1962/22
COPY B
3

COMMONWEALTH OF AUSTRALIA.

DEPARTMENT OF NATIONAL DEVELOPMENT.

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS.

RECORDS.

1962/22

REPORT ON THE SYMPOSIUM OF THE INTERNATIONAL ASSOCIATION OF SCIENTIFIC HYDROLOGY (I.A.S.H.) ON 'GROUNDWATER IN THE ARID ZONES' HELD AT ATHENS, 11TH TO 21ST OCTOBER, 1961

by

D.A. White

REPORT ON THE SYMPOSIUM OF THE INTERNATIONAL ASSOCIATION OF SCIENTIFIC HYDROLOGY (I.A.S.H.) ON 'GROUNDWATER IN THE ARID ZONES' HELD AT ATHENS, 11th to 21st OCTOBER, 1961.

by

D.A. White

RECORDS 1962/22

CONTENTS

CONTENTS (ii)

FIGURES

REPORT ON THE SYMPOSIUM OF THE INTERNATIONAL ASSOCIATION OF SCIENTIFIC HYDROLOGY (I.A.S.H.) ON 'GROUNDWATER IN THE ARID ZONES' HELD AT ATHENS, 11th to 21st OCTOBER, 1961.

SUMMARY

The symposium of the International Association of Scientific Hydrology (I.A.S.H.) on 'Groundwater in the Arid Zones' was held at Athens from the 11th to the 21st October, 1961. About one hundred and ten (110) scientists attended the symposium and twenty-six (26) countries were represented.

Sixty (60) papers were presented at the symposium and these, together with another sixteen (16) papers which were not presented, were published in two volumes totalling 746 pages in the I.A.S.H. Bulletin. The papers covered six aspects of groundwater in arid zones; these were :-

i) General hydrogeology;
ii) Hydrogeology of regions;
iii) Hydrodynamic tests;
iv) General views on the development of ground-water resources;
v) Detailed study (recharge); and
vi) Detailed study of the development of regions.

During the symposium, meetings of the I.A.S.H. Council and Standing Committee on Hydrogeological Maps were attended. The important items discussed in the Council meetings were : the proposed Hydrological Decade; the programme of the International Union of Geodesy and Geophysics (I.U.G.G.) XIIIth General Assembly to be held at Berkeley, California, in 1963, and the symposium entitled 'The Upper Mantle of the Earth's Crust' to be held during the Assembly. The Standing Committee on Hydrogeological Maps made good progress in preparing a standard list of symbols for use on hydrogeological maps. The list is included in this report as Appendix V.

Four excursions were conducted during the symposium to places of archaeological and hydrological interest - the Marathon Dam, Cape Sounion, the Parnassos-Ghiona, and the Argos-Tripolis regions were visited.

INTRODUCTION

This report is an outline of the symposium on 'Groundwater in the Arid Zones' conducted by the International Association of Scientific Hydrology (I.A.S.H.) at Athens, Greece from the 11th to the 21st October, 1961. I attended the symposium as an observer for the Department of National Development, Bureau of Mineral Resources, Canberra.

The symposium was attended by 113 scientists and 26 countries were represented. The United States of America had the largest delegation with 25 representatives. France (19) and Greece (13) were the next best represented. Appendix I lists the participants at the symposium.

The programme for the symposium consisted of 10 working sessions during which 60 papers were presented, and 5½ days of excursions. During the symposium I attended meetings of the I.A.S.H. Council and the Standing Committee on Hydrogeological Maps.

COMMITTEE MEETINGS

During the symposium, I attended two sessions of the I.A.S.H. Council Meeting and three sessions of the Standing Committee on Hydrogeological Maps.

I.A.S.H. COUNCIL MEETING :

The agenda consisted of :-

i) U.S. proposal for an Hydrological Decade;
ii) Programme of the I.U.G.G. XIIIth General Assembly;
iii) Symposia during and prior to the I.U.G.G. Assembly;
iv) Exhibition of hydrogeological maps;
v) Resolution by the British National Committee on the future publications of the I.A.S.H. Bulletin;
vi) Relations with U.N.E.S.C.O.;
vii) Relations with W.M.O. (World Meteorological Organization);
viii) Relations with F.A.O. (Food and Agricultural Organization);
ix) Financial statement.

(i) Hydrological Decade :

It was decided to discuss this proposal at the I.U.G.G. XIIIth General Assembly, Berkeley, California in 1963, where it is anticipated that a Hydrological Decade Committee will be formed from representatives of I.A.S.H., I.U.G.G., U.N.E.S.C.O., W.M.O., and F.A.O.. I.A.S.H. will first inform all National Committees of the proposal and ask them for comment.

(ii) Programme of the I.U.G.G. XIIIth General Assembly :

Discussion took place on the role of the I.A.S.H. in the proposed I.U.G.G. symposium entitled 'The Upper Mantle of the Earth's Crust' to be held at the I.U.G.G. XIIIth General Assembly at Berkeley in 1963. The Secretary, Professor L.J. Tison, suggested that only the section on 'Recent Movements' would be of interest to the hydrologist. It was decided to send two or three selected general papers or reports prepared by I.A.S.H. to the symposium.

(iii) Symposia during and prior to the I.U.G.G. XIIIth General Assembly:

The I.A.S.H. Council decided to hold a joint symposium with W.M.O. during the I.U.G.G. General Assembly, Berkeley, on one or both of the topics -

Hydrological forecasting;

Networks for hydrological meteorology.

Also it is hoped that some members may be able to attend the pre-Assembly symposium to be held by the A.G.U. at Stanford University on the subjects of -

Humidity of soils;

Water chemistry;

Physics of Snow.

(iv) Exhibition of Hydrogeological Maps :

After the exhibition of Hydrogeological Maps at the I.U.G.G. XIIth General Assembly, Helsinki 1960, the I.A.S.H. received many requests for a repeat exhibition. To allow as many international hydrologists as possible to examine these maps, the I.A.S.H. Council decided to invite countries to apply to the Secretary for these maps to be exhibited for a short time in their own country rather than to exhibit them at the General Assembly where only a small number of hydrologists could see the maps. The cost of freight of the maps is to be charged to the country requesting the exhibit. I made tentative enquiries to Professor Tison for these maps to be exhibited in Australia in 1962 during the Annual Underground Water Conference in Adelaide. Professor Tison indicated that the map exhibition would be restricted to Europe in 1962, but that it may be possible to exhibit the maps in Australia in 1963, if a formal request was received from the Underground Water Conference of Australia.

(v) Resolution by the British National Committee on the future publications of the I.A.S.H. Bulletin.

The resolution was
'That the General Secretary of the International Association of Scientific Hydrology be informed that the Hydrology Sub-Committee of the British National Committee for Geodesy and Geophysics :

expresses its appreciation of the services rendered to the I.A.S.H. by Professor Tison and his family, not least in the field of publication;

wishes to ensure that Professor Tison and M. Gerard Tison will continue to take part in the preparation and supervision of growing international hydrological publications;

hopes that Professor Tison and the North-Holland Publishing Company (now preparing publication of an independent Journal of Hydrology) will work out a basis for collaboration so that a single international publication may be produced for the benefit of hydrologists in all countries supporting the I.A.S.H., combining the editorial strength of the I.A.S.H. with the commercial strength of the North-Holland Publishing Company, and

recommends that Professor Tison inform the various Committees of the position as regards international hydrological journals, by mail, in time for it to be discussed at the next meeting of the Council in Athens in October 1961. '

Most countries voted against any change in the present I.A.S.H. publications. Some countries, particularly the U.S.A., cited the publication of a 'Journal of Hydrology' as a healthy sign for the science of hydrology. Professor Tison received much praise for his efforts in publishing 4 Bulletins every year as well as all symposium papers prior to the symposium. It may be of interest to note the form of the Bulletin. It consists of two parts, one containing short scientific papers, and the other part containing administrative details of the I.A.S.H. The administrative part contains information of future symposia and many items of current interest to the hydrologist.

(vi) Relations with U.N.E.S.C.O. :

Notice was received from the Advisory Committee for Arid Zone U.N.E.S.C.O. that they would support the I.A.S.H. 1962 Bari Symposium on 'Continental Erosion'.

(vii) Relations with W.M.O. :

The proposed joint W.M.O. and I.A.S.H. symposium at Berkeley in 1963 and the co-operation between the two organizations in the preparation of an International Bibliography on Hydrology are mentioned in Appendix III.

(viii) Relations with F.A.O. : This was not discussed.

(ix) Financial statement : I was not present when this item was discussed.

STANDING COMMITTEE ON HYDROGEOLOGICAL MAPS :

Acting Chairman: Professor G. Maxey, U.S.A. (in place of Dr. Buchan, U.K., who was unable to attend the Athens meeting).

Secretary: G. Santing, Netherlands.

The main business of the Committee which consisted of 15 members, was to discuss the list of symbols for use on hydrogeological maps so that some symbols could be recommended to U.N.E.S.C.O. before the close of the Athens symposium. This list was compiled by the Secretary from maps requested from as many countries as possible by the I.A.S.H. after the 1960 Helsinki General Assembly. Maps were received from only three countries : Germany, U.S.A., and France. Russia also forwarded maps, but they arrived too late to be included in the printed list. Appendix V shows the list of symbols discussed at the meeting together with some of the Committee's recommendations.

The Acting Chairman stressed that the Standing Committee could not force countries to abide strictly by the symbols; he further commented that the symbols are only a guide to hydrogeologists, but it was hoped that international hydrogeologists would try to use these symbols where they were applicable to their maps.

It was decided to hold a working meeting of the Committee at the U.N.E.S.C.O. headquarters in Paris in February 1962. The I.A.S.H. will be asked to send a representative to the Paris meeting.

FUTURE HYDROLOGY SYMPOSIA

1. The I.A.S.H. will hold two symposia in 1962: the first is a symposium on 'Continental Erosion' at Bari, Italy. U.N.E.S.C.O. will provide financial assistance for this symposium. Summaries of papers are requested by the Secretariat before the 1st March, 1962, and the complete paper to be delivered before the 1st June 1962;

   the second symposium is on 'Variations of existing glaciers' to be held at Obergurgl (Tyrol) Austria, from the 10th to the 18th September 1962. Nominations to submit a paper were requested before the 30th June 1962. The Secretary (Professor L.J. Tison) of I.A.S.H. reported that already many papers have been received for the Austrian symposium.

2. The A.G.U. pre-I.U.G.G. XIIIth General Assembly Symposium at Stanford University, U.S.A., 1963.

   Subjects are : Humidity of soils;
   Water chemistry;
   Physics of snow.

3. The combined W.M.O. - I.A.S.H. Symposium to be held during the I.U.G.G. XIIIth General Assembly in Berkeley, California in 1963.

   Subjects are : Hydrological forecasting;
   Networks for hydrological meteorology.

FORMAL PAPERS

During the symposium, 10 working sessions were held in which 60 papers were presented and discussed; these papers, together with 16 others, which were not read at the symposium, were printed in two volumes totalling 746 pages by the I.A.S.H. and presented to the participants before the symposium. U.N.E.S.C.O. staff provided simultaneous English and French translations of all papers read and of discussions at the symposium.

The papers on 'Groundwater in the Arid Zones' were divided into 6 groups (arranged in order of presentation) :

General considerations - General hydrogeology : 12 papers;
Hydrology of regions : 18 papers;
Hydrodynamic tests : 18 papers;
General views on the development of ground-water resources : 11 papers;
Detailed study (recharge) : 8 papers;
Detailed study of the development of regions : 9 papers.

GENERAL CONSIDERATIONS - GENERAL HYDROGEOLOGY : 12 papers.

Four of the 12 papers presented in this section were by Frenchmen, and 3 were by Russians.

The papers presented in this section were :

1. 'REFLECTIONS ON THE CO-OPERATION OF SEVERAL DISCIPLINES TO HYDROGEOLOGICAL RESEARCH'

   by R. Ambroggi, R. Hazan, U. Margat & F. Mortier (National Office of Irrigation, Morocco.).

Some considerations on the need of co-operation were discussed, based on some 15 years experience in the U.N.O. Water Resources Service.

2. 'PRINCIPLES OF EVALUATION OF RESOURCES OF UNDERGROUND WATERS FOR WATER SUPPLY AND IRRIGATION'

by G. Bogomolov, B. Kudelin & N. Plotnikov (U.S.S.R.)

Four important points were stressed and discussed : the volume of water in an aquifer; the discharge of underground flow in its section; the replenishment of water in an aquifer (recharge), run-off (discharge) out of it, as well as fluctuations of the volume of water in it, that is, balance elements of underground waters; and, discharge which occurs when exploiting the aquifer by capitation.

3. 'GEOMORPHOLOGY AND GROUNDWATER'

by J. Tricart (Director of the Centre of Applied Geography, University, Strasbourg, France).

The author outlined a geomorphological method aimed to make more accurate the balance of subterranean waters. This method combines : (a) systematical geomorphological mapping with special emphasis on angle of slope, permeability of soils and solid rock, unconcentrated run-off, rills, gullies, etc.; (b) regional geomorphological analysis; and (c) morphometrical analysis of the hydrographic basins. This method requires specialized training.

4. 'EVALUATION OF PRESENT RECHARGE OF GROUNDWATER IN DESERTS'

by N.A. Ogilvie & V.N. Chubarov (All-Union Scientific Research Institute of Hydrogeology and Engineering Geology, U.S.S.R.).

Two main methods of evaluation of recharge of groundwater by studying its balance were outlined : the unstable hydrogen-tritium isotope balance in groundwater ; and the moisture balance and dynamics in the zone of aeration. The authors calculated that the rate of recharge in sands without vegetation was about 15 mm. per annum.

5. 'EXAMPLE OF HYDROGEOLOGICAL PROSPECTING IN MEXICO BASED ON THE GEOCHEMISTRY OF WATERS'

by E.J.P. Stretta (Expert in Hydrogeology for U.N.E.S.C.O., National University of Mexico.).

Geochemical study of water samples in the basin of San Luis Potosi in Mexico (450 km. north-north-east of Mexico City) confirmed the nature of influent seepage of the watertable situated at the southern end of the basin, which provides more than 8 cubic metres/sec. for irrigation. This study has enabled the direction of ground-water circulation to be estimated, as well as the interdependence between phreatic water and thermal water along valleys with natural drainage, as well as some mixing of calcareous layers and andesitic flows.

A coloured hydrogeological map of the San Luis Potosi area at a scale of 1:200,000 was issued to accompany this paper.

6. 'THE CIRCULATION OF GROUNDWATER IN AN AREA BUILT OF CRETACEOUS MARL EXEMPLIFIED BY THE UPPER SZRENCAVA RIVER'

by Irena Dynowska, (Poland).

This paper was not presented at the symposium. It is published in Volume 1, p. 49-54.

7. 'METHODS OF STUDY OF AQUIFERS'

by G. Castany, (Chief Engineering Geologist for the Bureau of Geological Research and Mining, France.).

8. 'ON THE PROBLEM OF REFLECTING THE UNDERGROUND WATERS RESOURCES ON HYDROGEOLOGICAL MAPS'

by F.M. Bochever, B.I. Kudelin & M.V. Churinov (U.S.S.R.).

This paper was not read at the symposium but it is published in Volume 1, p. 68-74.

U.S.S.R. hydrogeological maps are classified as either 'survey' or 'general'. The survey maps are produced at two scales, 1:500,000 for larger and at 1:100,000 for smaller ones. These maps show the general laws of distribution of underground waters of different composition within the whole area of U.S.S.R.; they show the natural and exploitation resources of underground waters. The general hydrogeological maps are compiled generally at a scale of 1:200,000. These maps distinguish the exploitation resources of underground waters which are evaluated according to the corresponding computation for each aquifer or a number of aquifers. According to the available data, the general hydrogeological maps are divided into separate districts which are characterized by certain volume of exploitation resources.

9. 'CIRCULATION OF UNDERGROUND WATER IN THE ALTERED ERUPTED ROCKS AND FISSURES'

by G. Koliopoulos & E. Mariolakos, (Geologists from the Land Reclamation Service, Ministry Of Agriculture, Greece)

10. 'GEOBOTANICAL METHODS OF GROUND-WATER STUDY'

by S.V. Viktorov, E.A. Vostokova, A.V. Shavyrina & N.G. Moskalenko, (All-Union Scientific Research Institute of Hydrogeology and Engineering Geology, U.S.S.R)

This paper was not read at the symposium. It is published in Volume 1, p. 78-80.

11. 'GENERAL METHODS OF EVALUATION OF THE UNDERGROUND WATER RESOURCES, PRINCIPALLY IN THE ARID ZONE'

by M. Gosselin (General Engineer of Rivers and Bridges, France.).

12. 'ON THE DIFFICULTY OF FORMATION OF AQUIFERS IN THE LIMESTONES OF GREECE AND THE TECTONICS OF THE LATTER AND SOME EXCEPTIONAL CASES'

by J. Frangopoulos & G. Zervoyannis (Geologists from the Land Reclamation Service, Ministry of Agriculture, Greece).

The limestones of Greece are Mesozoic and have an alpine type of tectonics. The alpine folding, as well as the Tertiary vertical movements, has determined their tectonic position on the crystalline substratum. The limestones generally have an anticlinal structure, caused by the movements which have folded and fractured them. They are exposed either as widespread beds or in large fractured masses, which are generally intersected by a network of fractured karsts. The limestones do not offer the possibility of developing aquifers because of their profound fracturing.

HYDROGEOLOGY OF REGIONS : 18 Papers.

Fifteen of the eighteen papers published in this section were read at the symposium ; 4 papers were presented by Germans and 3 by Frenchmen. The papers are :

1. 'FURTHER HYDROGEOLOGICAL INVESTIGATIONS IN CENTRAL ANATOLIA, TURKEY'

by K. Erguvanli, (Professor of Applied Geology, Technical University of Istanbul, Turkey.).

This paper outlined the results of hydrogeological investigations carried out during the summer of 1957-60 (on behalf of the State Water Department) in the Kayseri-Kirsehir arid region of Central Anatolia, Turkey.

2. 'ON THE ORIGIN OF THE SALT IN SOLUTION IN WELLS AND BOREHOLES OF NIASSA, NORTHERN MOZAMBIQUE'

by V.L. Bosazza (Bechuanaland).

This paper was not presented at the symposium. A summary of the paper is on page 97, Volume 1.

An examination of over 1300 wells and boreholes in Niassa showed that the salinities are highest and commonest near the coast. A windborn origin of the salts in solution is not favoured, but it is suggested that the geological formations and vegetation are responsible for the salts in solution.

3. 'HYDROGEOLOGY OF THE CENTRAL TUWAIQ MOUNTAINS AND ADJOINING REGIONS (SAUDI-ARABIA)'

by R. Wolfart, (Hannover).

4. 'HYDROGEOLOGY OF THE CENTRAL REGION OF ASIA MINOR'

by H.N. Pamir, (Turkey).

5. 'HYDROGEOLOGICAL OBSERVATIONS IN THE SEARCH FOR UNDERGROUND WATER IN THE WESTERN DESERT OF EGYPT, U.A.R.'

by M.K. El Ayouty & M.A. Ezzat (General Desert Development Authority, Cairo.).

This paper dealt with the artesian water of the Palaeozoic-Mesozoic Nubia Sandstone of the Western Desert of Egypt, U.A.R., which supplies water to the development programmes in the oases of Kharga and Dakhla.

6. 'THE AQUIFERS IN THE NEOGENE BEDS OF GREECE'

by G. Koliopoulos & J. Frangopoulos, (Geologists from the Land Reclamation Service, Ministry of Agriculture, Greece).

Neogene sediments occupy a large part of the country. The Neogene beds are deposited unconformably either on the Tertiary flysch formations, or on the Mesozoic limestone, or on the metamorphic rocks of the crystalline substratum of the country. The stratigraphic structure of the Neogene sediments, which range from marine to lagoonal facies, consists of a sequence of beds of grit, marl, marly limestone, marine limestone, and conglomerate. The Neogene deposits are the zones of concentration of very large quantities of water. Over a period of [illegible] years 2116 bores yielded a total discharge of 215,000,000 cubic metres of water.

7. 'HYDROGEOLOGICAL INVESTIGATIONS IN THE SOUTHERN DESERT OF ISRAEL'

by Y. Harpaz, (Water Planning for Israel Ltd, Tel-Aviv, Israel)

This paper referred to a zone averaging a precipitation of less than 100 mm. per year and with a free water surface evaporation estimated at more than 2,000 mm. per year. Groundwater is scarce, of varying degrees of salinity and usually found at great depths. Natural recharge of groundwater occurs through local stream-beds or through underground flow from remote areas. The playas constitute the principal natural discharge outlets of groundwater within this region.

8. 'THE WATERS OF THE LIAS LIMESTONES IN MOROCCO'

by F. Mortier (National Irrigation Office, Morocco.)

9. 'METHODS OF INVESTIGATING THE GROUND-WATER RESOURCES OF THE PARNASSOS-GHIONA LIMESTONES'

by D.J. Burdon & N. Papakis, (United Nations Special Fund Project for the investigation of the groundwater resources of karstic limestone; Institute for Geology and Subsurface Research, Athens, Greece).

(The Parnassos-Ghiona area was visited during the 3-day excursion after the symposium - see Figure 2.)

Standard methods were used for the investigation of ground-water resources of the 1774 square kilometers forming the Parnassos-Ghiona limestone region. Boundaries were chosen so as to eliminate or minimise subsurface ground-water underflow in or out of the region beneath the terrestrial boundaries.

The area is covered by good topographical and geological maps on the 1:50,000 scale. A base map was prepared, showing the 88 drainage basins into which the 1774 square kilometers can be subdivided ; there are 32 basins of open drainage and 56 closed karstic basins, totalling an area of 214 square kilometers. A new precipitation map was prepared for the region and a coefficient of infiltration determined for a new precipitation map. A balance between water income and out-going was established; calculated annual infiltration greatly exceeds discharge from the known terrestrial, coastal, and submarine springs. Hydrolithological maps showing aquifers and aquicludes were prepared from existing geological maps. The effect of tectonics and structure on the direction of ground-water movement was studied. Hydrochemical studies were carried out on the ground-water in the aquifers. Electrical resistivity surveys were used to locate drilling sites for exploitable groundwater.

10. 'A COMPARISON BETWEEN SOME HYDROLOGICAL OBSERVATIONS MADE IN THE JURASSIC AND CENOMANIAN LIMESTONE MOUNTAINS, SITUATED TO THE WEST AND TO THE EAST OF GHAB BRABEN, (U.A.R., SYRIA)'

by C. Voute, (Netherlands).

From a detailed study of altitude, flow characteristics, temperature, and chemistry of many springs along the margins of the Ghab Graben, it was shown that the fractured Cenomanian limestones along the east side of the graben act more or less as a single underground reservoir, with a major recharge area situated to the south-east and a secondary area to the north-east of the springs. Along the west side, the water circulation is restricted to shallow and small isolated reservoir areas in fractured and karstic Jurassic limestones.

After this paper, some time was spent in discussing many aspects of hydrology and geomorphology in limestone and dolomite regions.

11. 'EVALUATION OF THE RESOURCES OF UNDERGROUND WATER IN ARID ZONES - THE PHREATIC WATER TABLE OF PRE-SAHARIEN MOROCCO'

by J. Margat (Engineering Geologist for the Water Resources Service, National Office of Irrigation, Morocco).

The evaluation of ground-water resources consists of determining the water balance of a given water table and an estimation of the possibilities of modifying its elements without turning the natural water balance. In arid zones it is important to evaluate evapo-transpiration.

The two areas studied were the phreatic water table of Tafilalt, principally fed by infiltration of surface water naturally (floods) or artificially (irrigation waters) brought, and mainly discharged by evapo-transpiration ; and the water table of Ferkla, mainly fed by a continuous supply from upstream.

12. 'VARIATIONS IN WATER LEVEL AND SALINITY IN THE CLARENDON PLAINS, JAMAICA, W.I.'

by H.R. Versey (Great Britain).

The discharge from one of the springs varies directly with the elevation of the water table nearby and inversely with the concentration of dissolved solids and the radiation intensity. The ionic ratios are comparable to those of sea water although the spring rises to 4 feet above sea level. The salinity of the well water varies generally with the water table elevation, serious pollution occurring when the pumping level is still above sea level. There is a close relationship between the water level fluctuations in the affected wells and in other wells throughout the plain. Thus, if over-pumping is occurring, it is a regional rather than a local feature.

13. 'GROUND-WATER CONDITIONS IN THE CHACO BOREAL OF PARAGUAY'

by F. Bender and H. Flathe (Hannover).

The decisive regulating factors for the ground-water balance were determined from the analyses of 200 water and soil samples, and drillings, and a geoelectrical survey (160 resistivity readings by the four-point method), which provided indications about hydrogeological conditions down to 200 metres depth by utilizing the different electrical conductivities of the underground layers.

14. 'CONSIDERABLE CONCENTRATIONS OF UNDERGROUND WATER IN FISSURED MARLS'

by J. Frangopoulos, (Geologist from the Land Reclamation Service, Ministry of Agriculture, Greece.).

This paper was not read at the symposium.
It is published in Volume 1, 186-188.

15. 'HYDROGEOLOGY OF NORTHERN JORDAN'

by R. Wolfart, (Hannover.)

This paper was not read at the symposium.
It is published in Volume 1, 189-199.

16. 'SOME RESULTS OF GROUND-WATER INVESTIGATIONS IN THE REPUBLIC OF SUDAN'

by G. Gubert, H. Kleinsorge, K. Kreysing & H. Venszlaff, (Hannover).

This paper was not read at the symposium.
It is published in Volume 1, 201-213.

17. 'STATUS OF HYDROGEOLOGICAL INVESTIGATIONS IN THE NEW VALLEY PROJECT, WESTERN DESERT, EGYPTIAN REGION, UNITED ARAB REPUBLIC'

by H.A. Waite (United States Overseas Mission, Cairo, Egypt, U.A.R.) & H. Idris (General Desert Development Authority, Cairo, Egypt, U.A.R.)

The New Valley Project of some 90,000 square kilometers is the largest of five principal ground-water development projects planned for the Egyptian region. Lands in the oases depressions in the Western Desert are being reclaimed and developed by utilizing artesian water. Hydrogeological investigations began in January 1960 to determine the development potential of the Nubian Series of alternating clays, shales and sandstones. The sandstones are the principal aquifer underlying the Western Desert.

Investigations currently in progress consist of : geological mapping; subsurface geological studies; gravimetric surveys; exploratory test drilling and production drilling of pilot development wells; analysis of drill cuttings, cores, electric logs, and drill-stem tests; aerial photography and airborne magnetometer surveys; periodic measurements of discharge and artesian pressures in representative wells; tests to determine aquifer characteristics; studies of chemical quality and of well-corrosion problems; detailed soils-classification studies; and agricultural pilot-development studies to explore the adaptability of soils to different methods of irrigation.

18. 'ESTIMATION OF THE VALUE OF THE CIRCULATING DISCHARGE IN THE CONTINENTAL INTERCALAIRE IN THE SAHARA, SOUTH ALGERIA'

by A. Cornet & P.L. Rognon, (France).

<u>HYDRODYNAMIC TESTS</u> : 18 Papers.

Fourteen out of the 18 papers published in Volume 1 were read at the symposium. French delegates were the main contributors to this section, presenting 4 papers. The papers published are :

1. 'CHARACTERISTICS OF DISCHARGE OF AQUIFER FORMATIONS'

by A. Wieczysty (Poland).

This paper was not read at the symposium.
It is published on pages 243-253 of Volume 1.

2. 'THE DISTRIBUTION OF GROUNDWATER BENEATH ARTIFICIAL RECHARGE AREAS'

by D.K. Todd (Associate Professor of Civil Engineering, University of California, Berkley.).

The unsteady flow of groundwater beneath surface spreading areas having uniform recharge rates is governed by subsurface boundary conditions. Where lateral boundaries exist, flow approaches a steady state, but where vertical boundaries govern, the flow may never approach equilibrium. Only the simplest situations are subject to analytic solution; whereas laboratory models can reveal flow patterns for complex conditions.

3. 'RECHARGE OF GROUNDWATER BY RIVER WATER'

by M. Boreli (University of Belgrade, Yugoslavia), M. Vukovic (Water Institute, Belgrade), and M. Milojevic (University of Belgrade, Yugoslavia).

This paper dealt with the recharge of groundwater by the flow from a river and the characteristics of the contact zone between the river and the intake. It showed the possibility of utilizing the existing well data as well as piezometric head data for determining a flow net near the river, and particularly at the contact of the river and the aquifer. The conditions of settling and scouring of the transported bed material on the river/aquifer contact were discussed.

4. 'ON THE RECHARGE OF ARTESIAN AQUIFERS AS A RESULT OF WATER RELEASE FROM CLAY LAYERS'

by V.D. Babuschkin, S.P. Prokhorov, & A.A. Saar (All-Union Scientific Research Institute of Hydrology and Engineering Geology, U.S.S.R.)

During pumping from deep-lying aquifers, cones of depression are usually characterised by by much more development than during pumping from comparatively shallow artesian aquifers under the same conditions. This is explained by water leakage through clay-layers from adjacent aquifers.

5. 'THE GENETIC DEPENDENCE BETWEEN DEEP WATER AND SURFACE WATER'

by Z. Kajetanowicz (Poland).

This paper was not read at the symposium. It appears on pages 281-291 of Volume 1.

6. 'FORECAST OF WATER TABLE FLUCTUATIONS IN A COASTAL AQUIFER BY THE HELE-SHAW MODEL'

by Y. Kahana and J. Bear (Israel).

The model simulated natural and artificial replenishment and water table fluctuations. By using two liquids with different densities and velocities, the problem of sea-water intrusion including the shape and position of the interface and its relationship with the rate of flow of fresh water into the sea and with the fresh water elevations near the coast were investigated.

7. 'SEMI-EMPIRICAL ESTABLISHMENT OF THE COEFFICIENT OF FILTRATION AND OF PUMPING TIME IN QUATERNARY FORMATIONS'

by W. Kollis, (Poland).

8. 'FORECASTING OF THE FLUCTUATIONS OF THE PIEZOMETRIC SURFACE OF A PHREATIC WATER TABLE IN THE ARID ZONE; THE TAFILALT PLAIN (PRE-SAHARIEN MOROCCO)

by R. Hazan & J. Margat, (National Irrigation Office, Water Resources Service, Morocco).

This water table is mainly fed by infiltration of irrigation and flood waters and it is out of balance; pluri-annual and long lowering movements of the piezometric surfaces could occur during a series of drought years. The hydrodynamical study of the discharge curves allows, by extrapolating the theoretical exponential curves approaching them, to compute the evaluation of the water table if any recharge takes place.

9. 'DETERMINATION OF SAFE YIELD IN A COASTAL AQUIFER'
by Y. Kahana & J. Bear, (Israel).

Water table elevations were used to determine the regional safe yield.

10. 'HYDRODYNAMIC STUDY OF THE INTERACTION OF TWO WELLS IN THE CASE OF SIMULTANEOUS INJECTION'
by R. Hazan & G. Chapond, (Morocco).

11. 'ECONOMICAL SPACING OF INTERFERING WELLS'
by M.S. Hantush (Senior Hydrologist and Professor of Hydrology, New Mexico Institute of Mining & Technology, Socorro, New Mexico, U.S.A.)

This paper was not read at the symposium. It is printed on pages 350-364, Volume 1.

The formulae for drawdown around wells draining aquifers of infinite areal extent are used in conjunction with economic considerations to obtain expressions for computing the most economical spacing between interfering wells.

12. 'INTERFERENCE OF RADIAL COLLECTOR WELLS ADJACENT TO THE RIVER BANK' by M. Milojevic (Assistant at the Civil Engineering Faculty, University of Belgrade, Yugoslavia).

13. 'RELATION BETWEEN DISCHARGE AND HYDRODYNAMIC CONDITIONS IN THE VICINITY OF THE WELL'
by G. Öllös & K. Ubell, (Hungary).

The authors discussed hydraulic phenomena occurring in the immediate vicinity of the well-mantle, and the applications of pumping tests results.

14. 'GEOPHYSICAL METHODS AND THE SEARCH FOR UNDERGROUND WATER'
by J.J. Breusse, (France).

The advantages and disadvantages of the different geophysical methods in the search for underground water were discussed ; in the arid zones of Africa, the electrical method was the best geophysical method for the search for underground water.

15. 'SOME INTERESTING GEO-HYDROLOGICAL STUDIES ON A TEST WELL AT DEODAR, BANASKANTHA DISTRICT, NORTH GUJARAT'
by B.K. Baweja, (Geological Survey of India).

This paper was not presented at the symposium. It is contained in Volume 1, pages 404-412.

16. 'THE PROBLEMS OF FILTRATION COMPUTATIONS OF PERFECT AND IMPERFECT WELLS' by V.M. Shestakov, (U.S.S.R.)

The paper described methods and computational relationships for defining the yield of imperfect and perfect wells.

17. 'VERIFICATIONS FOR THE SEARCH FOR UNDERGROUND WATER AND .... OF SOME DIVERSE SYSTEMS OF DRILLING.

by L. Zori, (Italy).

18. 'HYDRODYNAMICAL STUDY OF RATIONAL TYPES OF WATER CATCHMENT AND RESEARCHES ON THE MEANS OF INCREASING THE PERIOD OF EXPLOITATION'

by R. Hazan, (Morocco).

The equation determining the effects resulting from pumping an underground water sheet was considered. Precisions were given as the application of this relation to the level of mining operations. Some conclusions and remarks from this study made it possible to work out 'rational' drilling in the proper sense of the word. Some advice was given for carrying them out and prolonging the period of exploitation, still by means of a hydrodynamic study of the water catchment.

GENERAL VIEWS ON THE DEVELOPMENT OF GROUND-WATER RESOURCES : 11 Papers

Eight out of the 11 papers published in this section in Volume II of the Symposium were read at Athens. Five of these papers were prepared by Americans. During this session two recent publications on ground water development were brought to the notice of the participants ; the publications are :

(i) 'Manual for Groundwater Development'. American Society of Civil Engineers, Number 40, March, 1961.

(ii) 'Large scale development of ground water'. United Nations Water Centre, August, 1961.

The papers presented in this section were :

1. 'PLANNING FOR GROUND-WATER DEVELOPMENT'

by R.O. Thomas (Engineer, United States Technical Cooperation Mission to India.).

The discussion was divided with respect to basins in a natural (virgin) condition; in a condition of partial development (beneficial use equal to natural recharge); and, fully developed basins, where the natural supply was augmented by artificial recharge and conjunctive operation with surface water supply development.

2. 'THE RELATIONS BETWEEN THE SUPERFICIAL WATER AND THE UNDERGROUND WATER'

by J. Tixeront, M. Chaumont, & H. Zebidi, (France).

3. 'THE HUMBOLDT RIVER RESEARCH PROJECT, NEVADA'

by G.B. Maxey, (Professor of Geology, University of Illinois, and Head of Section of Ground-Water Geology, Illinois State Geological Survey) & H.A. Shamberger, (Director, Dept of Conservation and Natural Resources, Nevada).

Since it was not possible to study adequately the whole Basin at once, a reach of the River believed to be a well-defined hydrologic province was selected to begin investigations. The primary aims in this initial phase of the project include :

(i) Development of methods and procedures for evaluating the magnitude of the components of the hydrologic cycle in a semi-arid basin.

(ii) Determination of geologic and geomorphic controls on water resources of the Basin, especially those related to movement, storage, and availability of water.

(iii) Determination of consumptive use of water by crops, native useful vegetation, and non-beneficial vegetation.

(iv) Determination of the amount of water presently non-beneficially used by phreatophytes or otherwise being wasted that can be salvaged. Also devising and testing methods for the replacement of non-beneficial plants with beneficial ones.

(v) Evaluation of the economics of modifying present farm practices or other water use in the Basin to increase the values of crops and products and thus the efficiency of water use.

The project has been in operation for two years and it involves the co-operation of two State agencies, two Universities, and six Federal agencies.

4. 'HYDROGEOLOGICAL COMPUTATIONS OF EXPLOITATION RESOURCES OF UNDERGROUND WATERS FOR LARGE WATER SUPPLY'
by F.M. Bochever (All-Union Scientific Research Institute, "Vodgeo", Moscow.).

5. 'DEVELOPMENT OF AN INDUSTRIAL GROUND-WATER SUPPLY IN SOUTHERN TURKEY'
by J.B. Graham, (Leggette, Brashears & Graham, New York, U.S.A.)

Ground-water investigations for a new oil refinery requiring 1500 gallons per minute consisted of preliminary geologic reconnaissance, inventory of existing wells, drilling of eight test borings, one of which penetrated 600 feet and the others 150 feet, construction of two test production wells and eight observation wells, pumping tests during both wet and dry seasons, and the location and design of four final production wells. Gravel-packed wells with 12-inch stainless steel screens will produce more than 500 gallons per minute without danger of salt-water contamination from the nearby shore.

6. 'NOTE ABOUT THE UNDERGROUND WATER RESOURCES IN TUNISIA'
by A.Bonnier, M.Bouzid, & O.W. Tscholtzoff, (Tunisia).

Methods used for evaluation of the hydrologic balance of underground formations are presented with examples concerning dune, sand, and limestone formations.

7. 'LABORATORY TESTS ON TEST DRILLING SAMPLES FROM RECHNA DOAB, WEST PAKISTAN, AND THEIR APPLICATION TO WATER RESOURCES EVALUATION STUDIES' by A.H. Kazmi, (Senior Geologist, Water Resources and Engineering Geology Branch, Geological Survey of Pakistan.)

Test hole samples down to depths of 600 feet were tested in the laboratory for grainsize distribution, porosity, permeability, and moisture equivalent. Interpretation of the laboratory data helped to zone the subsurface alluvium into the coarser and more permeable stream bed and meander belt deposits and the finer and less permeable flood plain deposits. This has resulted in the location of buried ground-water channels. Using the laboratory data coefficients of permeability, transmissibility, and storage were computed for the aquifer at each test hole. Based on these hydraulic properties the aquifer was zoned and these zones were mapped.

8. 'WAYS OF INCREASE OF EXPLOITATION UNDERGROUND WATER RESOURCES (SUPPLIES)'
by Professor Plotnikov, (Moscow Geologic Prospecting Institute, U.S.S.R.)

The increase of exploitation underground water resources is accomplished by :

(i) a good choice of water collecting areas with the best filtering properties and the decrease of resistances of underground water in the wells ;
(ii) the increase of the regulating capacity of the aquifer ;
(iii) the better feeding of the aquifer ;
(iv) the increase of the lowering of the water level in exploitation and shortening the distance between the water-collecting and feeding areas of underground water ;
(v) the decrease of the expenditure part of underground water balance (transpiration of plants, evaporation from the soil, etc.) ;
(vi) a good choice of the water lifting pump including rationalization of the self-flow.

9. 'WAYS TO INCREASE EFFICIENCY OF EXPLORATION WELLS'
by F. Noring, (Germany.).

Collect data concerning ground-water levels and chemistry, also of precipitation and runoff, before beginning to drill. Relate all data to sea level or another uniform base.

Renounce stiff drilling programmes. Settle each new borehole after fully using the results of the preceding exploration well.

Examine the principal composition of water samples.

In unknown regions, first, recognise the different strata and aquifers, second, examine the aquifers of great promise by pumping tests; finally, build production wells.

10. 'GROUNDWATER IN THE ARID AND SEMI-ARID ZONE; ITS SOURCE, DEVELOPMENT, AND MANAGEMENT'
by C.S. Conover, (Assistant Chief, Groundwater Branch, United States Geological Survey).

Groundwater in arid and semi-arid areas is governed by the same geologic and hydrologic controls as in humid areas. For recharge the frequency and intensity of wet years is more significant than the frequency and length of periods of drought.

Successful long-term development and management of ground water in water-deficient arid and semi-arid areas must recognise and be tailored to two main situations :

in areas where the volume of groundwater in storage is large and the recharge meagre, groundwater must be mined;

in stream valleys where the ground and surface waters are intimately related, the two must be utilized as a unit water resource on a perennial basis.

11. 'MAN-MADE CHANGES IN THE WATER RESOURCES OF TRIPOLITANIA, LIBYA'

by C. Vita-Finzi, (University of Cambridge) & R.C. Vorkis, (U.S. Geological Survey, Atlanta, Georgia, U.S.A.).

DETAILED STUDY (RECHARGE) : 8 Papers

Seven out of the 8 papers published in Volume II were read at the symposium. The papers published are :

1. 'GAMMA-METHOD FOR OBSERVING OF DYNAMICS OF MOISTURE PERCOLATING IN SOILS AND CONSIDERED IN EVALUATING OF GROUND-WATER RESOURCES'

   by V.I. Ferransky and F.S. Zavelsky, (All-Union Scientific Research of Hydrology and Engineering Geology, U.S.S.R.).

This method is based upon gamma ray absorption by soils. It is considered that the dry density of the soil down the zone of heaving is unchangeable and the degree of gamma attenuation changes as a result of change in moisture content. Measurements up to a depth of 20 metres have been made.

2. 'AQUIFERS OF BERRECHID AND CHARF EL AKAB. FEEDING MECHANISM AND EVALUATION OF UNDERGROUND WATER RESOURCES. ARTIFICIAL RECHARGE.' by R. Hazan, (Morocco).

3. 'ON THE MECHANISM OF THE REPLENISHMENT OF AQUIFERS IN THE NEGEV (THE ARID REGION OF ISRAEL) - A PROGRESS REPORT'

   by M.J. Goldschmidt, (Israel).

The normal pattern of run off in arid regions with other than highly permeable soil is conditioned by the scarcity of precipitation. Soil moisture above air dryness occurs only in the few top decimetres, and only after precipitation. Below this narrow belt, concentration of underground water by gravity and accretion directly through precipitation does not occur - except at places where water happens to accumulate on the surface and downward movement is thus temporarily possible. When non-sandy soil is saturated and rain continues with an intensity exceeding downward percolation, overland flow starts. Replenishment through flood water is generally fresh, that caused by temporary accumulation in depressions may be brackish or saline.

4. 'IMPORTANCE OF LATERAL RECHARGE FOR PHREATIC WATER-TABLES IN ARID ZONES' by F. Mortier, (Morocco).

From computing the water-balance surplus in arid and semi-arid zones, the impossibility or at least interannual irregularity of slimy plains rainwater infiltrations seems obvious. So a permanent phreatic underground reserve would be impossible, without its recharge from water tables formed in more humid zones and in areas where lithology allows a rapid infiltration.

5. 'AN ANALYSIS OF RESERVOIR CAPACITY REQUIREMENTS FOR CONJUNCTIVE USE OF SURFACE AND GROUND-WATER STORAGE'

   by N. Burns and W.A. Hall, (Department of Engineering, University of California, U.S.A.).

Maximum development of water resources requires conjunctive utilization of surface- and groundwater reservoirs. To do so, one has to determine the amount of surface storage to be provided, and to establish a pattern for allocating the available water to surface and to groundwater storage.

The operational problem is considered first, and the allocation to each of the two kinds of storage is attempted. The allocation problem is shown to result in an 'all or nothing' proposition, i.e., all available water should be stored in surface storage or in the aquifer, depending on the state of the system. The surface storage capacity is determined by optimizing the total net benefit over the reasonable economic life of the project, using a proper discount rate for selected surface storage capacities in a logical range. A mathematical model is set up, solvable by the use of high speed digital computers, so that particular situations may be solved for the optimal reservoir capacity.

6. 'DEVELOPMENT OF A KARST LIMESTONE SPRING IN GREECE'
by G. Aronis, D. Burdon & K. Zeris, (Greece).

It is planned to regulate the flow of a group of springs in the Parnassos region by pumping during the irrigation season to such an extent, that the underground reservoirs in the limestone would be so depleted that the earlier portion of the winter infiltration would be stored underground and free flow from the spring would not recommence until the middle of winter.

7. 'GROUND-WATER RECHARGE BY DIRECT INFILTRATION OF RAINFALL'.
by K. Ubell (Candidate of Technical Sciences, Research Institute for Water Resources, Budapest, Hungary).

This paper contains data observed during 10 years on two experimental areas - one a karst-land, the other a sand-ridge. The conclusions are : (i) annual quantity of groundwater recharge and monthly distribution thereof under different circumstances; (ii) in case of infiltration through fissured rocks a perennial recharge of more considerable quantity appears, than in granular sediments; (iii) in this latter case evaporation of ground water is significant owing to the effect of fluctuations in soil temperature, whereby periodical replenishment will be exhausted; (iv) according to the observation data, in granular sediments a more considerable perennial groundwater recharge comes into being, when the annual sum of precipitation is greater than 77-80 percent of the value Eo computed by the formula of Penman.

8. 'GROUND-WATER DILEMMA AT TEBOULBA, TUNISIA'
by H.E. Thomas and L.C. Butcher, (U.S.A.).

Teboulba's dilemma is that the current rate of pumping from wells is depleting the subterranean reservoir; but the water thus being withdrawn from storage is of better quality than some of the water that replenishes the reservoir, so that even if the rate of withdrawal is reduced, the quality of water in some wells may deteriorate.

DETAILED STUDY OF THE DEVELOPMENT OF REGIONS : 9 Papers.

Eight out of the nine papers published in Volume II in this section were presented at the symposium. Four of the papers were submitted by Greek hydrologists and three papers were submitted by U.S.A. hydrologists.

1. 'THE EXPLORATION AND DEVELOPMENT OF GROUND-WATER RESOURCES IN IRAN' by W.H. Bierschenck & G.R. Wilson (Consulting Engineers).

An engineering approach to the exploration and development of groundwater resources has proved successful in Iran. Geohydrological reconnaissances followed by engineered well construction and development, and by controlled pumping tests at 17 sites have led to the completion of 40 production wells with an average yield of 400 g.p.m.

Evaluation and publication of data obtained during the drilling, sampling, screening, developing, and testing of some of these wells is a major contribution to the science of ground-water hydrology, since most of the available quantitative studies are limited by a variety of unknown quantities that usually defy adequate determination.

2. 'RECONNAISSANCE METHODS OF LOCATING STOCK WELLS IN ARID REGIONS OF THE UNITED STATES' by H.V. Peterson (U.S. Geological Survey).

Because the yield of most stock wells need not exceed 5-10 g.p.m. (gallons per minute) a variety of aquifers that would be unsatisfactory for larger wells will qualify as a source for stock wells. These include alluvium of varying texture, moderately permeable consolidated rock, and some dense rocks made sufficiently permeable by joints and fractures. In evaluating the potential of any prospective aquifer geologists examine wells in the vicinity to obtain information on the aquifer and the level of the water table. Features such as seeps, springs, streams, and phreatophyte growths are investigated since they are important indicators of ground-water occurrence and movement and may show the approximate position of the water table.

3. 'OESTROGENE ACTION OF ORGANIC SUBSTANCES FROM THE MUD OF SOME THERMAL SPRINGS OF GREECE' by N. Louros, B. Terzis, M. Pavlaton & A. Evangelopoulos (Greece).

4. 'PLANNED EXPLOITATION OF THE AQUIFER FEEDING THE NA'AMAN SPRING' by S. Mandel & F. Mero (Water Planning for Israel Ltd., Tel Aviv).

The average yield of the Na'aman spring in Northern Israel near Haifa, was 43 mcm/year of water with a salinity of 650-700 p.p.m. Cl ion. The aquifer feeding the spring consists of limestone and dolomite and is exploited by wells which now yield an average annual supply of 25 mcm/year of fresh water. As a consequence yield of the spring has been sharply reduced. Salinity is observed by frequent analyses and with the aid of an observation well. Yearly water balances of the aquifer are calculated from the decay characteristics of spring discharge and water levels, corrected for the dynamic influence of pumpage. Forecasts of the spring yield can be worked out on a yearly and monthly basis.

It is intended to divert the maximum safe yield of fresh water from the aquifer by pumping in wells and use the residual saline flow of the spring for industrial purposes and fish ponds.

5. 'RELATION BETWEEN THE CHEMICAL COMPOSITION OF HOT MINERAL SPRINGS IN GREECE AND THE GEOLOGICAL CONSTITUTION OF THE COUNTRY' by Dr. M. Pertessis (ex-Chief of the Geochemical Section of the Geological Service of Greece).

6. 'TECHNIQUES OF GROUND-WATER DEVELOPMENT IN THE NAVAJO COUNTRY: ARIZONA, NEW MEXICO AND UTAH, U.S.A.' by J.W. Harshbarger (Professor of Geology, College of Mines, University of Arizona).

The Navajo country, a high (5,500 feet) tableland, has a cool climate and arid environment - the region is 50 percent desert. The streamflow is small and intermittent, as much precipitation is lost to evapotranspiration. Early ground-water development by shallow alluvial wells was subject to failure in drought periods. Techniques to determine the occurrence of groundwater included : (i) differentiation of the sedimentary rocks and mapping their lateral and vertical distribution; (ii) measurement of water levels, saturated thickness, well yield, and quality of water; (iii) correlation of data from flat-wells with regional studies.

7. 'HYDROCHEMISTRY OF THE PARNASSOS-GHIONA AQUIFERS AND PROBLEMS OF SEA-WATER CONTAMINATION IN GREECE' by D.J. Burdon (United Nations Special Fund Manager of the Project for the Investigation of the Ground-water Resources of Karstic Limestone) & A. Dounas (Assistant Hydrogeologist, Institute for Geology and Sub-surface Research, Athens).

The average chemical composition of the different waters from the limestone-dolomite, the flysch, the alluvium, the talus, the conglomerate, and shaley limestone aquifers of the Parnassos-Ghiona region have been determined by the analysis of 119 samples. (This region was visited during an excursion after the working session of the symposium.) Waters contaminated with sea-water have been separated and the 16 types, sub-types, and average waters have been plotted on the Durov diagram.

Mg exceeds Ca in waters from dolomites or magnesium limestones which have come in contact with flysch rich in serpentine pebbles. High magnesium is found in other dolomites and limestones, some due to contact with serpentine pebbles. However, most of the limestone-dolomite waters show normal low magnesium and high calcium. No correlation was established between Ca:Mg ratios and the porosity of the aquifers.

Nineteen sea-contaminated limestone waters examined contained from 10% to 95% sea-water. An original composition was calculated for the postulated groundwater ; it was found that a groundwater of such a composition could not exist in the Parnassos-Ghiona lithological facies. The mixed sea-water/groundwater shows strong increases in its content of (Na+K) and SO_4; the causes of these changes are still unknown. Mg decreases, while Ca and HCO_3 increase; in part, this may be due to base exchange. As the percentage of sea-water in the mixed water increases, so also does the amount of the excess sulphate anion.

8. 'THE NATURAL DENTAL FLUORINE OF WATER OBSERVED AMONGST THE PEOPLE AND DOMESTIC ANIMALS OF THE LAURIUM REGION: ITS EFFECT ON DENTAL DECAY'
by J. Caminopetros & M. Pertessis (Greece).

9. 'A SYMPOSIUM ON THE HISTORY OF DEVELOPMENT OF WATER SUPPLY IN AN ARID AREA IN SOUTH-WESTERN UNITED STATES SALT-RIVER VALLEY, ARIZONA'
by H.E. Skibitzke, R.R. Bonnett, J.A. da Costa, D.D. Lewis and T. Maddock, Jr. (U.S. Geological Survey, U.S.A.).

This paper was preceded by an hour-long movie film illustrating the project.

The first section of the paper was a historical review of the activities of man in the area, with particular reference to water-supply development. The second section, which covered the early period of modern water-supply development in the area, was concerned primarily with the surface-water resources and the construction of the large irrigation systems. The third section dealt with an intermediate period of water-supply development during which the interrelationships between the surface- and ground-water systems became apparent. The fourth section, considered to cover the modern period (1940-1961), described the significant controlling factors involved in the extensive development of ground-water resources. The final section summarized the history of water development and described the principal hydrologic problems involved in the management of water resources in the area.

EXCURSIONS

During the symposium one half-day, two one-day, and one three-day excursions were organized. The main emphasis was on archaeology, and little time was spent on hydrology, except at the Marathon Dam and in the Delphi region. ~~Plate~~ Figure 1 shows the places visited during the excursions. The excursions were :

1. To Marathon Dam and Khalkis - Saturday 14th October.

The Marathon Dam was visited and the tides of Euripe and Khalkis were examined.

The Marathon Dam (Figures 6 and 7) is situated about 20 miles north-east of Athens and it is the main water reservoir for the city. It is a concrete gravity dam, the walls of which are faced with Pentelic marble. The crest of the dam wall is 15 feet wide and 935 feet long. The base is 158 feet wide and the height from top to base is 177 feet.

A water-tight curtain wall was built to a depth of 200 feet below the ground by grouting. The catchment of the dam is 46 square miles in area; and the capacity of the dam is 33,250 acre feet or 10.9 billion gallons. Its maximum depth is 163 feet.

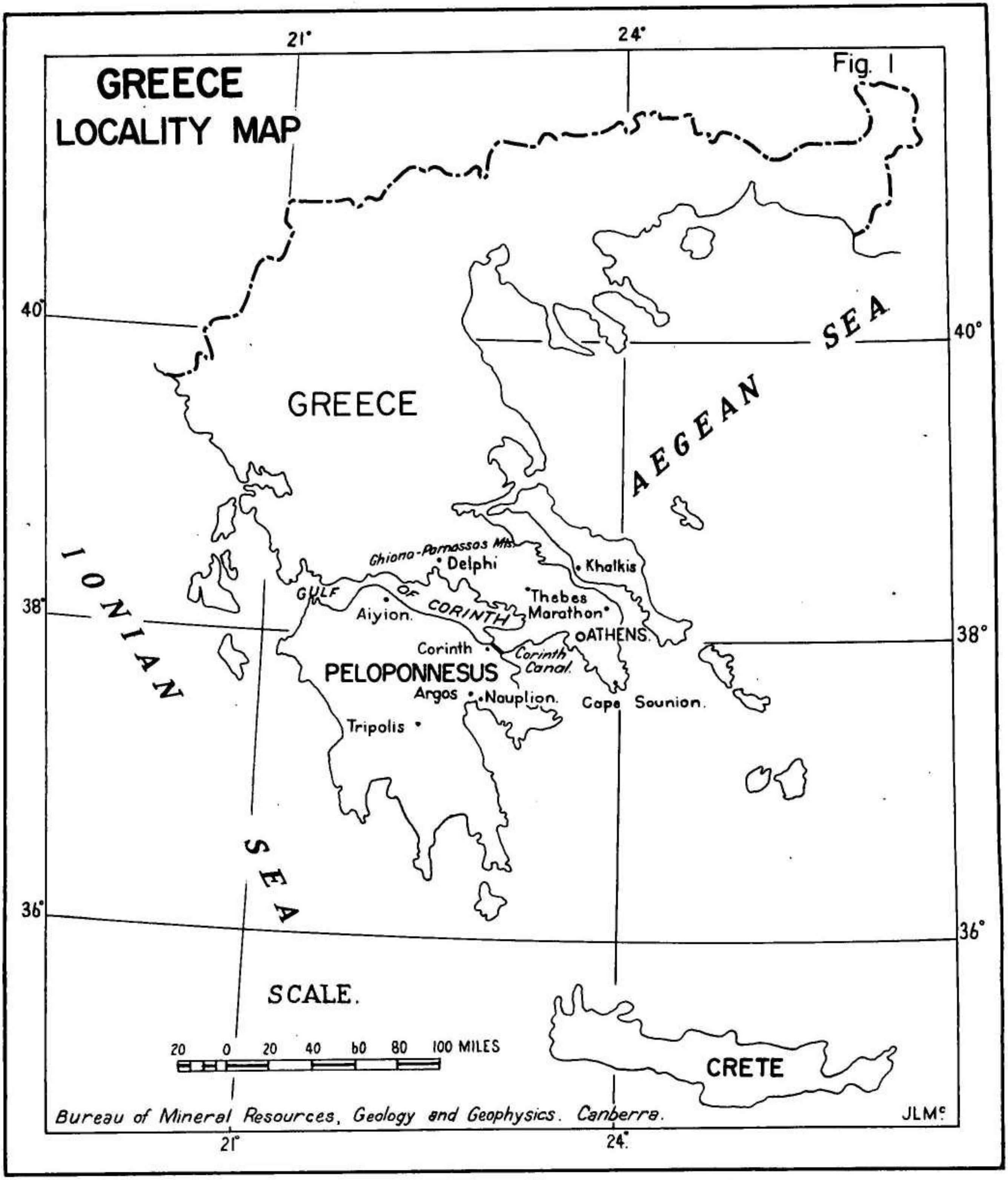


Fig. 1
GREECE
LOCALITY MAP
21°
24°
40°
38°
36°
GREECE
AEGEAN SEA
IONIAN SEA
Chiona-Parnassos Mts.
Delphi
Khalkis
GULF OF CORINTH
Aiyion.
Thebes
Marathon
ATHENS.
Corinth
Corinth Canal.
PELOPONNESUS
Argos
Nauplion.
Cape Sounion.
Tripolis
SCALE.
20 0 20 40 60 80 100 MILES
CRETE
Bureau of Mineral Resources, Geology and Geophysics. Canberra.
JLMc

2. To Cape Sounion - Sunday 15th October.

This excursion was mainly to places of archaeological and historical interest.

3. Visit to Athens (Acropole and National Museum) - Tuesday morning 17th October.

This excursion was to places of archaeological and historical interest.

4. To Delphi - Mt. Ghiona region; Corinth, Argos, Nauplia, and Mycenae, all on the Peloponnesus Island. (Figs 2,3,4, & 5).

Two reports prepared by the Institute for Geology and Sub-surface Research, Athens, were issued to the participants of this three-day excursion; these were :

(i) 'Prospecting for karst groundwater in the limestones of the Amphissa-Itea region'.

(ii) 'Research into the hydrogeology of the limestones of the Argos-Tripolis region'.

Both these reports are held in the library of the Geological Branch, Bureau of Mineral Resources, Canberra.

The ground-water investigations on the limestones of the Parnassos-Ghiona region, an area of 1775 square kilometres, are part of a project which is being carried out in Greece with the assistance of the United Nations 'to determine, test, and demonstrate methods for the successful and efficient development of ground-water resources in limestone terrain'. The project, which is a joint undertaking between the Special Fund of the United Nations (with F.A.O. acting as the executing agency) and the Government of Greece (with the Institute for Geology and Sub-surface Research nominated as the co-operating Government Agency) was set up to establish the most suitable methods of investigating problems of karst groundwater and to determine the best way they can be developed and utilized. The project began in April, 1960; the main hydrogeological investigations have been completed in the Parnassos-Ghiona area and the project has passed on to the drilling stage in June, 1961. The project in the Argos-Tripolis region is still in the research stage with hydrogeological mapping being carried out.

Figure 2. The south-eastern part of the Parnassos-Ghiona region as viewed from the south. Itea township is on coastline. Mesozoic limestones and dolomites of Parnassos Mountains in the background; Tertiary flysch in foothills; and Quaternary sediments in plains.

Figure 3. The south-western part of the Amphissa-Itea region showing the coastline 5 miles south of Figure 2. Note thrust contact of Mesozoic limestone (light-coloured on top of range) and Tertiary flysch (dark on foothills).

Figure 4. The northern part of the Argos-Tripolis region as viewed looking south-west from the ruins of Mycenae temple. Cultivation (grapes) on Quaternary sediments in the plains; high ranges of Mesozoic limestone and dolomite in background with foothills of Tertiary flysch.

Figure 5. The Corinth Canal cut in faulted Quaternary sediments. The canal links the Aegean and Ionian Seas; it is 4 miles long and depth to water surface in foreground is about 400 feet.

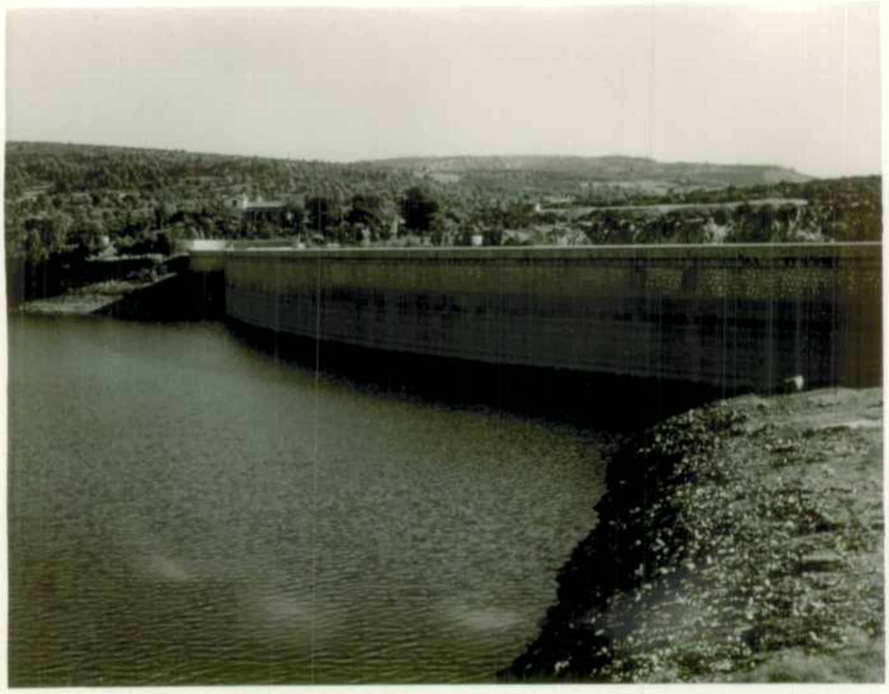


Figure 6. The Marathon Dam - the main water reservoir of Athens.

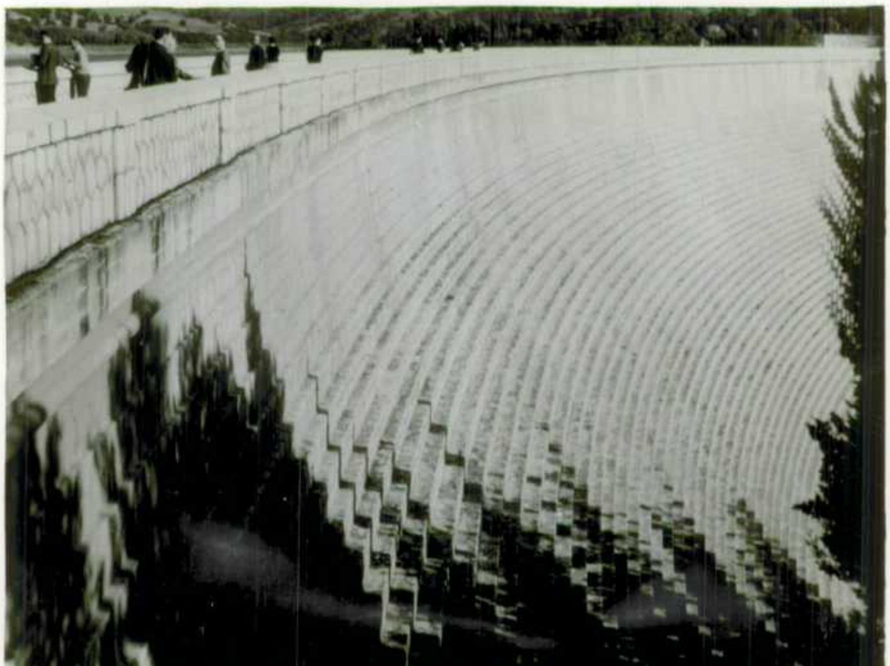


Figure 7. The outer wall of the Marathon Dam showing the Pentelic marble face.

CONCLUSIONS

1. The countries which appear to be most active in hydrology are the U.S.A., France, and Israel, and perhaps Russia, although it was difficult to assess the hydrological field in Russia owing to the language difficulty; however, it was generally agreed that the Russians had very few new hydrological techniques to offer. It is of interest to note that countries such as Israel and Pakistan employ between 30 and 40 professional officers, mostly geologists, working full-time on hydrology in their Geological Surveys. Hydrology in the U.S.A. has greatly benefited from some of the hydrologists who, after gaining experience in the U.S. Geological Survey, have joined the State Universities where they have established courses in hydrology and have carried out research work on combined hydrological study projects with the State Geological Surveys.

2. It was generally felt that there was room for improvement in the standard of the I.A.S.H. symposium. There were perhaps too many papers presented in too much detail with the result that little time was left to discuss the important points. Some attempt should be made in future I.A.S.H. symposia to limit the number of papers by inviting selected specialists to present papers on one or two aspects of hydrology and to highlight the modern trends.

3. Many authors failed to take advantage of the fact that their papers were published in full in the I.A.S.H. Bulletin, copies of which were issued to all participants prior to the symposium. Some authors wasted time reading word by word the summary, and in some cases the whole text, of their papers from the Bulletin.

4. Professor Tison, Secretary of the I.A.S.H., must be congratulated on his effort in assembling and arranging for printing the 76 papers, which were published in two volumes of about 745 pages before the beginning of the Athen's symposium, and for his role in organizing a successful symposium.

RECOMMENDATIONS

1. Australia should be represented at all international hydrological conferences and symposia. Many valuable contacts and much information can be obtained at these meetings, particularly in the informal discussions, which take place after the working sessions. For instance, most of the information concerning international organizations working in hydrology, their interests in hydrology, and general knowledge of the current hydrological work being carried out in other countries, were obtained during informal discussions.

2. Future delegates to overseas conferences and symposia are advised to carry with them a supply of printed introduction cards thus enabling contacts to be made more readily than otherwise. Participants at the Athens symposium were not issued with name tags. Also, future delegates should have some reprints or other publications for exchange or distribution to other participants.

3. Mr. L.C. Noakes, British Commonwealth Geological Liaison Officer, stressed the importance of the need for groundwater in crystalline rocks in arid zones. Smaller quantities of water, but nevertheless extremely important, were generally needed for stock in these parts than has been the general case in the areas discussed at the Athens symposium. He recommended that a future symposium might be held on this topic. Noakes' remarks were supported by Professor Dixey, Geological Advisor to U.N.E.S.C.O., and others at the symposium.

4. It is suggested that the Underground Water Conference of Australia submit an early request to the Secretary of I.A.S.H. for the display of the hydrogeological maps held by I.A.S.H. during their annual meeting in 1963. The maps were exhibited during the 12th I.U.G.G. General Assembly at Helsinki in 1960.

APPENDIX I

LIST OF PARTICIPANTS (113) AT THE I.A.S.H. SYMPOSIUM, ATHENS, 11th-21st October, 1961.

(Countries arranged in order of greatest representation)

UNITED STATES OF AMERICA (25)

R.R. Bennett (Geologist, U.S. Geological Survey).
W. Bierschenk (Engineer, Frank E. Basil, Inc., Consulting Engineers, Teheran, Iran, & Washington, D.C.).
R. Brigham (Geologist).
N. Buras (Engineer, Dept. of Engineering, University of California, Los Angeles).
S. Csallany (Engineer).
J.A. da Costa (Engineer, U.S. Geological Surgey).
L.C. Doutcher.
W.C. Ellis (Hydrogeologist).
H.O. Folsom
J.W. Harshbarger (Professor of Geology, College of Mines, University of Arizona).
? Jibbitte
P. Lamoureaux (State Geologist of Alabama; Professor of Geology, University of Alabama).
T. Maddock (jr.) (Geologist, U.S. Geological Survey).
G. Maxey (Professor of Geology, University of Illinois; and Geologist and Head of Section of Ground-water Geology, Illinois State Geological Survey.)
R. Naee
? Oquilbee
S. Remington (Geologist).
H.G. Rodis
H.E. Skibitzke (Geologist, U.S. Geological Survey; Representative of the American Geophysical Union).
R. Sundstrom
H. Thomas (Engineer).
R.O. Thomas (Engineer, United States Technical Cooperation Mission to India).
D.K. Todd (Associate Professor of Civil Engineering; University of California, Berkeley).
H. Waite (U.S.O.M. Cairo, Egypt, United Arab Republic).
W.Q. Wright.

FRANCE (19)

A. Allene (Engineer)
J. Avias (Professor of Geology).
M. Batisse (Chief of the Division of the Natural Sciences, U.N.E.S.C.O.)
F. Bazin (Engineer)
J. Bertin (Engineer)
A. Bonnier (Chief of the Inventory Mission of Hydrological Resources of the Central Society for Territory Equipment).

J.J. Breusse (Geophysicist, General Company of Geophysics, Paris).

APPENDIX I contd.

FRANCE contd.

G. Castany (Chief Engineering Geologist, Bureau of Geology and Mineral Resources).

A. Cornet (Geologist)
G. Filliat "
M. Gosselin (General Engineer of Bridges and Highways).
J. Jacquet (Engineer)
M. Legrand "
J. Margat (Engineering Geologist, Water Resources Service).
R. Ouvrard (Engineer)
L. Serra "
E.J.P. Stretta (U.N.E.S.C.O. Hydrology Expert, National University of Mexico.)
P. Taltasse (Engineering geologist).
H. Vogt

GREECE (13)

G. Aronis (Head Hydrologist, Hydrogeological & Petroleum Research, Institute for Geology and Subsurface Research, Athens.)
J. Caminopetros
? Christides (Civil Engineer)
G. Koliopoulos (Geologist, Land Improvement Service, Ministry of Agriculture)
A.G. Dounas (Assistant Hydrogeologist, Institute for Geology and Subsurface Research, Athens).
G. Georgalas (Professor of Geology)
J. Katsoulis (Director, Mineral Industry).
N. Papakis (Hydrogeologist; Co-Manager, United Nations Special Fund Project for the investigation of the groundwater resources of karstic limestone; Institute for geology and subsurface Research, Athens.)
M. Pertessis (Ex-Chief of the Geochemical Section of the Geological Service of Greece.)
G. Xenos (President of the Greek Committee of Geodesy and Geophysics.)
K. Zahos (Director-general of the Geological Research Institute for the Substratum.)
C. Zeris (Hydraulic Engineer, Hydromechanical Coy, Athens.)
G. Zervoyannis (Geologist)

UNITED KINGDOM (7)

? Borthwick (Geologist).
F. Dixey (Geological Advisor, U.N.E.S.C.O.)
L. Makes
D. Morris (Geophysicist).
T. O'Donnell
S.H. Shaw (Director, Overseas Geological Survey).
H.R. Versey (Geologist).

APPENDIX I contd.

NETHERLANDS (6)

C.H. de Jong (Engineer)
F. Santema "
G. Santing (Civil Engineer)
C. Voute (Geologist)
A. Volker (Civil Engineer)
L. Wartena

ISRAEL (5)

M. Goldschmidt (Engineer, Jerusalem)
Y. Harpaz (Engineer, Tahal - Water Planning for Israel Ltd., Tel-Aviv.)
Y. Kahana
S. Mandel (Tahal - Water Planning for Israel Ltd., Tel-Aviv.)
W. Stern (Director, Hydrological Service, Water Commission, Ministry of Agriculture.)

TURKEY (4)

I. Civaoglou
K. Erguvanli (Professor of Applied Geology, Technical University of Istanbul.)
I. Ketin (Professor of Geology.)
H.N. Pamir

GERMANY (4)

W. Friedrich
F. Noring (Geologist)
W. Richter
R. Wager

U.S.S.R. (4)

G. Bogomolov
L. Mirzaev
N. Ogilvie (All-Union Scientific Research Institute of Hydrology and Engineering Geology.)
N. Plotnikov (Moscow Geological Prospecting Institute.)

TUNISIA (3)

M. Bouzid (Hydrological Engineer)
J. Tixeront (Chief Engineer, Bridges and Highways)
H. Zebidi (Hydrological Engineer)

YUGOSLAVIA (3)

M. Borelly (Engineer, University of Belgrade)
M. Milojevic (Assistant Engineer, Civil Engineering Faculty, University of Belgrade)
M. Vukovic (Engineer, Water Institute)

APPENDIX I contd.

AUSTRALIA (2)

L.C. Noakes (British Commonwealth Geological Liaison Officer, London.)
D.A. White (Geologist, Bureau of Mineral Resources, Canberra, A.C.T.)

EGYPT (2)

E.M. Ayouty (General Desert Development Authority, Cairo)
M. Sadek (Engineering Geologist)

ITALY (2)

T. Gazzolo (Engineer)
L. Zorzi (Engineer, Italian Commission of Scientific Hydrology, National Council of Research)

PAKISTAN (2)

H.A. Kazmi (Senior Geologist, Water Resources & Engineering Geology Branch, Geological Survey of Pakistan)
M.A. Lateef (Hydrologist)

POLAND (2)

Z. Kaczmarek (Engineer)
J. Lambor.

BECHUANALAND PROTECTORATE (1)

O.J. van Straten (Geologist)

CANADA (1)

L.V. Brandon (Geologist)

CZECHOSLOVAKIA (1)

J. Smetana

HUNGARY (1)

K. Ubell (Engineer, Candidate of Technical Sciences, Research Institute for Water Resources, Budapest.)

JORDAN (1)

U.H. Mudallal (Geologist)

MOROCCO (1)

R. Hazan (Chief Hydrological Engineer, National Office of Irrigation, Water Resources Service.)

UGANDA (1)

R.J. Johnson (Geologist)

SUDAN (1)

Y. Suleiman.

IRAN (1)

H. Alizadeh (Engineering Geologist)

IRELAND (1)

D.J. Burdon (United Nations Special Fund Manager of the Project for the investigation of the ground-water resources of karstic limestone; Institute for Geology and Subsurface Research, Athens.)

APPENDIX II

Chart showing the position of the International Association of Scientific Hydrology (I.A.S.H.) in the International Council of Scientific Unions (I.C.S.U.).

INTERNATIONAL COUNCIL OF SCIENTIFIC UNIONS

(I.C.S.U.)

- ASTRONOMY
- BIOCHEMISTRY
- BIOLOGICAL SCIENCES
- CRYSTALLOGRAPHY
- GEODESY & GEOPHYSICS
  - 7 Associations
    - GEODESY
    - GEOMAGNETISM & AERONOMY
    - METEOROLOGY & ATMOSPHERIC PHYSICS
    - PHYSICAL OCEANOGRAPHY
    - SEISMOLOGY & PHYSICS OF THE EARTH'S INTERIOR
    - SCIENTIFIC HYDROLOGY (I.A.S.H.)
      - 4 Commissions
        - GROUNDWATER
        - SOIL EROSION
        - SOIL WATER
        - SNOW & ICE
    - VULCANOLOGY
- GEOGRAPHY
- GEOLOGICAL SCIENCE
- HISTORY & PHILOSOPHY OF SCIENCE
- MATHEMATICS
- PHYSIOLOGICAL SCIENCES
- PURE & APPLIED CHEMISTRY
- PURE & APPLIED PHYSICS
- SCIENTIFIC RADIO
- THEORETICAL & APPLIED MECHANICS

APPENDIX XII

LIST OF KNOWN INTERNATIONAL ORGANIZATIONS CONCERNED WITH HYDROLOGY

1. International Association of Scientific Hydrology (I.A.S.H.). The I.A.S.H. has a Commission of Groundwater, which contains a Standing Committee on Hydrogeological Maps. The committee is currently engaged in compiling a set of symbols for hydrogeological maps (Appendix IV).

2. International Association of Hydrology (I.A.H.). Formed in 1958 ? by a French group of hydrologists. Members mainly French working in France, Northern Africa, and Morocco. Administration is not of high quality; and activities are limited. A combined working meeting between I.A.H. and I.A.S.H. on hydrogeological maps will be held in February, 1962 at U.N.E.S.C.O Headquarters, Paris.

* 3. United Nations Water Resources Centre (Headquarters New York). This organization in August 1961 published an article entitled 'Large scale development of groundwater'.

* 4. U.N.E.S.C.O. Arid Zone.

* 5. World Meteorological Organization (W.M.O.) This organization has recently formed a Commission for Hydrological Meteorology (C.H.M.), which held its first session in Washington D.C. on the 12th-25th April, 1961. The results of this session are reported in the I.A.S.H. Bulletin, 6th year, Number 3, September, 1961. The main results of interest are that the C.H.M. and the I.A.S.H. have agreed to collaborate in many items of mutual interest and to organize joint symposia. The I.A.S.H. Committee decided at the 1961 Athens Symposium to hold a joint symposium with W.M.O. during the I.U.G.G. XIIIth General Assembly at Berkeley, California, in 1963. The subjects of the joint symposium are : (i) Hydrological Forecasts; and (ii) Networks for Hydrological Meteorology. The C.H.M. are also contributing publications on hydrological forecasting to the International Bibliography on Hydrology published by the I.A.S.H. During the 1961 session of the W.M.O. it was decided that on research questions of common interest which fall within the competence of C.H.M., and which involve discussions and action at an inter-governmental level, the Commission felt that W.M.O. should have the primary responsibility and that I.A.S.H. should be invited to be represented on any relevant W.M.O. working groups.

   It may be of interest to note that C.H.M. have established working groups on : (i) hydrological forecasting; (ii) network design; (iii) publication and exchange of data for hydrological meteorology; (iv) terminology; (v) instruments and methods of observation; (vi) guide on hydrological meteorology; and (vii) hydrological design.

* 6. Food/and Agricultural Organization (F.A.O.) (Headquarters Rome). This organization has an active hydrological interest in problems of irrigation.

* United Nations Organizations.

APPENDIX III contd.

* 7. World Health Organization (W.H.O.). This organization considers, among others, chemical and biological problems of water.

8. International Council of Irrigation and Drainage (Headquarters at New Delhi). Very little is known of the organization, but they are of immediate interest to Australian hydrologists since they have recently published a Handbook of hydrological terms.

9. French Association for the Study of Water (A.F.E.E.). Headquarters, Paris. This association has published an English-French terminology of hydrology.

10. American Geophysical Union (A.G.U.). The A.G.U. has a Section of Hydrology, which has organized a 3-day pre-General I.U.G.G. Assembly - Symposium at Stanford University in 1963. The proposed subjects of the symposium are (i) humidity of soils; (ii) water chemistry; and (iii) physics of snow.

11. American Society of Civil Engineers. This society published, in March 1961, a Manual (Number 40) for Groundwater Development.

* United Nations Organization.

APPENDIX IV.

List of Literature received at the symposium and now held at the library of the Geological Branch, Bureau of Mineral Resources, Canberra, A.C.T.

AMBROGGI, R., and MARGAT, J., 1957 : General list of conventional signs on hydrogeological map of Morocco. I.A.S.H. Bull. Publ., 50

ARIZONA HIGHWAYS, 1961 : Water and the thirsty land. April. (Illustrates the Salt River Valley Project U.S.A., which includes the Theodore Roosevelt Dam).

ATHENS WATER WORKS COMPANY, 1961 : Marathon Lake and Dam. Inf. Bull.

BIERSCHENK, W.H., and WILSON, G.R., 1961 - The exploration and development of ground-water resources in Iran. Extract from I.A.S.H. Bull. Publ., 57

HYDROMETRISCHE WERKSTATTEN DR. BOVENSIEPEN," KAUFBEUREN, ALLGAU. : Pamphlets illustrating hydrological equipment; Water Depth Recorder; Universal Vertical Registration Gauge; Double Registration Gauge; Water level recorder; Ground-water Registration Gauge; Band Recording Indicator for measurements of groundwater and upper water; Graphic Flow Meter; Water Level Indicators; Reading Instrument for groundwater measurements and depth soundings; Pipe Cover Attachment for groundwater level measuring pipes 2 and 4 inches diameter.

I.A.S.H., 1961 : I.A.S.H. Bull., 6th year, No.2, June.

__________ : Idem., 6th year No.3, September. (This bulletin contains the Hydrology Proceedings of the 12th General Assembly of the I.U.G.G. held at Helsinki.)

__________ : Symposium of Athens - Groundwater in Arid Zones. I.A.S.H. Bull. Publ., 56

__________ : Idem. Ibid., 57

INSTITUTE FOR GEOLOGY AND SUBSURFACE RESEARCH, ATHENS, 1961 : Prospecting for karst groundwater in the limestones of the Amphissa-Itea region. Field note No.1 to illustrate certain aspects of the field trip during the I.A.S.H. Athens symposium.

__________ : Research into the hydrogeology of the limestones of the Argos-Tripolis region. Ibid., No.2.

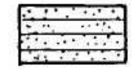
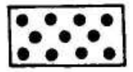
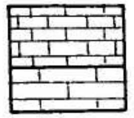
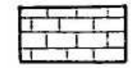
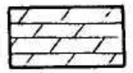
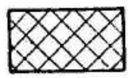
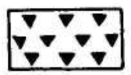
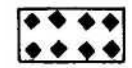
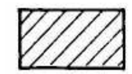
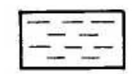
LAND RECLAMATION SERVICE, MINISTRY OF AGRICULTURE, 1961 : Present and future irrigation development in Greece (a Global Revue).

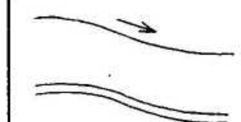
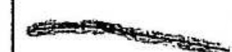
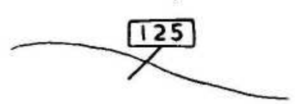
PERTESSIS, M., 1961 : The mineral springs of Loutraki, Greece. A note to illustrate part of excursion during I.A.S.H. Athens symposium.

U.N.E.S.C.O., 1961 : A coloured hydrogeological map of the San Luis Potosí area, Mexico. Scale 1:200,000.

A. GEOLOGY					
1. Geological formation (adopted)	colours conforming as much as possible with international geological practice	as II	as II	as II or: permeable formations by symbols, imperm. form. near the surface by colours (see D.15 V and D.18 V)	mostly colours
2. Stratigraphy (adopted)	written in black	as II	as II	as II	
3. Altitude of formation (top or base) above C.D. (see also F.15a V) (adopted)	contour line 78 (black)	as II	as II 600 (black) or: 600 (black)	as II or: 400 (grey)	
4. Id., uncertain (adopted)	78 (black)	as II			
5. Contact between permeable and imperm. or semi-perm. formations (suggested rephrase to permeable & less permeable - may have been rejected)	Line of contact (black)	as II			
6. Dip (adopted)	(black)	as II	(black)		
7. Axis of anticline, with directions of axial plunge (adopted)	(black)	(black)	as II		
8. Axis of syncline, with direction of axial plunge (adopted)	(black)	(black)	as II		
9. Flexure, with direction of upthrow side (adopted)	(black)	as II			

10. Id., not affecting covering layers	(black)	as II			
11. Fault, with direction of upthrow side	(black)	as II	dip (black)	or or (brown or black)	
12. Id., not affecting covering layers	(black)	as II		or (brown or black)	
13. Abnormal contact (Doubt as to meaning replaced by Thrust with symbol)	(black) (Thrust)	as II			
14. Rim of a terrace (Not Required - abolished)					
15. Altitude of soil surface (Not Required - rejected)					Netherl.: contour lines (grey or brown)
E. LITHOLOGY					
1. Gravels, gravelly deposits, dejecta (rejected 'dejecta' - meaning?)	(in the colour of the geological formation)			(black or in a colour indicating well yield (Höffigkeit))	Netherlands: black symbols
2. Sand (adopted)	(in the colour of the geological formation)	as II		"	

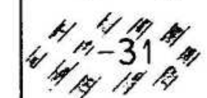
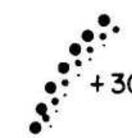
3. Sandstone (adopted)	 (in the colour of the geological formation)	as II		 (black or in a colour indicating well yield)	
4. Conglomerate (adopted)	 (in the colour of the geological formation)	as II		"	
5. Limestones (adopted)	 (in the colour of the geological formation)	as II		 "	
6. Dolomites (adopted)	 (in the colour of the geological formation)	as II			
7. Calcareous sinter (adopted)	 (in the colour of the geological formation)	as II			
8. Porous volcanic ejecta (adopted)	 (in the colour of the geological formation)	as II		 "	
9. Loam (adopted)	imperm. or semi-permeable formations are not indicated	impermeable formations by negative symbols ad libitum or by a plain colour		 "	
10. Clay (adopted)	imperm. or semi-permeable formations are not indicated			 "	
11. Marl (adopted)	imperm. or semi-permeable formations are not indicated				
12. Compact limestones (adopted)	imperm. or semi-permeable formations are not indicated				
13. Volcanic ejecta (adopted)	imperm. or semi-permeable formations are not indicated				

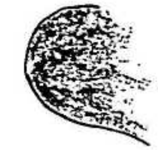
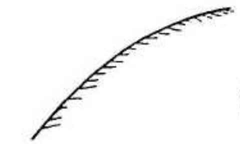
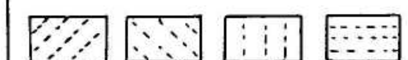
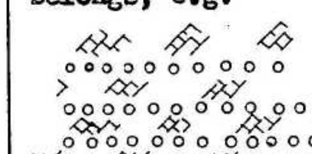
14. Shale (adopted)					
20. Grain size (no decision)				indicated by a classification number written in the symbol (black)	
21. Chemical properties (see E 9)					
<u>C. HYDROGRAPHY</u>					
1. All <u>natural</u> waters (adopted)	in blue	in blue			
2. Perennial stream (adopted)	 (blue)	as II		 (black) or (blue)	
3. Id., highly polluted (no decision)				 (with grey lining)	
4. Id., with high chlorine content (no decision)		 (with blue lining)		 (with green dots)	
5. Seasonal stream (adopted)	 (blue)	as II			
6. Intermittently flowing stream (adopted)	 (blue)	as II			
7. End of stream (adopted)		as II			
8. Gauging station, with yearly average flow in million m^3/year (adopted)	 (blue)	as II	▲ (blue) or ✕ (black)		

9. Marsh, seasonal marsh (adopted)	(blue)	as II			
10. Surface water divide (adopted)	(blue)	as II or: + + + + + (blue)			
11. Spring (general) (recommended use for used spring and for unused spring. Fillings in dark blue)	(blue)	as II	or (blue)	(violet) or: (violet or blue) (> 2 l/sec) (analysis and other data available) (in different colours, indicating yield)	
12. Id., exploited (no action)					
13. Id., not exploited (no action)					
14. Id., cold (no action)			(blue)		
15. Id., hot (no action)			(blue)		
16. Outflow spring (no contact with impermeable formation) (no action)	(blue)	as II			
17. Overflow spring (contact with lower imperm. formation) (no action)	(blue)	as II			
18. Overflow spring (contact with lateral or upper imperm. form.) (no action)	(blue)	as II			

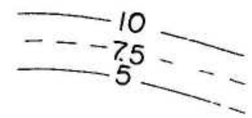
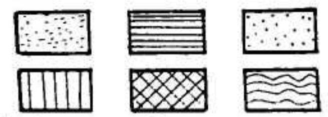
19. Spring or resurgence in Karstic formations	(blue)	as II			
20. Intermittent Vauclusion spring	(blue)	as II			
21. Artesian spring (adopted)	(blue)	as II			
22. Thermal or thermo-mineral spring (adopted)	(blue outline, yellow fill)	(blue outline, red fill) or (on special hydro-chemical maps): ○ mineral spring (red) ● thermo-mineral spring (red)	T ; T (thermal spr) M ; M (mineral spr) (blue)		
23. Average discharge of a spring, in l/sec (adopted)	120 (blue)	as II		symbol in colour indicating discharge	
24. Natural pond or waterhole with no outlet (adopted)	(blue)	as II			
D. HYDRO-GEOLOGY					
1. Elevation of water table (phreatic w.) (should be described in reference to time)	isohypses (blue) main isohypse 450 normal isohypse intermediate isohypse	as II	isohypses 410 blue, red or black (Sometimes: blue = above sea level red = below sea level	isohypses 80 85 (blue, violet, red or black)	U.S.S.R.: isohypses

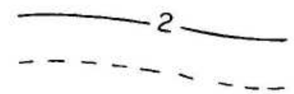
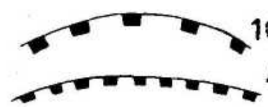
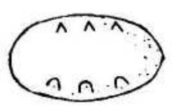
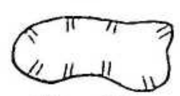
2. Elevation of piezometric surface	450 (in blue, or in the colour of the water-bearing formation, or in blue edged with the colour of the water-bearing formation)		isohypses	isohypses	U.S.S.R.: isohypses
3. Seasonal fluctuations of the ground-water table or piez. surface					Netherl.: lines of equal fluctuations 0.70
4. Direction and velocity of the groundwater flow (in m/day)		10 (blue) or (blue)	(blue)		
5. Ground-water divide			(blue)		
6. Disturbed ground-water conditions (due to mines, excavations, etc.)				boundary in red	
7. Depth to water table See also F 15 C			Different symbols for different depths (in colours indicating probable yield of a well) or: different colours or shades or: isobath lines (blue)		

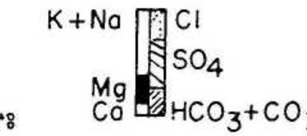
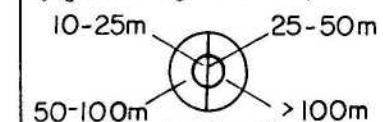
8. Depth of top of water-bearing formations below ground surface	isobath lines in the colour of the formation main isobath -150 normal isobath	as II		isobath lines	Netherl.: isobath lines
9. Elevation of top and/or base of water-bearing form. (see also A 3)				figures (eg $^{+18}/_{-6}$) or: different colours for different elevations or: contour lines in the colour of the formation or (for flat areas):  base of 1st aquifer  base of 2nd aquifer (in the colour of the formation)	Netherl.: different colours for different elevations.
10. Local intercalated impermeable or semi-pervious strata (with average elevation)				 (in the colour of the formation)	
11. Confinement (deferred)	indicated by edging of the isohypses with the colour of the formation (see D.2.II)	as II		different arrangement of lithological symbols e.g. sand: aquifer not covered; covered or deeper aquifer limestone: aquifer not covered; covered or deeper aquifer (in different colours indicating well yield)	

12. Area where the ground water is artesian (deferred)	 (in the colour of the formation)	as II	 (red)			
13. Boundary of water-bearing formation	 (only for confined ground water) (in the colour of the formation)	as II		 (black)		
14. Ground-water barrier			 (blue)			
15. Different ground-water horizons (aquifers)				different arrangement of symbols indicating geological formation, e.g.  1st 2nd 3rd 4th  5th aquifer (in colours indicating well yield) or: different arrangement of lithological symbols, the arrangement indicating the geological formation to which the aquifer belongs, e.g.  continuous symbols = upper aquifer; interrupted symbols = 2nd aquifer.		

16. Ground-water regions			different symbols in blue		
17. Thickness of aquifer	not indicated on small scale maps	range of blue shades e.g. for <10, 10–50 and >50 m or: by means of isopachs 20 (blue)	different symbols or: isopachs 60 (black)	isopachs 20 (grey)	Netherl.: isopachs 20
18. Transmissibility or: instantaneous yield of a well of usual construction	lithological symbols drawn at different scales, e.g. or: a range of shades of one or two colours, e.g. blue and brown	as II or: different symbols e.g. <10 10–50 50–100 >100 l/sec (red) or: lines of equal transmissibility (m^2/sec) 1×10^{-2} (red)	different colours or: different symbols or: lines of equal transmissibility (red) or: vertical bars (black) height indicating transmissibility	lithological or geol. symbols printed in different colours (see B.1–5 V and D. 11 V) or: a range of shades of two colours, e.g. blue and violet	U.S.S.R.: different symbols for different well yields (in m^3/day per 10 m drawdown)

19. Instantaneous yield of a well of usual construction (measured)	not indicated on small scale maps	∘ e.g. <10 l/sec ∘ 10 – 50 ⊙ 50 – 100 ◉ >100 (red) (only for large scale maps)			
20. Natural discharge of the aquifer (in l/sec per km^2 or m^3/day per km^2, or mm/year)	a range of shades of blue, if desired with lithological symbols in black or grey	as II		lines of equal minimum discharge (in l/sec per km^2)  (green)	U.S.S.R.: different symbols or different colours
21. Annual rainfall (depth in mm)	isohyets 300 (blue)	as II	isohyets (violet)		
22. Infiltration capacity of covering layers			 6 classes from favourable to unfavourable	 good medium poor (grey shades)	

<u>E. HYDROCHEMISTRY</u>					
1. Total concentration	a range of shades (preferably of red) **or:** isocone contours (with total concentration in g/1)  (red)	as II	different symbols  **or:** 	isocones (green) (for chlorine content)  100 mg/1 40 mg/1	Netherl.: a range of shades
2. Interface between fresh and salt ground water					Netherl.: lines of equal depth  **or:** depth indicated by different colours
3. Potability	2 colours indicating drinkable and undrinkable				
4. Conditions on the soil surface affecting the chemical properties of the ground water: **a. wood** **b. peat** **c. built-up areas with sewer systems** **d. id. without sewer systems**				 (black)  (black) or  (brown)  (grey)  (grey)	

5. Polluted ground water, saline intrusions etc.					
6. Chemical composition of the ground water (on special maps only) (deferred)	colour representing predominant property; bi-coloured streaks representing mixed features. Concentration is indicated by different shades of the colour, or by isocones	as II	 or: ◔ or: ○ ◔ ◑ ◕ ● (for one property)	× / × × / × × × in different colours for different properties or a range of shades of a colour (for one property, e.g. hardness or pH	Netherl.: bar diagrams, different symbols (in black or in different colours):  or: (specially for Cl)  section indicating depth, colour indicating content.
7. Temperature (adopted)	figure (red) 40	as II	● 57 (max.temp) 54 (min.temp)		U.S.S.R.: ○ $\frac{54}{963}$ (temp) (depth) or: geo-isothermal ——15—— or: different symbols for zones of different temperature

8. Mineral waters, classified with regard to their main property (adopted, except spring symbol)	symbols in red mineral / thermo-mineral ◇ ◆ bicarbonate △ ▲ sulphate ▽ ▼ sulphur □ ■ chlorine ○ mineral spring ● thermo-mineral spring	as II ○ gaseous water		symbols in blue ⊙ □ • chlorine △ ◆ sulphate ▲ hydr.carbonate △ ▼ acid waters ▽ ■ iron, iod, sulfur, radium, arsenic ○ thermal waters well with mineral water (blue cross on brown dot)	
9. Chemical properties of the water-bearing formation				the lithological symbols may also indicate the chemical properties of the material.	
10. Dilution and concentration (on special maps)		□ (blue) zone of dilution □ (brown) neutral zone □ (red) zone of increasing concentration			

F. WELLS, BOREHOLES AND OTHER WORKS.	All artificial works in red colour.				
1. Borehole (adopted)	⌖ (red) a colour in the circle may indicate the deepest formation reached	as II (or black)		● (black) or: ○ ● ⊙ <-300 < -300 >-300 m OD Quaternary fully penetrated	Netherl.: ○ depth 10-30 m ϕ depth 30-100 ● depth > 100
2. Id., in artesian aquifer (adopted)	(red)	as II			
3. Well (deferred)	● (red)	○, ● (red)	○ depth 40- 80 ft ● depth 80-130 ft		
4. Well, (sometimes) dry	○ (red)		ϕ		
5. Well with windmill					
6. Irrigation well			◎ or ◓ (red)		
7. Domestic well			○ (black or red)	● (black)	
8. Well of public water supply			⊙ (red) ●, ϕ, ⊕	⊙ (black)	
9. Industrial well			○ (red), ●, ⦶	⌖ (black)	
10. Observation well			⌖, ✦, ⌖	◎ (black) ○ ● ⊙ ✦ (red) 1st 2nd 3d 4th aquifer	Neth.: (key well) (normal obs.well)
11. Id., with recording gage			▲		

12. Artesian well or flowing well			● (red) (O = non flowing)	⇑ O (red)	
13. Abandoned well			⌖		
14. Injection well or other system for ground-water recharge	(red)	as II			
15. Additional data: a. filing number; b. total depth; c. depth to ground water; d. elevation of water table; e. altitude of between two formations; f. top and base of geol. formation and thickness of water-bearing stratum g. altitude of base of upper aquifer and of 2nd aquifer; or top and base of aquifer	 1550 (red) 275 (black) 65 (blue)	 as II as II as II	 ● 413 (black)	● Plei/Plio - 350 - 810(10) ● Tur/Cen - 825 ● +64 ● +51 or ● +18/+2 over - 5/(-14) (1st aquifer) (2nd aquifer not fully perforated)	
16. Pumping station or wells with pumping station	◉ (red)	as II (or blue)	◉ , ◎ (flowing) (non flowing)	△ (violet) or: ▫ ▫ □ □ ⊞ (black) size indicating capacity	
17. Cistern	⌓ (red)	as II			

18. Storage reservoir for surface water	(red)	as II or: (blue)			
19. Catchment of a spring	(red square, symbol for spring blue)	as II			
20. Drainage gallery	(red)	as II			
21. Yield of spring or gallery (l/sec)	50 (red)	as II			
22. Pipe line	(red)	as II		(violet or black) (planned)	
23. Dam of reservoir or diversion (with capacity of reservoir in million m^3)	(red)	as II		7,5 (blue)	
24. Underground dam	(red)	as II			
25. Canal			(blue)		
26. Irrigation canal (perennial waters)	(red)	as II			
27. Id. (flood waters)	(red)	as II			
28. Drainage canal or natural drain	(red)	as II			
29. Gauging station at a stream (see C.8)					

APPENDIX V

LIST OF SYMBOLS FOR HYDROGEOLOGICAL MAPS

as suggested by I.A.S.H. Standing Committee on Hydrogeological Maps

LEGEND

Symbols and signs as used in different countries

I	II	III	IV	V	VI
Action decided at Athens Committee Meeting in brackets	Recommended by I.A.S.H. Standing Committee in its report to UNESCO (for small scale maps only)	Morocco (Centre des Etudes hydro-geologiques du Maroc)	U. S. A. (U.S. Geological Survey and other agencies)	Germany (F.R.) (Federal and State Services)	Other countries