international legend for hydrogeological maps

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INTERNATIONAL ASSOCIATION OF HYDROGEOLOGISTS (IAH)

INTERNATIONAL ASSOCIATION OF HYDROLOGICAL SCIENCES (IAHS)

UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION (UNESCO)

International Legend for Hydrogeological Maps

- Revised version, 1983 -

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FOREWORD

The large and growing number of hydrogeological maps throughout the world is evidence of the general tendency to present both data and their interpretation in map form. This method of presentation permits a rapid areal evaluation of the hydrogeology linked to the advantages of a topographic base. There is, however, likely to be a considerable variation in the amount of information depicted upon a given map, depending both upon the chosen scale and upon the purpose the map is intended to serve.

This Legend is intended to be a guide to the preparation of hydrogeological maps at any scale to a uniform standard. A list is given of the symbols, ornaments and colours which have specific meanings and that are internationally recognised.

This present Legend is based upon the International Legend for Hydrogeological Maps published jointly in 1970 by the International Association of Hydrogeologists, the International Association of Hydrological Sciences, UNESCO, and the Institute of Geological Sciences (London). Used in many mapping projects throughout the world, the 1970 Legend is now out of print, and a revised edition is being prepared. As a preliminary step, a simple and inexpensive version has been produced here as a UNESCO document in English language only, and without colour illustrations. At some future date, after adequate review and trial of this revised Legend, it is intended that a definitive and multi-lingual version with colour illustrations will be published.

For the compilation of the 1970 Legend, working groups were set up within the International Association of Hydrogeologists (IAH) and the International Association of Hydrological Sciences (IAHS). The recommendations of these working groups have come to fruition with the continuing publication of the various sheets of the International Hydrogeological Map of Europe on a scale of 1 : 1 500 000, a project largely carried out by the IAH Commission on Hydrogeological Maps and published jointly by UNESCO and BGR (Federal Institute for Geosciences and Natural Resources of the Federal Republic of Germany). For this reason, that Commission was given the task of preparing the revised Legend, taking into account nearly two decades of experience in hydrogeological mapping. In making this revision, the Commission has collaborated with IAHS and with UNESCO and was supported by BGR.

As a consequence of the application of the original Legend to widely differing environments, varying from tropical climates to permafrost regions, a number of amendments and additions have been proposed. Nevertheless, the basic techniques proved to be universally applicable and have led, in Europe in particular, to a useful degree of uniformity. This successful outcome has encouraged the Commission to press for the continued general acceptance of the Legend as a basis for the preparation of hydrogeological maps.

This revised Legend is intended to provide for the requirements of a general hydrogeological map rather than one produced solely to emphasize one or more particular aspects. Such specialized maps may of necessity use non-standard symbols, ornaments or colours. Suggestions for legends for certain specialized maps have been published, for example, Hydrogeology of Karstic Terrains (IAH, IAHS and UNESCO, 1976) and Legend for Geohydrochemical Maps (UNESCO, 1978). However, the Commission strongly recommends the preparation of a general hydrogeological map before any attempt to produce specialized maps.

The revised Legend contains a list of all the hydrogeological maps known to the Commission which have been published after 1970 at a scale of 1 : 200 000 or less. The exhaustive bibliography on the methodology of hydrogeological mapping that was included in the 1970 Legend has been omitted from the revised version.

Final editing of the revised Legend was carried out by a panel consisting of the following members:

W. Struckmeier (Chairman, IAH)
R. A. Monkhouse (IAH)
S. Jelgersma (IAHS)
W. H. Gilbrich (UNESCO)

The Commission would be glad to receive criticisms and suggestions for amendments or additions to the revised Legend from hydrogeologists throughout the world. These should be addressed to the Chairman of the IAH Commission of Hydrogeological Maps.

G. CASTANY	H. KARRENBERG	W. STRUCKMEIER
President of IAH	Advisor to IAH	Chairman of the IAH Commission on Hydrogeological Maps

1. HISTORICAL DEVELOPMENT OF THE INTERNATIONAL LEGEND FOR HYDROGEOLOGICAL MAPS

The first hydrogeological maps were produced in several countries during the two decades from 1940. The scales employed varied widely, for the most part between 1 : 25 000 and 1 : 200 000, but with a few maps up to 1 : 500 000 (Grahmann, 1952 - 57) and even smaller. These maps were intended to serve as a basis for the water resources planning required to satisfy the generally increasing demand by agriculture, industry and public supply, particularly so since the groundwater resources were not limitless. Since these hydrogeological maps were produced in connection with local developments, the features shown tended to be those considered important to each individual scheme, and even when these features were common to a number of maps they were generally depicted in different colours, with various dissimilar ornaments, and by a wide range of symbols. Comparison of the hydrogeology between areas shown on different, even neighbouring, maps was often difficult, and the maps themselves were not always easy to understand. Moreover, there were few, if any, hydrogeological maps which displayed a coverage on an international, a national, or even a truly regional basis.

The numerous and diverse ideas of the map-makers were demonstrated at an exhibition held in Helsinki in 1961 during the general meeting of the International Association of Hydrological Sciences (IAHS). Approximately 200 hydrological and hydrogeological maps wre displayed, with an extraordinary variety of map content, of colour, and of ornament and symbol use. During 1960 and 1961, the International Association of Hydrogeologists (IAH) attempted a survey of the techniques used in the preparation of such maps by circulating a questionnaire to hydrogeologists in many countries.

The replies received were revealing. Apart from the widely varying opinions expressed, largely due to a concentration on individual projects to the neglect of universally acceptable concepts, great weight was generally placed on theoretical considerations which altogether ignored the practical difficulties of expressing such matters on a two-dimensional map.

In short, there was a complete lack of uniformity, whereby a symbol, an ornament or a colour would have the same hydrogeological significance on whatever map it might appear. There were few maps with a regional rather than a parochial outlook, and there was no consensus of opinion as to what hydrogeological features would be significant on a regional or international rather than a local basis. Above all, there were no specialists in the preparation and production of hydrogeological maps.

Two factors had become clear, the necessity for co-ordination on an international basis on the methods of presenting hydrogeological information in map form, and agreement, again on an international basis, on which hydrogeological features were of sufficient importance to require depiction upon a map wherever and whenever they occurred within the area covered.

Two international scientific bodies in particular, IAH and IAHS, concerned themselves with these problems. After many discussions, IAH had established in 1959 the Commission for Hydrogeological Maps with a remit first to prepare a Legend of recommended symbols, ornaments and colours, and secondly to plan the production of a series of small scale maps to cover the whole of Europe (Karrenberg, 1964) A Working Group wasset up within the Commission to provide co-ordination on these projects. Simultaneously, IAHS

established within their Commission for Unterground Water a Permanent Standing Committee on Hydrogeological Maps. Contacts were established with UNESCO, with FAO, and with interested parties of many nationalities. As a starting point, both the Working Group and the Standing Committee considered the legend that had been produced for the hydrogeological maps of Morocco (Ambroggi and Margat, 1960).

A joint meeting of the IAHS Committee and the IAH Working Group was held in Paris 1962 under the auspices of UNESCO. Representatives of the latter organisation and of FAO attended. Agreement was reached on a draft legend for hydrogeological maps, and this was published by UNESCO in the following year (Anon, 1963). The purpose of the legend was stated in the preface to be to "facilitate the work of all those, whether specialists or not, who are concerned in the problem of water resources".

Since part of the draft Legend was based more on theoretical considerations rather than on practical experience, the IAH Commission used the preparation of the series of hydrogeological maps for Europe, named the International Hydrogeological Map of Europe, as a practical test. Part of the Sheet C5(Bern) was selected for the prototype since it covered a region with very varied geology and for which a large amount of data was available. The scale was 1 : 1 500 000. Hydrogeologists from Austria, Czechoslovakia, the Federal Republic of Germany, France, Italy, Switzerland and Yugoslavia were involved in the compilation of this map from 1962 to 1964. In order to evaluate the different ideas put forward to the Working Group, many of which differed from the draft Legend, it was necessary to produce printed examples of the map. In all, four variations were printed, referred to as Models 1 to 4, using the relatively inexpensive but less accurately registerable silk-screen process. The printing costs were borne by the Deutsche Forschungsgemeinschaft (as part of the German

contribution to the International Hydrological Decade) by the International Union of Geological Sciences, by the Bundesanstalt für Bodenforschung, and by the Geologisches Landesamt Nordrhein-Westfalen.

Models 1 and 2 were presented at the International Congress in New Delhi (1964). Both models were basically geological maps, with Model 1 having notes in the map legend on the permeability and other hydrogeological data for each formation depicted, while Model 2 attempted to show potential source yields in the different formations. Neither model proved generally acceptable.

A third version, Model 3, was produced in 1965. Geological formations were classified into good aquifers, moderate aquifers, and poor aquifers (including non-aquifers). The lithology was illustrated by a background ornament in grey. Good aquifers were distinguished by a blue colour, moderate by green, and the poor by brown. Unfortunately, the members of the Working Group experienced considerable difficulty in finding general agreement on what constituted "good", "moderate" and "poor". In consequence, Model 4 was placed in 1966 before a joint meeting of the IAH Working Group and the IAHS Committee. This version took the fundamental step of illustrating the aquifer type by colouring green the outcrop of those aquifers through which the dominant groundwater flow was by fissures, and blue for those with dominant intergranular flow. Brown was reserved for those strata not generally considered to be aquifers. Additionally, dark green and dark blue indicated the outcrop of extensive aquifers with large resources, while light green and light blue indicated local or discontinuous aquifers with lesser resources. Similarly, light brown represented strata which might have small but very localised resources (aquitards), and dark brown related to rocks with little or no usable

groundwater (aquicludes and aquifuges). Lithology was still shown by grey base ornament, and was used also to assist in stratigraphic differentiation. While Model 3 had departed from being a simple geological map with hydrogeological additions, Model 4 had moved away from the concept of well yield into that of aquifers and groundwater resources. Even at the present day, more than a decade after the first appearance of such a map, the world at large barely appreciates the importance of groundwater resources and their distribution as against the mere ability of a well to yield water, the latter often no more than a measure of technical efficiency in well construction. Model 4 was accepted as the prototype of the planned series of the International Hydrogeological Map of Europe, scale 1:1 500 000, and the final version on Sheet C5 (Bern) was published in 1970, financed primarily by contributions from UNESCO and from the Bundesanstalt für Bodenforschung, predecessor of the Federal Institute for Geosciences and Natural Resources (BGR).

Much of the information assembled during the preparation of Sheet C5 could not be shown on the map itself without obscuring more essential features. After the sheet had been published, it was considered adviseable to prepare a volume of Explanatory Notes, limited to not more than 100 pages on an B5 format. This volume could, it was felt, usefully supplement the map with tabulated information (particularly on groundwater chemistry), detailed vertical cross-sections of special interest, additional small maps to illustrate features of local importance, and a general explanatory text. Compiling this first volume involved the participation of more than fourteen geological surveys. The Explanatory Notes for Sheet C5 (Bern) were published as a 96 page volume in Hannover in 1974. The same principle has been followed with the subsequent sheets of the series, similar volumes being published as standard accompaniments.

The progress through the four versions of the draft for sheet C5 led naturally to additions and modifications to the draft Legend. Moreover, new symbols and ornaments for karst areas, for arid zone features and for other hydrogeological aspects had been considered by the IAH Working Group and by the IAHS Committee at joint meetings during 1967. The revised draft was finally published in 1970 in the United Kingdom under the supervision of the Institute of Geological Sciences. The publication was in colour, and the text was printed in English, French, Spanish and Russian. An interesting feature was the deliberate incorporation of a wide margin in which a manuscript translation of the text in any other language could be inserted.

Work upon the European hydrogeological map series has shown up a number of inadequacies in the 1970 Legend. The lithologies of the strata depicted upon the maps proved to be more varied than had been anticipated, and additional symbols were needed to quantify groundwater resources, to illustrate groundwater flow, and to accomodate ideas on aquifer protection. A special additional list of these symbols and ornaments was prepared in 1974 for use by the editors of the European map series (KARRENBERG et al, 1974), but it was not published for general use.

Since its publication in 1970, the Legend has provided the basis for the preparation of many hydrogeological maps, both inside and outside Europe. Although now out of print, the Legend is still in demand, and serious thought has been given to its reprinting. However, in its 1970 form, the Legend already contained some supplementary information appended to the main text, and work both on the European map series and elsewhere had suggested the need for further modifications and additions. To publish a new Legend in a definitive form containing these changes would, nevertheless, have been inappropriate before the latter had been tested in practical

map production. The IAH Commission has, therefore, decided upon the production, with the co-operation of UNESCO and IAHS, of this revised Legend as a single language, mono-colour publication at minimum cost. The intention is that, after a trial of a few years in practical use, a fully revised version in colour and with a multi-lingual text will be published.

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Karrenberg, H. 1964. Der Plan der A.I.H. bezüglich einer hydrogeologischen Karte von Europa 1 : 1 500 000. Mem. Assoc. Int. Hydrogeol., Athens, V, 386-393.

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2. INTRODUCTION

This legend has been compiled in order to present an internationally agreed means of displaying hydrogeological information in map form.
Hydrogeological maps are maps upon which are depicted the extent of aquifers, together with such geological, hydrogeological, meteorological and surface water features that may be necessary for an understanding of the groundwater regime. Such maps may be international, national, regional or local, and may vary from small (1 : 1 000 000, or smaller) to large (1 : 250 000, or greater) in scale.

Hydrogeological maps are of importance to hydrogeologists and groundwater specialists. They are of use also to non-specialists such as administrators and economists, engineers in the fields of town and country planning, technicians in agriculture and horticulture, as well as to farmers, schoolteachers and private individuals.

Purpose of hydrogeological maps

The purpose of hydrogeological maps is to enable various areas to be distinguished according to their hydrological character in relation to the geology. They should indicate, on a topographic base, such items as the extent of the principal groundwater bodies, the scarcity of groundwater elsewhere, the known or possible occurrence of artesian basins, areas of saline groundwater and the potability of groundwater. They should also show, according to scale, information of a local character, such as the location of boreholes, wells and other works, contours of the potentiometric surface, the direction of groundwater flow, and variations in water quality.

In general, any information leading to a better understanding of occurrence, movement, quantity and quality of groundwater, should be shown on hydrogeological maps, depending upon the scale adopted. The data normally presented relate to such matters as precipitation, evaporation, surface hydrology, geometric data on water-bearing formations, hydrochemistry and availability of water. In addition, sufficient geology should be shown to lead to a proper understanding of the hydrogeological conditions. However, the geology should remain subdued and the hydrogeological features should be prominent.

Scales

In general, small scale maps (1:1 000 000, or smaller) will show only the general location and disposition of aquifers and non-aquifers, together with a broad picture of the surface drainage. It may be possible in some cases to show a small number of other features, such as generalised contours of the potentiometric surface in the more extensive and important aquifers. However, the introduction of fine detail is not usually warranted, and on such small scales may well be meaningless.

At the other extreme, a considerable array of data may be expressed on large scale maps (1 : 250 000, or greater), and this may often be increased by insert maps, on a small scale, illustrating factors of general importance such as rainfall, relief and certain aspects of groundwater chemistry.

The selection of a particular scale for a hydrogeological map may depend not only upon the purpose to which the map may be put, but also to the amount of information that is either available for inclusion or desired to be shown. There is little advantage in producing large scale maps of areas for which there is only scanty information, and equally little in entering data so profusely upon a small scale map that a clear distinction of the individual factors can no longer be made.

Definitions

Certain terms are used rather loosely in both hydrogeology and cartography, and it is easy for misunderstandings to arise. A short list of definitions is here included which refer to the usage for this Legend.

Ornament: a pattern of marks, lines or other symbols denoting the occurrence of a particular factor over an area of ground as represented upon the map; e.g. a stipple to represent sandy strata.

Symbol: a single graphical representation to denote the presence of a particular factor at a point location on the map; e.g. a small circle to show the location of a spring.

Line: a solid or broken line may be used either to delimit an area (such as an aquifer outcrop), or to join points of equal altitude (contour), equal thickness (isopachyte), or similar parameters.

Sign: a sign may consist of a line, a symbol, or an ornament, or a combination of any or all of these.

Colour: a colour refers to an even "wash" of constant tone. It may be used for lines, symbols or ornaments as well as for emphasising areas of importance.

Tone: screens may be used in order to reduce the density of a colour. The value of the tone is usually expressed as a percentage of the original or full (100%) colour.

Background information (Section A of the Legend)

This comprises largely geographical detail such as major roads, railways, the larger conurbations, and so forth. Relief is generally not shown on the map since it tends to obscure hydrogeological detail, but insert maps can be used for the purpose. The international grid (UTM grid-Universal Transversal Mercator projection - is suggested), a national grid, or lines of latitude and longitude should be shown.

Background information is generally printed in grey with the grid or latitude-longitude lines in black. Regional and town names may also be printed in black, but the type faces should be clearly different from those used for the stratigraphic symbols (see Section E).

Aquifers and non-aquifers (Section B of the Legend)

All strata that appear in outcrop upon the map, whether aquifers or non-aquifers are shown in plain colour. Intergranular aquifers are coloured blue and fissure aquifers are coloured green, in each case a dark colour indicating an extensive and highly productive aquifer while a lighter tone indicates other aquifers (see Sections B.I and B.II).

Formations giving only limited or local yields are coloured a light tone of brown, while strata with essentially no groundwater resources are coloured dark brown (see Section B.III, a and b).

Where it is considered to be particularly important to show the continuation of an aquifer beneath a thin but persistent cover of drift, the appropriate aquifer colour (blue or green) may be continued over the relevant area, but should be crossed by vertical bands of the appropriate colour of brown (see Section B.III c). The legend normally printed in the margin of the map sheet should state the order of maximum thickness of the drift cover.

Lithology (Section C of the Legend)

The lithology of the strata in outcrop is represented by ornament printed in grey beneath the colour. Where the ornament indicates recognisably stratified bedrock, the ornament itself is also recognisably laminar: when the ornament is arranged horizontally (in an east-west orientation upon the map), it indicates horizontal or gently inclined strata, and arranged in a vertical position (a north-south orientation upon the map) indicates steeply inclined or folded strata.

A list of suggested ornaments is given in Section C of the Legend, and these may be varied in size, or combined with each other, either to show mixed lithologies or to differentiate between different formations.

Representation of detailed data (Section D of the Legend)

Detailed hydrological information is shown by the use of symbols, and occasionally of lines and ornaments, printed in various colours. Numerical figures, in the same colours, may be added for clarification, e.g. to put values on contours.

The different sections into which the data are grouped are as follows:

	Group	Colour
1.	groundwater, including springs	violet
2.	groundwater quality and temperature	orange
3.	surface water and karst hydrography	blue
4.	man-made features and alterations to the natural groundwater regime	red
5.	horizon contours, isopachytes and limits of permafrost	dark green
6.	geological and stratigraphical information	black

Stratigraphy (Section E of the Legend)

While stratigraphic information is not of primary importance upon hydrogeological maps, it is generally convenient to indicate at least the approximate age of the strata depicted. The symbols, printed in black, are listed in Section E, and are taken from the International Geological Map of Europe 1 : 1 500 000 scale. On large scale hydrogeological maps, it may prove adviseable to use symbols of more local than international significance.

Climatology (Section F of the Legend)

It is rarely possible to include meteorological information on a hydrogeological map without obscuring more pertinent data. It is, therefore, recommended that climatological information be presented either in insert maps upon the margins of the hydrogeological map, or as figures in any accompanying text.

Vertical sections (Section G of the Legend)

Vertical cross-sections are commonly used to illustrate the relationships between aquifers and non-aquifers in relation to depth. Other hydrogeological features are also amenable to such treatment. The use of vertical cross-sections to accompany hydrogeological maps is strongly recommended. The colours, lines, symbols and ornaments used on the vertical cross-sections should be the same as those used upon the map. While in general the horizontal scale should be the same as that of the map, the vertical scale may need to be exaggerated to permit detail to be shown. However, the minimum exaggeration possible should be employed since, particularly upon large scale maps, an over-exaggeration may present a misleading picture.

3. International Legend for Hydrogeological Maps

A Background information

1. All background information is printed in screened black with the exception of the simplified topographic base map which is printed in dark grey (60% black). It presents mainly the

   location and names of important localities and the geographic names (streams, lakes, mountains, etc.), international and administrative boundaries.

2. The actualized drainage network is printed in blue.

3. Grids or lines of longitude and latitude are printed in black.

4. Additional background information to topography and orography where required is presented in the explanatory notes or on insert maps.

B Groundwater and rocks

1. Intergranular aquifers

blue	1.1	Extensive and highly productive aquifers
screened blue	1.2	Local or discontinuous productive aquifers or extensive but only moderately productive aquifers

2. Fissured aquifers, including karst aquifers

green	2.1	Extensive and highly productive aquifers
screened green	2.2	Local or discontinuous productive aquifers, or extensive but only moderately productive aquifers

3. Strata (intergranular or fissured rocks) with local and limited groundwater resources or strata with essentially no groundwater resources

screened brown	3.1	Strata with local and limited groundwater resources
brown	3.2	Strata with essentially no groundwater resources
brown stripes	3.3	Where there is an extensive aquifer immediately underlying a thin cover the option be used of continuing the appropriate aquifer colour crossed by brown stripes (one mm wide and three mm separation)

Note:
Certain aquifers combine intergranular and fissure characteristics. In such cases the relevant colours described in sections 1 and 2 should be used depending on which characteristic is dominant. Further explanation, if required may be added to the map legend.

C Lithology

Ornament indicating the lithology is printed in grey.

The orientation of the ornament indicates the type of bedding:

Horizontal = unfolded horizontal or gently inclined strata

Vertical = folded strata

The following list contains ornaments which indicate general lithological types as well as some combinations to symbolize strata of varying lithology.

Note:
The ornament represents the lithology of the strata which is shown on the map. The exact lithological composition may be explained in detail in the map legend. Where combinations of ornaments are required, examples are shown in section C 3.
Combination of more than two ornaments is not recommended.

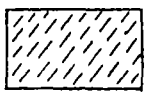
The identification numbers given below are purely for convenience and do not refer to any commercial listings.

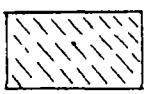
Additional ornaments other than listed here can be used for special purposes.

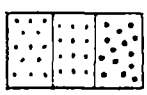
Recommended ornaments:

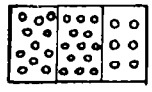
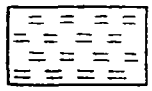
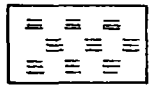
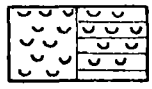
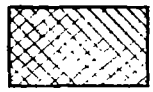
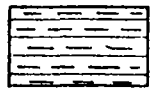
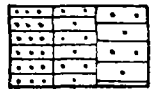
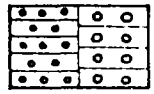
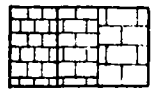
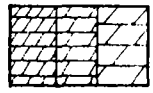
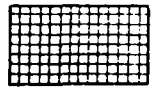
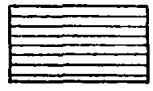
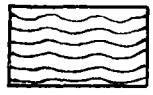
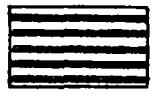
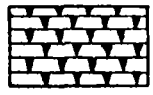
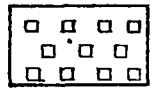
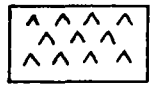
1. Lithology of sedimentary rocks

1  clay, clayey loam, mud, silt, marl

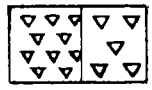
2  clayey-loamy alteration products

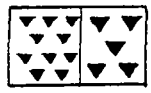
3  loess

4  sands (units can be distinguished by variation of thickness of points)

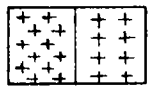
5		gravels (distinction by variation of the arrangement of circles)
6		moraines
7		peat
8		lignite
9		pyroclastics
10		made ground
20		claystone, siltstone, shale
21		sandstone (distinction by variation of size)
22		conglomerate
23		limestones (distinction by variation of rectangle size)
24		dolomites (distinction by variation of parallelogram size)
25		travertine
26		marlstone
27		flysch
28		complex alternation of different lithology
29		radiolarite, lydite, siliceous shale
30		rock salt
31		gypsum

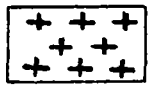
2. Lithologies of igneous and metamorphic rocks

40  acid to intermediate extrusives (distinction by variation of triangle size)

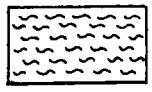
41  basic extrusives (distinction by variation of triangle size)

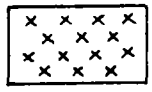
42  ultrabasite, serpentinite

43  acid to intermediate intrusives (distinction by variation of arrangement of crosses)

44  basic intrusives

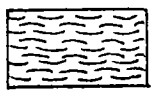
45  slate, phyllite, mica schist, etc.

46  gneiss

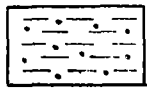
47  gneiss and granite, undifferentiated

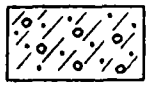
48  marble

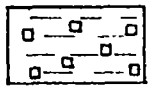
49  quartzite

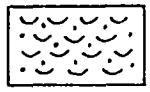
50  metamorphic rocks, undifferentiated

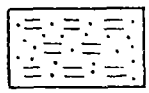
3. Examples of combined types


1+4

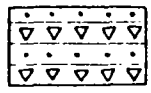

2+4+5

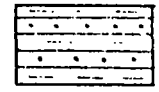

1+30

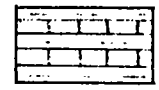

4+9

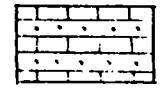

4+7

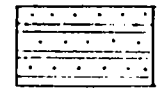

26+31


21+40

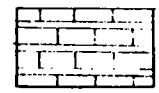

20+21

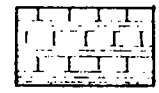

20+23


21+23


21+26


21+45


23+26


23+45

Distinction between different geological formations may be made by varying the size of the ornament.

D Representation of detailed data

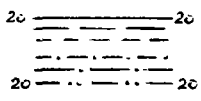
Signs are printed in several colours grouped as shown below:

1. violet: groundwater and springs
2. orange: groundwater quality and temperature
3. blue: surface water and karst hydrography
4. red: man made features and alterations of the natural groundwater regime
5. dark green: horizon contours (isopachytes) and limits of certain features, such as permafrost
6. black: geological information

Detailed examples of internationally used colour charts* are given in brackets to standardize the colours.

1 Groundwater and springs

Colour: violet (ITC No. 062,)



1.1 Contours of the potentiometric surface (solid or broken lines with height relative to reference level)

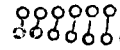
1.2 Direction of groundwater flow

a)

b)

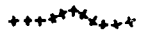
1.3 Connection between karstic loss and resurgence a) proven, b) inferred

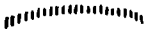
a)

b) 

1.4 Groundwater divide a) stationary, b) periodically changing

*) ITC Colour Chart (1982), ITC Journal 1982-2, Enschede

 1.5 Limit of area with confined groundwater

 1.6 Limit of area of artesian flow

 1.7 Lens of fresh water surrounded by salt water

 1.8 Limit of area with insignificant natural replenishment to the groundwater (50% screen colour)

average discharge of a) less than 100 l/s
b) 100 - 1000 l/s,
c) more than 1000 l/s

a)	b)	c)			
			1.10	Spring	Fresh water
			1.11	Perennial karst spring	
			1.12	Submarine spring	
			1.13	Spring	Brackish water
			1.14	Perennial karst spring	
			1.15	Submarine spring	

 1.16 Group of springs
(relevant symbols are enclosed of circles)

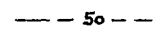
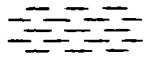
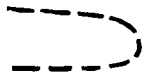
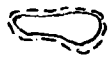
 1.17 Temporary karst spring
(large: 0 - less than 1 m^3/s,
small: 0 - more than 1 m^3/s)

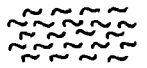
..... 1.18 Line of springs

 1.19 Groundwater seepage area

2 Groundwater quality and temperature

Colour: orange (ITC No. 650,)

	2.1	Boundary of saline groundwater in an aquifer
	2.2	Isolines of equal groundwater salinity
	2.3	Contours of the interface between fresh and saline groundwater, in m below reference level
	2.4	Area of sea water intrusion
	2.5	Limit of mineralization of shallow groundwater inland
	2.6	Area of mineralized groundwater inland
	2.7	Area with mineralized water overlying fresh groundwater
	2.8	Limit of continental mineralization
	2.9	Stream with mineralized water (blue stream with orange band)
	2.10	Lagoon or lake with saline or brackish water (blue shore line with orange band inside)
	2.11	Periodical salt-water lake (broken blue shore line with orange band inside)
	2.12	Shotts (playas) with epidosical water (dotted blue shore line with orange band inside)



2.13 Salt marsh

2.14 Limit of formations containing minerals susceptible for groundwater quality deterioration (grey line with orange band)

cf. 1.13 Spring

cf. 1.14 Perennial karst spring

cf. 1.15 Submarine spring

} Brackish water (circles in violet, centres in orange)

2.15 Cold mineral spring

2.16 Thermomineral spring

2.17 Thermal spring

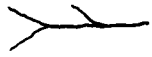
2.18 Area of increased geothermal heat

2.19 Meltwater chamber beneath glacier

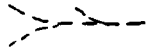
2.20 Glacier burst from meltwater chamber beneath glacier

3 Surface water and karst hydrography

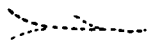
Colour: blue (ITC No. 006)



3.1 Stream with perennial runoff



3.2 Stream with intermittent runoff



3.3 Dry valley, possibly with episodical runoff (ephemeral stream)

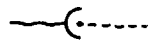
3.4 Sander

3.5 Stream ending in inland depression

cf. 2.9 Stream with mineralized water (blue stream with orange band)

3.7 Karstic loss in river valley

a)  a) perennial flow downstream

b)  b) seasonal flow downstream

c)  c) no flow downstream

3.8 Aven

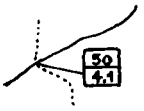
3.9 Doline filled with water

3.10 Dry doline

3.11 Limit of karst area

3.12 Main surface water divide

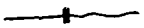
3.13 Secondary water divide



3.14 Flow gauging station
$\frac{\text{mean annual runoff}\,[m^3/s]}{\text{catchment area}\,[\cdot\ 1000\ km^2]}$

3.15 Glacier

3.16 Glacier burst from ice dammed lake



3.17 Waterfall

3.18 Fresh water lake

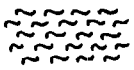
cf. 2.10 Lagoon or lake with mineralized water (blue shore line with orange band inside)

cf. 2.11 Periodical salt-water lake (broken blue shore line with orange band inside)

cf. 2.12 Shotts (playas) with episodical water (dotted blue shore line with orange band inside)

3.19 Periodical fresh water lake

3.20 Dry lake with only episodical water



3.21 River marsh

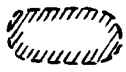
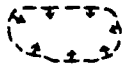
3.22 Bog

4 Man made features and alterations of the natural groundwater regime

Colour: red (ITC No. 660)

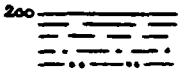
- 4.1 Well, shaft or borehole, with phreatic or confined groundwater
- 4.2 Group of wells or boreholes, with phreatic or confined groundwater
- 4.3 Well or borehole, artesian flowing
- 4.4 Group of wells or boreholes, artesian flowing
- 4.5 Mineral water well
- 4.6 Thermomineral water well
- 4.7 Thermal water well
- 4.8 Injection well

average quantity of discharge or pumping
(categories at the discretion of the author,
e.g.
a) 3 - 30 million m^3/year
b) 30 - 300 " " "
c) more than 300 million m^3/year)

a) b) c)		
	4.9	Pumping station, pumped well
	4.10	Pumping station from spring (red square with violet dot inside)
	4.11	River intake
	4.12	Pipeline
	4.13	Aqueduct
	4.14	Storage reservoir or pond
	4.15	Dam or weir, with capacity of the reservoir in million m^3
	4.16	Levee or coastal dike
	4.17	Flood-tide barrage or tidal power plant
	4.18	Groundwater recharge site
	4.19	Installation for desalination
	4.20	Oasis cultivation
	4.21	Limit of area of intensive groundwater exploitation
	4.22	Area of underground mining effecting the natural groundwater regime
	4.23	Area of open cast mining effecting the natural groundwater regime

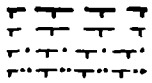
5 Horizon contours (isopachytes) and limits of certain features, such as permafrost

Colour: dark green (ITC No. 606)



5.1 Horizon contours or isopachytes (solid or broken lines with depth in m relative to reference level)

30 5.2 Thickness of aquifer in m



5.3 Limit of permafrost area (variation of broken lines for continuous, discontinuous and isolated distribution)

5.4 Talik (unfrozen zone) under a river, lake or reservoir
(river or lake in blue, green dots surrounding)

6 Geological information

Colour: black

6.1 Geological or hydrogeological boundary

6.2 Fault, certain (solid line) or inferred (broken line)

6.3 Overthrust, certain or inferred

6.4 Boundary of infilled erosional channel

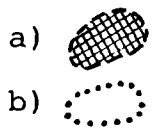
6.5 Fractured belt of hydrogeological importance

cf. 2.14 Limit of formations containing minerals susceptible for groundwater quality deterioration (grey line with orange band)

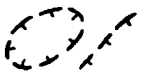
6.6 Salt plug (diapir)

a) near surface,

b) at depth (dotted line)

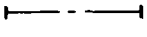


6.7 Area and edge of solution chambers formed in salinar formations (subrosion)



6.8 Volcanic cone

6.9 Volcanic crater



6.10 Line of cross-section

E Stratigraphic symbols

Simple stratigraphic symbols are printed in black.

They help to identify the unit which is represented on the map, whenever it is not characterized unequivocally by the combination of areal colour and screen. With the knowledge of the stratigraphy, the map reader can recognize the geological structures in an easier way.

It is recommended to use the stratigraphic symbols according to the general legend of the "International Geological Map of Europe and the Mediterranean Region 1 : 1 500 000, Hannover 1962" for areas built up of sedimentary strata. In magmatic and metamorphic areas, however, the age determination is often problematically. It is, therefore, up to the author to decide whether or not it is necessary to present stratigraphic symbols in those areas, since the combination of areal colour and screen is often sufficient.

Note: Stratigraphic symbols are to be used sparingly on hydrogeological maps. The representation of hydrogeological features is in any case predominant.

List of stratigraphic symbols

q	-	Quaternary undifferentiated	q+m-Cenozoic
qh	-	Holocene	
qp	-	Pleistocene	
m	-	Tertiary undifferentiated	
m4	-	Pliocene	
m3	-	Miocene	
m2	-	Oligocene	
m1	-	Eocene and Paleocene	
c	-	Cretaceous undifferentiated	ms-Mesozoic
c2	-	Upper Cretaceous	
c1	-	Lower Cretaceous	
j	-	Jurassic undifferentiated	
j3	-	Upper Jurassic	
j2	-	Middle Jurassic	
j1	-	Lower Jurassic	
t	-	Triassic undifferentiated	
t3	-	Upper Triassic	
t2	-	Middle Triassic	
t1	-	Lower Triassic	

p	-	Permian undifferentiated	pl-Paleozoic
p2	-	Upper Permian	
p1	-	Lower Permian	
h	-	Carboniferous undifferentiated	
h2	-	Upper Carboniferous	
h1	-	Lower Carboniferous	
d	-	Devonian undifferentiated	
d3	-	Upper Devonian	
d2	-	Middle Devonian	
d1	-	Lower Devonian	
s	-	Silurian	
o	-	Ordovician	
cb	-	Cambrian	
eo	-	Eocambrian	
pr	-	Pre-Cambrian	

F Climatology

Maps showing climatological features, e.g. precipitation, evaporation, temperature or other climatological features, should be presented separately from the hydrogeological map, either as an insert map on the main map or as figures in an accompanying explanatory text.

G Vertical cross-sections

It is standard practice to illustrate the geology and hydrogeology at depth by the use of vertical cross-sections. These sections may be printed upon the margin of the map, or alternatively within an accompanying explanatory text.

The lines along which the sections are drawn should be clearly indicated by lines printed in black upon the map. The significance of these lines should be clearly explained in the sheet legend and labelled, also in black, with the number identifying the particular section.

The horizontal scale of the cross-section should generally be the same as that of the map. The vertical scale is often exaggerated; however, the vertical exaggeration should be limited to that necessary to illustrate the required detail since over-exaggeration, expecially upon large scales, may present a grossly misleading picture.

The lines, symbols and ornament used upon the cross-section should be the same as those used upon the map.

The end-points of each section, together with any point of importance along the section, should have their locations specified, preferably by the use of grid references. A bar-scale of altitude (vertical scale) at each end of the section is compulsory.

4. SELECTED LIST OF HYDROGEOLOGICAL MAPS

A. International and Continental Hydrogeological Maps

Groundwater in Africa, 1:17,000,000, U.N., New York, 1973.

Hydrogeological Map of South America, 1:2,500,000, Rio de Janeiro, in preparation.

International Hydrogeological Map of Europe 1:1,500,000, IAH/Unesco/BGR, Hannover/Paris, 1970 - .

Water Resources Map of the Arab Countries 1:1,000,000, ACSAD, Damascus, in preparation.

B. National Hydrogeological Maps

AFRICA

Algeria

Cartes hydrogéologiques, 1:200,000 et 1:1,000,000, several sheets, Alger, 1973 - .

Botswana

Hydrogeological Reconnaissance Map, 1:500,000, 11 sheets, Lobatse, 1979 - .

Chad

Carte hydrogéologique, 1:500,000, 1972.

Ghana

Carte hydrogéologique, 1:1,000,000, 1972.

Ethiopia

Hydrogeological Map, 1:250,000, in preparation.

Madagascar

Hydrogeological Map, 1:500,000, 1972.

Morocco

Cartes hydrogéologiques, 1:200,000, 1:500,000 et 1:1,000,000, Rabat, 1960 - .

Carte des Systèmes Aquifères du Maroc an 1:1,000,000, Provinces du Nord, 2 sheets, Rabat, 1976.

Mozambique

Carte hydrogéologique (planification), 1:250,000, 1971.

Niger

Cartes des nappes d'eaux souterraines de la République du Niger, 1:500,000, 1:1,000,000, 1:2,000,000, Paris et Niamey, 1962 - .

Senegal

Carte hydrogéologique de la République du Senegal, 4 sheets 1:500,000, Paris, 1980.

Somalia

Carte hydrogéologique, 1:1,000,000, in preparation.

Tunesia

Cartes hydrogéologiques des eaux souterraines, 1:200,000, Tunis, 1971 - .

United Republic of Cameroon

Cartes hydrogéologiques, 1:500,000 et 1:1,000,000, 1975.

Carte de planification des ressources en eau, 1:1,000,000, 1980.

AMERICA

Argentina

Mapa hidrogeológico de la República Argentina, 1:500,000, 12 sheets, Buenos Aires.

Brazil

Mapa hidrogeológico do Brazil NA, escala de 1:2,500,000, Rio de Janeiro, 1983.

Canada

Major hydrogeological maps of provinces and regions, often at the scale of 1:7,603,000, Ottawa, 1967.

Hydrogeological maps at the scale of 1:500,000, for different regions of Alberta, Edmonton, 1978 - .

Ecuador

Hydrogeological map of Ecuador, 1:1,000,000, in preparation.

United States of America

National atlas of the United States of America. Productive aquifers and withdrawls from wells, 1:7,500,000, Washington, 1970.

Many hydrogeological maps at different scales, (1:62,500 to 1:3,168,000), of states or regions, mainly published by the U.S.G.S., Washington, 1960 - .

Venezuela

Mapa hidrogeologico de Venezuela, 1:500,000, Caracas, 1978.

ASIA

Afghanistan

Hydrogeological map of Afghanistan, 1:2,000,000, Kabul, 1977.

China

Hydrogeologic Atlas of the Peoples Republic of China, Peking.

India

Geohydrogeological map of India, 1:2,000,000, Madras, 1969.

Hydrogeological map of India, 1:5,000,000, Calcutta, 1976.

Indonesia

Peta hidrogeologi Indonesia, 1:250,000, several sheets, Bandung, 1981 -

Reconnaissance hydrogeological map of Bali, 1:250,000, Jakarta, 1972.

Tentative hydrogeologic map of the Island of Lombok, 1:400,000, Hannover, 1972.

Iran

Hydrogeologische Karte des Maharen-Sees und seiner Umgebung bei Shiras (Iran), 1:200,000, Aachen, 1972.

Japan

Hydrogeological map of Japan, 1:2,000,000, Kawasaki-shi, 1964.

Malaysia

Peta hidrogeologi semenanjung Malaysia, 1:500,000, Ipoh, 1975.

Mongolia

Hydrogeological map of Mongolia, 1:1,500,000, Moscow, 1971.

Philippines

Hydrogeologic map of Central Luzon, Philippines, 1:600,000, Manila, 1970.

Sri Lanka

Groundwater data and geological characteristics, 1:2,000,000, Colombo, 1970.

Taiwan

Hydrogeological map of Taiwan, 1:250,000, Tai-peh, 1968.

Thailand

Hydrogeological map of Northeastern Thailand, 1:500,000, Bangkok, 1973.

AUSTRALIA AND OCEANIA

Australia

Groundwater Resources of Australia, 1:5,000,000, Canberra, 1975.

Groundwater Resources of Queensland, 1:2,500,000, Brisbane, 1971.

Groundwater Resources of Victoria, 1:1,000,000, Melbourne, 1975.

Groundwater Resources of South Australia, 1:1,000,000, Adelaide, 1975.

Hydrogeological maps of Western Australia, 1:250,000, Perth, in preparation.

Fiji

Hydrogeological map of Viti Levu, 1:250,000, New York, 1974.

Tonga

Grundwasser-Karte der Insel Tongapu, 1:300,000, Hannover, 1972.

EUROPE

Austria

Hydrogeologische Karte der Republik Österreich, 1:1,000,000, Wien, 1969.

Hydrogeologische Karte von Oberösterreich, 1:250,000, Linz, 1973.

Grundwasser von Tirol, 1:200,000, Innsbruck, 1977.

Bulgaria

Atlas Narodna Republika Bulgaria. Chidrogeolož̌ka Harta, 1:1,500,000, Sofija, 1973.

Cyprus

Hydrogeological Map of Cyprus, 1:250,000, Nicoria, 1970.

Czechoslovakia

Hydrogeological Map of Czechoslovakia, 1:1,000,000, Prague, 1966.

Map of the Groundwater Runoff in the Č̌SSR, 1:1,000,000, Praha, 1982.

France

Carte hydrogéologique de la France. Systemes aquifères, 1:1,500,000, Orléans, 1980.

Carte et catalogue des principaux systèmes aquifères du territoire francais, 1:1,000,000, Orléans, 1976.

Carte du débit moyen des nappes d'eau souterraine de la France, 1:1,000,000, Orléans, 1970.

Carte hydrogéologique du bassin Rhin-Meuse, 1:500,000, Moulin-les-Metz, 1975.
Atlas des nappes aquifères de la région parisienne, 1:200,000, Paris, 1970.
Atlas hydrogéologique de la Beauce, 1:250,000, Orléans, 1975.

Germany, Federal Republic of

Geowissenschaftliche Karte des Naturraumpotentials von Niedersachsen und Bremen, 1:200,000, several sheets, Hannover, 1981 - .
Grundwasservorkommen in der Bundesrepublik Deutschland; 1:1,000,000, 3 sheets, Bad Godesberg, 1980.
Hydrologischer Atlas der Bundesrepublik Deutschland, 1:1,000,000, Bonn-Bad Godesberg, 1978.
Hydrogeologie Nordrhein-Westfalen, 1:500,000, Hannover, 1978.
Hydrogeologie Schleswig-Holstein, 1:500,000, Hannover,1973.
Karte der Grundwasserlandschaften in Nordrhein-Westfalen, 1:500,000, Krefeld, 1973.

Hungary

Borsod es Környekenek vizföldtani atlasza, 1:150,000 and 1:300,000, Budapest, 1978.

Israel

Groundwater Atlas of Israel, 1:500,000, Jerusalem, 1979.

Italy

Schema idrogeologico della Capania, 1:500,000, Napoli, 1974.
Schema idrogeologico dell'Appennino Carbonatico Centro-Meridionale, 1:400,000, Napoli, 1979.

Luxembourg

Carte hydrogéologique Beaufort, 1:200,000, Luxembourg, 1980-1981.

Netherlands

Hydrological Map of the Netherlands, 1:1,500,000, Delft, 1972.

Poland

Mapa hydrogeologiczna Polski, 1:1,000,000, Warszawa, 1970.

Portugal

Carta hidrogeólica de Portugal, 1:1,000,000, Lisboa, 1970.

Romania

Apele Subterane (Atlasul Republicii Socialiste Romanis), 1:1,500,000, Bucuresti, 1975.

The hydrogeological map of Romania, 1:1,000,000, 1975.

Spain

Mapa hidrogeologico nacional, 1:1,000,000, Madrid, 1972.

Sweden

Hydrogeological maps and explanatory notes, 1:250,000, Uppsala, 1981.

Switzerland

Atlas der Schweiz (Hydrogéologie), 1:500,000, Bern, 1965-1979.

Turkey

Hydrogeological map of Turkey, 1:500,000, 18 sheets, Ankara, 1967 - .

Union of Soviet Socialist Republics

Hydrogeological map of the USSR, 1:2,500,000, Moscow, 1972.

Gidrogeologiceskaja Karta Kemerovskoj oblasti u Altajskogo kraja, 1:1,000,000, Moskva, 1972.

Karta gidorgeologiceskich struktur SSSR, 1:10,000,000, Leningrad, 1974.

United Kingdom of Great Britian and Northern Ireland

Hydrogeological map of England and Wales, 1:625,000, London, 1977.

Yugoslavia

Hyrogeologiška, carte hydrogéologique des eaux souterraines en Bosnie Central, 1:300,000, Sarajevo, 1971.