VIII INTERNATIONAL CARTOGRAPHIC CONFERENCE

Moscow, USSR, August 3-10, 1976

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A SET OF MAPS OF BRACKISH AND SALINE GROUND WATER OF THE USSR

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Mapping is being widely applied in hydrogeological studies in the USSR. Many hydrogeological maps varying in scale, contents, purpose and representation have been published in the USSR in recent years. Two main groups of hydrogeological maps are distinguished: maps with general scientific and reference contents and thematic applied maps. The maps of the first group include a general hydrogeological map, or hydrogeological map proper, and a number of thematic hydrogeological maps - hydrogeodynamical, hydrogeochemical, of ground-water discharge, ground-water regime and others.

A unified legend for a general hydrogeological map like that for a geological map is absent, though requirements for the contents of this map have been largerly agreed upon in the USSR in discussions for many years.

A general hydrogeological map at a certain scale is considered to reflect all principal elements of hydrogeological conditions of a certain area with their quantitative characteristics and thus contributing to solution of different theoretical and practical problems of ground water. In keeping with this, natural systems composed of rocks and ground water with their many inner and outer relations are mapped. The rate of the movement of ground water and variation of ground-water characteristics in time, which is particularly significant due to man's present-day technological and economic activities, should also be taken into account.

Thematic hydrogeological maps differ in their application - water-supply, agricultural reclamation, development of mineral deposits, balneology, health-resort construction, etc. The majority of these maps are close to socio-economic and technological maps though they remain hydrogeological in a general sense. An example of these

maps is the map of discharges of economic resources of fresh and brackish ground water of the USSR at a 1:5,000,000 scale, edited by N.N. Bindeman and published in 1965.

The diversity of hydrogeological maps as to their contents, purpose, scale and areal extent determines the diversity of methods for compiling these maps. The common distinctive feature of compiling the majority of the maps is construction of the compiler's original and a supplemented thoroughly developed programme of the map where instructions for reflecting each element of the contents of the map are given. Particular attention is paid to the legend that may be very large and complicated. A scientifically constructed legend reflects the classification of phenomena and objects presented on the map and characterizes their types and varieties.

One of the requirements, which hydrogeological maps should comply with, is their standardization and unification both within one country and at the international level. The problem of standardization of hydrogeological maps includes problems of selecting map projection and scales, mapping units and indices, classifications and systems of conventional signs.

Depending on the purpose and scale of the map, a certain procedure of reflecting its principal contents may be applied. Various combinations of mapping procedures - qualitative background (colour and hatching), areals, lines, individual signs, figure and letter symbols are used in compiling maps with complex contents.

Hydrogeological maps commonly have very complicated contents. As aquifers occur at various depths and are characterized by a large number of different qualitative and quantitative indices, varying in time, it is difficult to represent cartographically the many-

stage geological sequence. Therefore one should not restrict himself to map projection of one real or conventional surface, and in map compilation it is advisable to apply methods allowing to reflect the volumetric expression of the combination of principal indices.

Let us discuss in more detail a series of thematic maps of ground water with a higher dissolved solids content, compiled at the Institute of Water Problems, USSR Academy of Sciences.

Resources of both surface fresh water and ground fresh water are distributed extremely irregularly over the area of the USSR, and many regions of the country are short of water suitable directly for drinking, stock water supply, and irrigation. One of the ways of combating this deficit is the use of ground water with a higher dissolved solids content - brackish and saline water that may be used in a natural state or desalted. Certain selected and purposefully interpreted hydrogeological information should be used in planning certain measures. The studies carried out for the above purposes have resulted in compilation of a set of maps; the sequence of the compilation was as follows: from smaller scales to larger scales, from the whole area of the USSR to individual regions, from maps of general contents to thematic detailed maps.

The set of maps begins with three maps at a 1:7,500,000 scale. The first map shows the geological age and prevailing composition of water-bearing rocks (aquifer systems) in the upper and lower parts of the zone of brackish and saline water (the map has a "transparent" legend). The second map shows the character of the distribution of brackish and saline ground water in plan, the depth of its occurrence and the spatial correlation of the hydrogeochemical zone, formed by this water, with zones of fresh ground water and brines. The third

map shows the thickness of the zone of brackish and saline ground water (less than 100, 100-200, 200-500 and over 500 m), its total dissolved solids content (gradations: up to 3 g/l, up to 10 g/l, up to 35 g/l and over) and chemical (anion) composition in horizontal and vertical directions.

Details and conventional signs are different for artesian basins and hydrogeological massifs, but the common feature of these maps is the volumetric (as if three-dimensional) representation of zones of brackish and saline ground water. The legends of the first and third maps are mainly analytical (each mapped element is reflected by its own conventional sign). The legend of the second map is synthetical. Each conventional sign for artesian basins characterizes: (1) the depth to ground water with a higher dissolved solids content (up to 100, 100-200, 200-500 metres and over 500 m); (2) the position of this water with respect to the earth surface and the fresh-water zone (the water occurs first from the earth surface; ditto, but underlain or broken by fresh-water aquifers; the water underlies the fresh-water zone of continuous extent, or the fresh-water zone of discontinued extent, or the permafrost strata and the fresh-water zone); (3) the character of the distribution of brackish and saline water over the basin area (the water occurs practically everywhere, alternates with brines or fresh water); (4) the position of the water in respect to the surface of the basin foundation (the water occurs down to the foundation, is underlain by brines); (5) the relative significance of the brackish and saline ground-water zone in the vertical section of the basin (prevails, predominates as to the thickness, has a smaller thickness as compared to fresh water or brines).

In compiling these maps, various mapping procedures in their reasonable combination have been used for reflecting all elements of

their contents. The selection of a certain procedure or a combination of proceduresois governed above all by their correspondence to the common character and essence of the phenomena being reflected. The qualitative background procedure has been mainly applied in various forms (strip colour division, colour background, colour hatching) which allows to reflect both qualitative and quantitative signs of the regions distinguished. This procedure is well correlated with point, line and area symbols. The legends contain a detailed description of the meaning of all colours, hatchings, and figure and letter symbols. The map legends, being large and complicated as to their contents and composition, express a whole complex of analytical and synthetic indices. The details of the map, however, do not hamper the reading of the map, they allow to obtain rapidly the necessary information by comparing all the three maps.

These maps may be considered as separate (parallel) sheets of a hydrogeological map that reflects fairly comprehensively a certain part of the hydrogeological section and that may be general-purpose, though compiled for special purposes.

These maps are supplemented by the map of hydrogeological subdivision of the USSR area as to conditions of formation of ground water with a higher dissolved solids content at a 1:10,000,000 scale and the map of geological (storage) resources of this water at the same scale.

A 1:10,000,000-scale map of USSR area subdivision as to conditions of use of ground water with a higher dissolved solids content has also been compiled. Areas where the use of this water is possible, limited or impossible because of hydrogeological conditions and areas where this use is advisable in the nearest or distant future, taking into account both hydrogeological and technological and economic in-

dices, are shown on this map. As to the contents, this map may be classed with appraisal maps.

A map of potential economic yields of brackish and saline ground water at a 1:5,000,000 scale has been compiled for regions where the use of water with a higher dissolved solids content is advisable (southern regions of the European area of the USSR and Western Siberia, plains in Kazakhstan and Middle Asia). The yields are expressed in values of the rate of ground-water development (in litre per second per square kilometre) and largest yields of separate standard water intakes are in cubic metres per day.

More detailed maps for the same purpose are compiled for separate regions which have prospects for the use of brackish and saline water. Procedures for compiling a set of these maps have been developed; the maps include: a combined map of main aquifers, maps of aquifer constants and economic yields of brackish and saline ground water, a combined map of economic yields, and a map of area subdivision as to conditions of the use of ground water with a higher dissolved solids content.

The principal practical conclusions made from the analysis of the maps discussed are as follows.

Hydrogeological conditions allow the use of ground water with a higher dissolved solids content over more than half the area of the USSR. The natural resources of this water occurring almost everywhere in platform artesian areas at depths of up to 500 m for the most part and occurring in limited areas in hydrogeological massifs and folded regions amount to about 500,000 cubic kilometres.

In the Middle and North-West provinces, ground water with a higher dissolved solids content is confined to hydrogeological zones with slow and very slow water circulation, and its natural resources

are not practically replenished. Within the South-West province, over an area of over 3,000,000 km^2, this water occurs in the zone of relatively intensive water circulation, and its natural resources may be expressed by a ground-water discharge of 0.05-0.5 litre/sec/sq.km.

The potential economic yields of ground water with a higher dissolved solids content in the South-West province are estimated at about 3,000 m^3/sec (about 2,000 m^3/sec is accounted for by brackish water) that is 1.5 times as large as the fresh ground-water resources of this province. Here, the use of brackish and saline ground water is possible and advisable now, but over the rest of the USSR area it is advisable in the distant or very distant future.

Planning the use of ground water with a higher dissolved solids content in individual regions should be based on the results of estimation of predicted economic yields of ground water and with allowance for the planned system of water supply and main technological and economic indices. The use of brackish and, to a lesser degree, saline ground water is urgent above all for rural water supply in southern regions of the Ukraine, European area of the RSFSR, Western Siberia, and in plain areas of Kazakhstan and Middle Asia. In these areas, constituting the South-West region, mainly brackish ground water may be used at a rate of no less than 300-500 m^3/sec, that is equal to the planned requirements for water for rural needs in this area for the nearest future.

Of particular importance are the ecological aspects of the problem of the use of ground water with a higher dissolved solids content whose after-effects may be both positive and negative. The former include possible formation of fresh ground-water resources as a result of brackish and saline water withdrawal. The latter in-

clude formation of residual brines in the course of water desalinization.

At a large scale of development of ground water with a higher dissolved solids content and deep-occurring, high-temperature artesian saline water in particular, its integrated use for water supply, heating, industrial extraction of chemical components is possible and advisable.

The above principles and procedures of compilation of thematic hydrogeological maps for one type of application allow to use them for consistent solution of problems of planning and designing certain measures - from most general qualitative estimates for a whole country to specific technological and economic estimates for certain regions or projects. The cartographic procedures applied allow to reflect visually the large amount of useful hydrogeological information and not only to show certain characteristics of the objects mapped, but also to make their practical appraisal.

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