumed foundation cost per square metre. Building development economy, on the other hand, would be forecasted on map upon dealing with the total cost of foundation and of setting public utilities for an area where a settlement by four- and ten-storey buildings might be erected.

EXPLANATORY BROCHURE

Explanations to each map variant should contain the followings:

1. Introduction. Administrative preliminaries, survey staff, duration of the survey, co-operators. Storage and accessibility of the data gathered together.

2. Geography of the survey area, in short. Definition of the area, its position related to the morphological and hydrographic land features thereabouts. Commentary on land economy and the concerning economical-geographic situation. Place-name register for any further reference.

3. Research history. Compilation of informations on former investigations, mapping and profilage.

4. Geological development and tectonics. Evaluation of the paleogeographic and faciological development with due conclusions. Morphological circumstances, explanations on the course of subsurface-geological, structure-geological and geophysical mapping.

5. Stratigraphy. Description of geological formations in chronological order. Illustrations as well as general sketches, sections, tables, maps etc.

6. Geohydrology. Hydrogeological characterization of the area, course of the hydrogeological survey effectuated. Explanations to hydrogeological map variants.

7. Engineering-geology. General characteristics. Summary on data collecting and laboratory tests, interpretations and conclusions. Dynamic-geological processes appreciable in the field. Informations yielded by other branches that could make influence on building develpment. Explanations to engineering-geological map variants. Detailed description of each distinguished field unit, and conclusions in the whole.

8. Economic geology. General characterizations. Occurrences of mineral raw materials, perspectives. Deep boreholes of primary singnificance. Artesian wells, medicinal and thermal water wells, data yielded by water-supply works.

9. List of References. Having had a list of every printed papers and manuscripts in which the survey area is anyhow dealt with, it came into an alphabetic order of the authors' names.

Explanations are closely integrated with the maps but they might not repeat any information appreciable on the maps. On the other hand, method and difficulty in map plotting as well as accuracy, reliability and way of utilization of the maps should thoroughly be enlightened.

APPENDIX

Some map fragments are shown here to be compared with the Legend referred to in the text. This is sufficient to demonstrate the type, form and content of our maps and in this way our extensive Legend system could expediently be abbreviated as requested by the aims of the present work.

The enclosed map series shows such an area where the commonest geological formations and engineering-geological features of the Lake Balaton Region could be observed and recorded. Reductions used here in size (third part of the original) and content, they led to some unavoidable modifications in form. In contrast with the more numerous original sheets, this series has been reduced to 5 variants as well as

a) Geological map (Fig. 1)
b) Hydrogeological map (Fig. 2)
c) Geomorphological map (Fig. 3)
d) Foundation map (Fig. 4)
e) Synoptic map (Fig. 5)

Otherwise essential but for the actual purpose innecessary topographic symbols are omitted here.

Annex 1

OBSERVATION MAP

Legend:

(good also for any sub-variant)

Boreholes

- up to 5 m
- 5–10 m
- 10–30 m
- 30–100 m
- 100–300 m
- deeper than 300 m

- Swamp, passable
- Stream water, constant
- Stream water, intermittent
- Damp area with vegetation
- Water-supply work
- Spring, uncased
- Spring, cased
- Spring under water management

Annex 2

MAIN COLOURS TO SHOW STRATIGRAPHIC AGES ON GEOLOGICAL MAPS

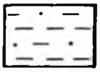
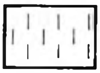
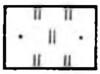
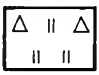
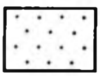
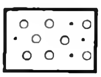
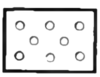
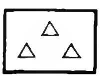
Age	Colour
Holocene	*White*
Pleistocene	*Lemon-yellow*
Pliocene	*Pale ocre*
Miocene	*Pale orange*
Triassic	*Shades of violet*
Permian	*Reddish-brown*
Early Paleozoic	*Greyish-green*

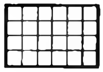
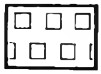
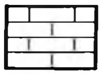
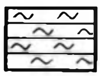
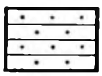
IGNEOUS ROCKS

Basalt, basalt tuff	*Bluish-green*

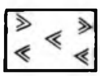
PETROGRAPHIC REMARKS

Sedimentary rocks

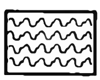
Graphic marks	Symbol	Rock name
	c	Clay
	sc	Sandy clay
	al	Silt (aleurite)
	al	Loess
	sal	Sandy silt
	deal	Silt with detritus
	s	Sand
	sg	Pebble with sand
	g	Pebbles
	de	Gravel

Graphic marks	Symbol	Rock name
	f	Replenishment
	y	Heterogeneous rock material, re-deposited by surface movements
	t	Peat
	l	Limestone
	d	Dolomite
	m	Marl
	sst	Sandstone

Igneous rocks

Graphic marks	Symbol	Rock name
	β_1	Basalt
	β_2	Basalt tuff

Metamorphic rocks

Graphic marks	Symbol	Rock name
	φ	Phyllite

CHRONOSTRATIGRAPHIC UNITS AND INDICES

Q	Quaternary						
		Qh	Holocene				
				Qh_2	New Holocene		
				Qh_1	Early Holocene		
		Qp	Pleistocene				
				Qp_4	Upper Pleistocene		
				Qp_3	Middle Pleistocene		
				Qp_2	Lower Pleistocene		
				Qp_1	Lowermost Pleistocene		
Tr	Tertiary						
		Pl	Pliocene				
				Pl_3	Upper Pliocene		
				Pl_{1+2}	Pannonian, in general		
				Pl_2	Upper Pannonian		
				Pl_1	Lower Pannonian		
		M	Miocene				
				M_3s	Sarmatian		
				M_2c	Tortonian	(M_2b	Badenian)
						(M_2k	Carpathian)
				M_2h	Helvetian	(M_2o	Ottnangian)
T	Triassic						
		T_3	Upper Triassic				
				T_3r	Raetian		
				T_3n	Norian		
				T_3k	Carnian		
		T_2	Middle Triassic				
				T_2l	Ladinian		
				T_2a	Anisian		
		T_1	Lower Triassic				
				T_1w	Werfenian	T_1c	Campilian
						T_1s	Seisian
Pz	Paleozoic						
P	Permian						
		P_3	Upper Permian				
		P_2	Middle Permian				
		P_1	Lower Permian				
P_{z_1}	Early Paleozoic						

Annex 5

LITHOFACIAL SYMBOLS

(Symbols added to geological indices, to their lower left-hand side)

Marine sediments	m
Terrigeneous sediments	c
Lacustrine sediments	l
Fluviatile sediments	f
Deluvial sediments	d
Wind-blown sediments	e
Rocks of volcanic origin	v
Proluvial sediments	P
Anthropogenetic materials	x

Annex 6.

OTHER REMARKS ON GEOLOGICAL MAPS

Rock boundary

Track of geological section plotted

Strike/dip reading

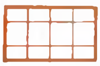
Fault

LEGEND TO GEOMORPHOLOGICAL MAPS


Boundary of regional denudation and accumulation


Top line of large-sized morphological forms

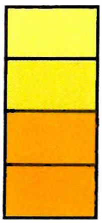

Foot line of large-sized morphological forms


High plain


Peak, hilltop, small elevation


Alluvial plain or basin-like depression

Slopes


0– 5°

5--15°

15–35°

> 35°


Drift terrace formed by hard rocks


Drift terrace formed by soft rocks


Hill-saddle


Valley


Detrital cone, in general


Fluviatile talus fan


Swallow hole, open


Swallow hole, boried


Karstic cave

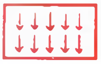
Wind furrow

Deflation hole

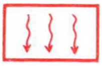

Slip, sole, with curved slip surface


Linear erosion


Slope, stabilized


Slope, with surface movements


Slope, unstable

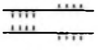

Soil erosion, intensive

Anthropogene forms


Drift terrace by hard rocks

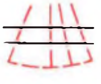

Drift terrace by soft rocks


Open pit


Replenishment i.e. cut

Roads


a) affected by scour


b) affected by silting up

Building damages


Damage by surface movements

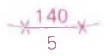

Damage owing to foundation imperfections


Breaks in linear objects

LEGEND TO HYDROGEOLOGICAL MAPS

Ground-water table, depth below surface

Ground-water table, height above sea level (Baltic sea)



Piezometric level and formation pressure of the artesian aquifers

General direction of the ground-water flow and fall

Boundary of various aquifers as compared to the first water table under the surface

Areas lacking with subsurface waters

Hydrogeologically disturbed area with surface rock movements

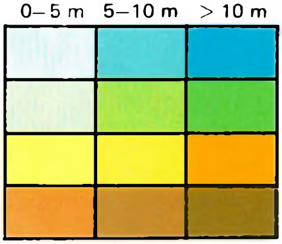
Areas of karst aquifers

Areas with formation waters underneath

Symbols for ground-water occurrences

Thickness of aquifer measured from the water table

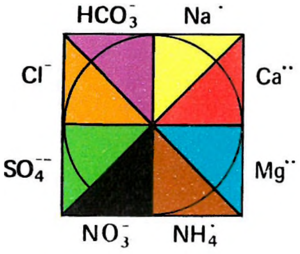
0–5 m 5–10 m > 10 m



	Water transmissibility
high	$k \geqslant 10^{-4}$ m/s
good	$k = 10^{-5} - 10^{-6}$ m/s
middling	$k = 10^{-7} - 10^{-8}$ m/s
bad (impervious)	$k < 10^{-9}$ m/s

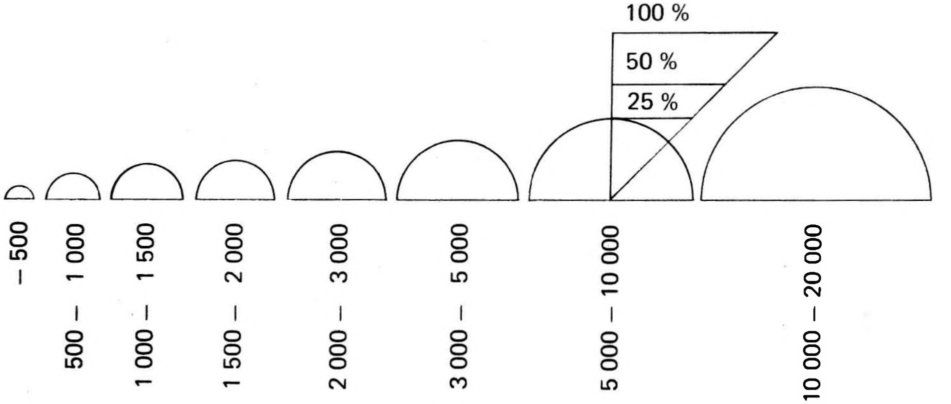
ILLUSTRATION OF WATER QUALITY

Hydrochemical diagram



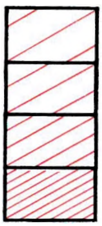
Materials solved in the subsurface waters*

*Size of the symbols is proportional to the total of dissolved solids



Agressive waters

Sulphate content



400–1000 mg/l

1000–2000 mg/l

2000–4000 mg/l

above 4000 mg/l

carbonic acid more than 10 mg/l

chloride content above 500 mg/l

LEGEND TO ENGINEERING-GEOLOGICAL MAPS FOR FOUNDATION ACTIVITY

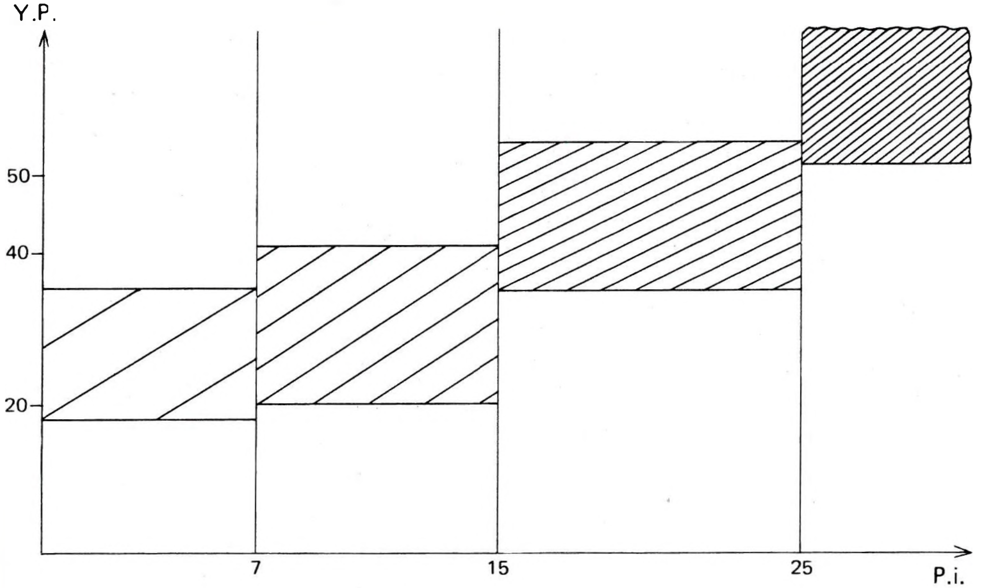
Loose sediments

Incoherent (grained) sediments

The symbols used here are identical with those of the geological map

Coherent (plastic) sediments

Indicated on the basis of plasticity index and yield point determined



Load capacity

Very high ($\delta_a > 5$ kp/cm^2)

Good (δ_a = 3–5 kp/cm^2)

Middling (δ_a = 2–3 kp/cm^2)

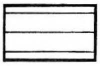
Low (δ_a = 1–2 kp/cm^2)

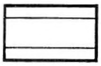
Unsuitable for building foundations ($\delta_a < 1$ kp/cm^2)

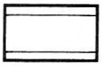
Consolidated rocks

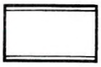
Stratification (black lines)

 Massive, unbedded

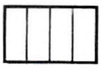
 Laminated or foliated (some cm)

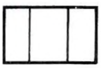
 Finely banded (up to 20 cm)

 Bedded (20–50 cm)

 Thick-bedded (> 50 cm)

Fissuring (black lines)

 Altered, pulverizing

 Very fissured

 Fissured

 Non-fissured

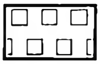
Crushing strength of solid rocks

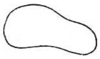
 $\delta_t < 50$ kp/cm^2

 $\delta_t = 50–250$ kp/cm^2

 $\delta_t > 250$ kp/cm^2

Other remarks

 Peat

 Rock boundary at a level given

 Category of the load capacity as limited within the same formation

 Ground-water overflowing the foundation level

Annex 11

LEGEND TO ECONOMIC-GEOLOGICAL MAPS

Building materials

 Limestone

 Dolomite

 Marl

 Basalt

 Sand

 Gravel

Subsurface waters

 Hydrocarbonatic

 Sulphatic

 Chloridic

Annex 12

LEGEND TO SYNOPTIC MAPS

— · — A Boundary and symbol of the morphological units

——— a Boundary and symbol of the lithological blocks

Areas unsuitable for building activity

Very steep slopes (> 35°)

Areas affected by surface movements

Factors unfavourable to building activity

Steep slopes (15–35°)

Agressive waters

Freatic water table close to the surface (within 2 m)

Organic materials close to the surface

Factors favourable to building activity

Areas highly favourable to housing

Areas favourable to housing

Areas of middling suitability for housing

Areal units

- A Mountainous region
- B Plain shore of the Lake Balaton
- C Plateau
- D Other zones

Illustration of lithological units set to be example:

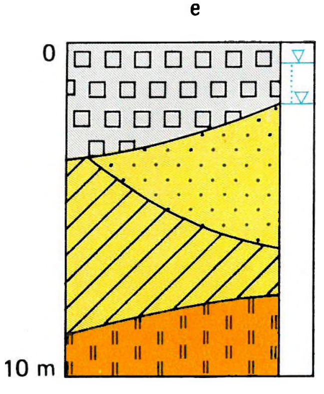


FIG. 1. ENGINEERING–GEOLOGICAL MAP SERIES OF THE ENVIRONS LAKE BALATON

Geological map

Plotted by P. GUÓTH

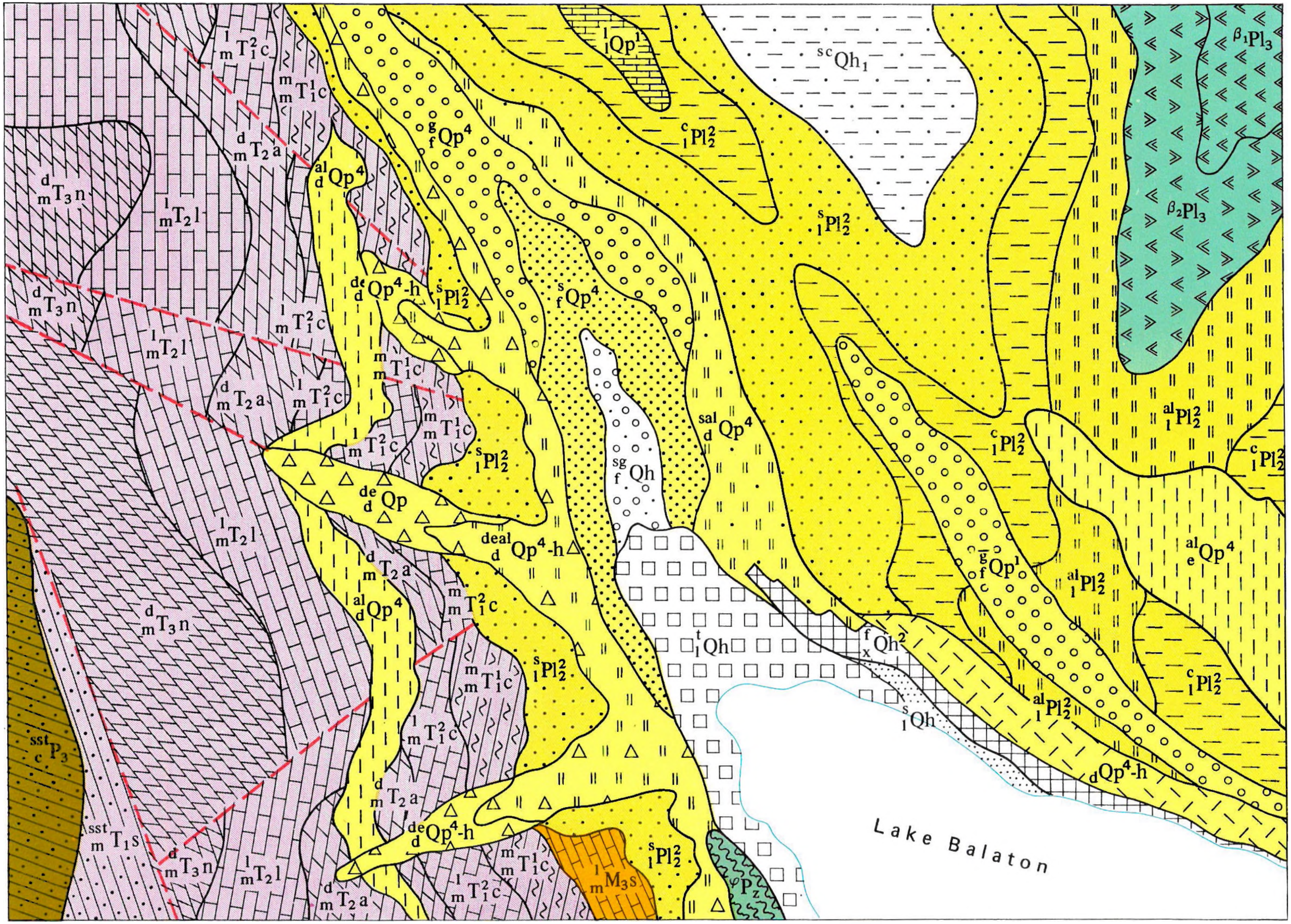
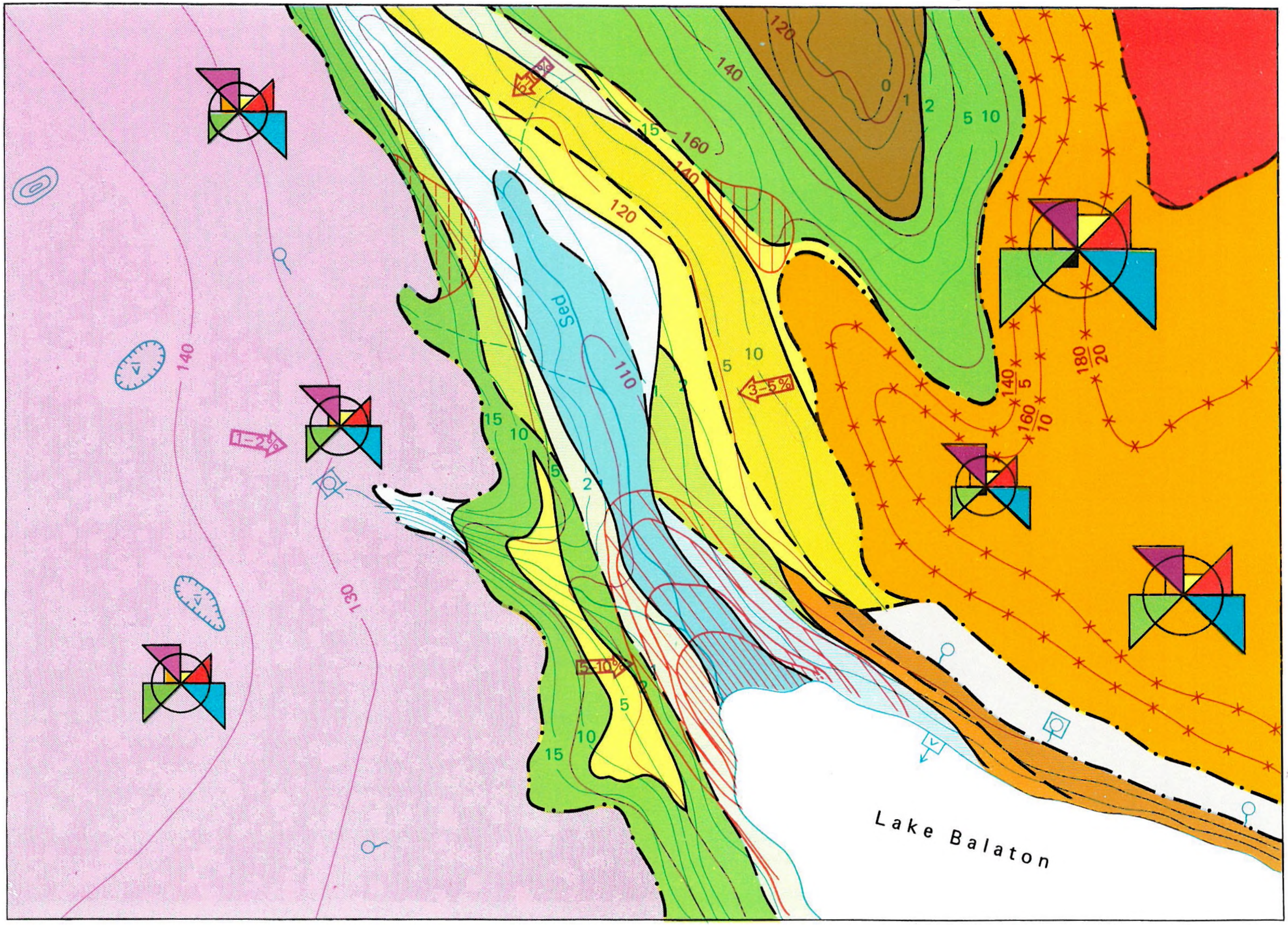

Lake Balaton

FIG. 2. ENGINEERING–GEOLOGICAL MAP SERIES
OF THE ENVIRONS LAKE BALATON

Hidrogeological map

Plotted by P. GUÓTH

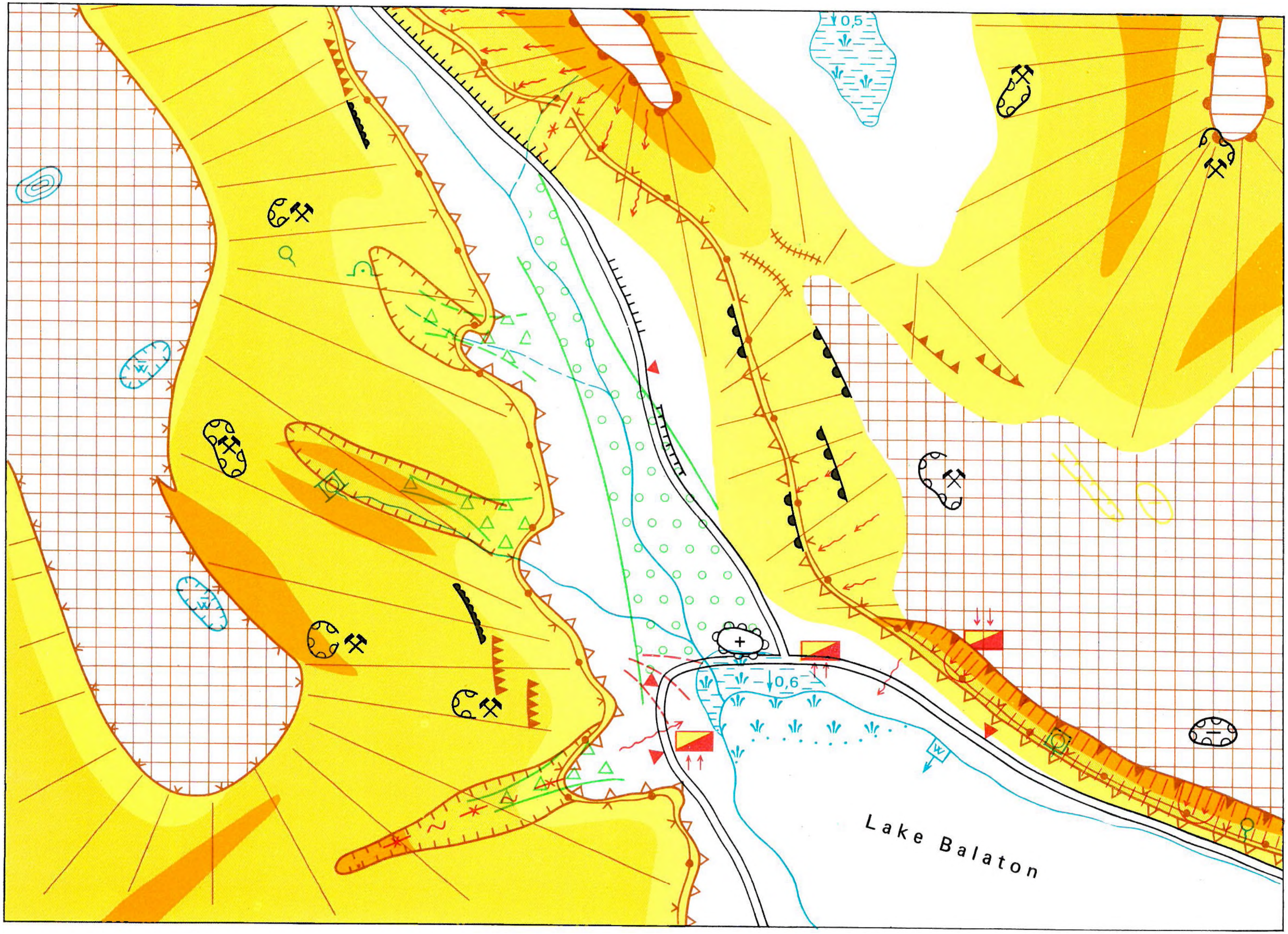


Lake Balaton
Sed
3–5%
1–2%
5–10%

FIG. 3. ENGINEERING–GEOLOGICAL MAP SERIES
OF THE ENVIRONS LAKE BALATON

Geomorfological map

Plotted by P. GUÓTH



Lake Balaton
0,5
0,6

FIG. 4. **ENGINEERING–GEOLOGICAL MAP SERIES OF THE ENVIRONS LAKE BALATON**

Map for foundation (3.5 m)

Plotted by P. GUÓTH

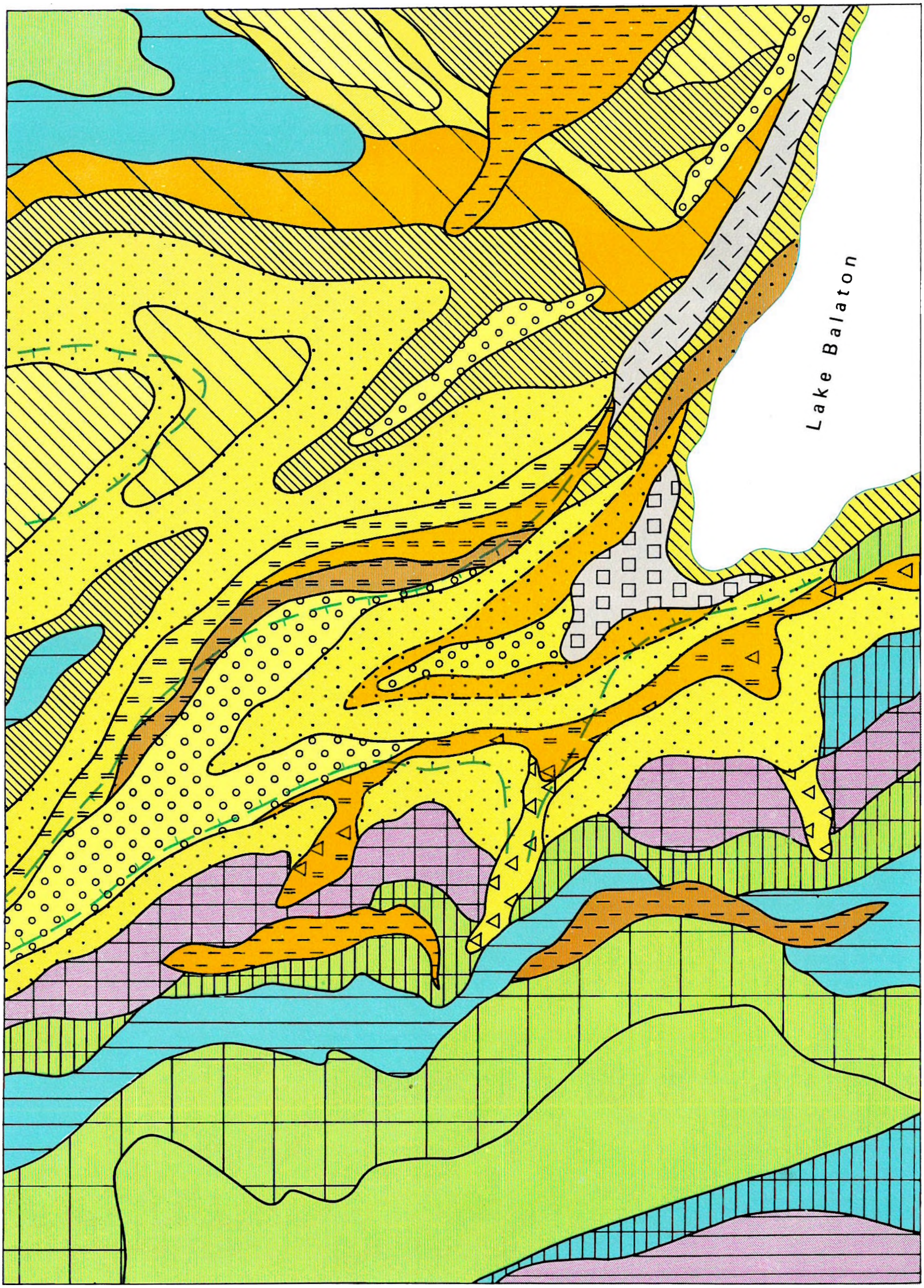
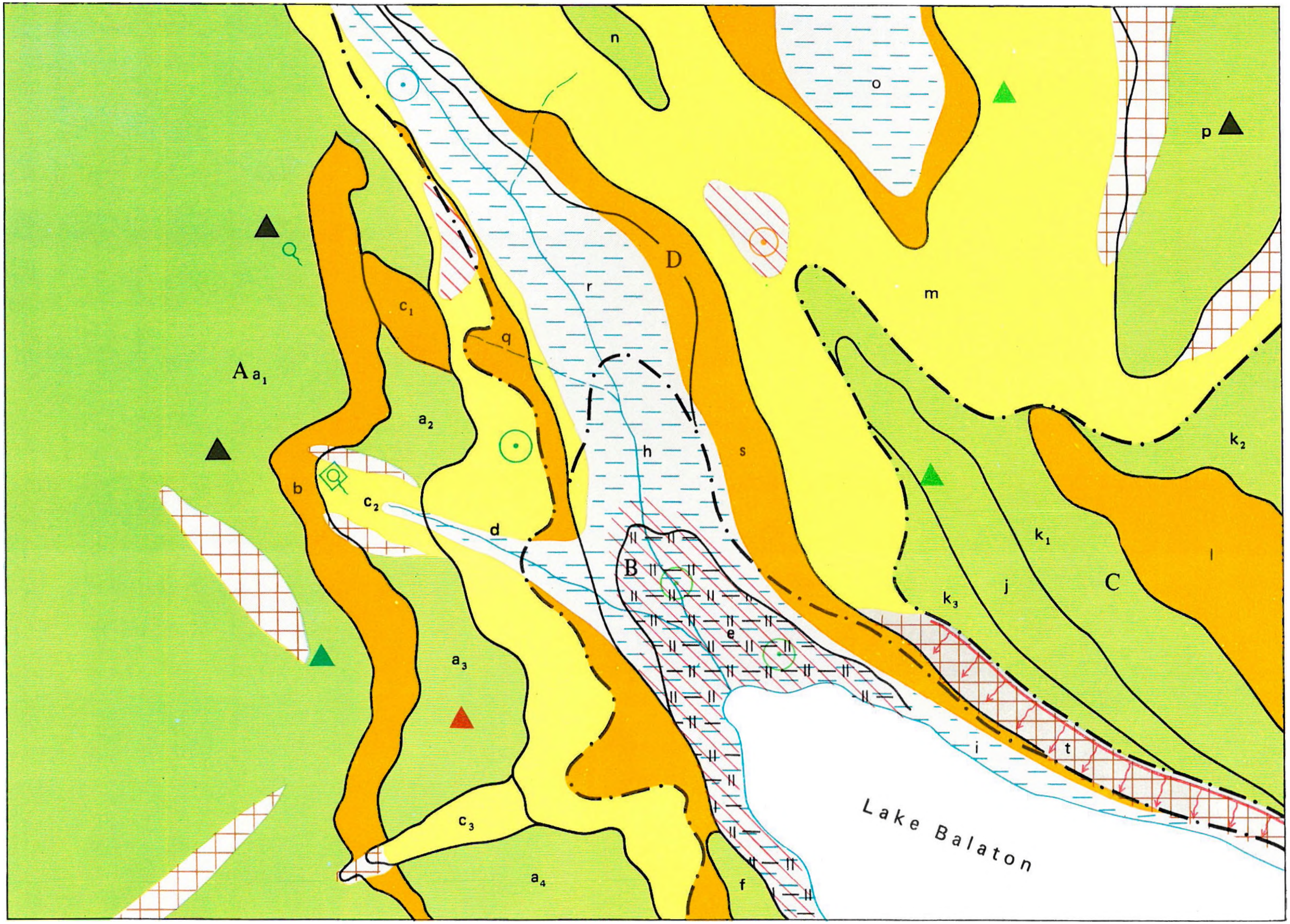

Lake Balaton

FIG. 5. ENGINEERING–GEOLOGICAL MAP SERIES
OF THE ENVIRONS LAKE BALATON

Synoptic map

Plotted by P. GUÓTH



Lake Balaton
A
B
C
D

CONTENTS

Kiadja a Magyar Állami Földtani Intézet
Felelős kiadó: Dr. Konda József
Készült a Magyar Állami Földtani Intézet nyomdájában
Terjedelem: 4,2 A/5 ív – Példányszám: 1000 – Engedélyszám: 99306/74
Felelős vezető: Balogh Ernő