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DIGITALIZATION OF HYDROGEOLOGICAL SURVEYS RESULTS IN ArcGIS

Abstract. Modernization of the state system of geodesic support and creating the maps in a single coordinate system and according to uniform data structures are required to digitize, unify, develop and maintain the integrity of spatial data [1]. A scientific and methodological basis for structurization of the hydrogeological maps using geoinformation systems is being developed, and a library of conventional signs of hydrogeological subject matter was created under the project No. AR05131239 [2]. Development of methodological approaches to solving the problem of unification of hydrogeological objects is important due to the lack of a unified methodology for drawing up digital hydrogeological maps in the Republic of Kazakhstan. Creation of a series of map sheets and use thereof when applying a software product ArcGIS with the same conventional signs is also relevant in other countries of Central Asia [3]. This article covers the stage of structurization of the "Hydrogeology" style of cartographic data within the ArcGIS environment.

Keywords: GIS, digitalization, hydrogeology, cartography, geodatabase, map.

Introduction. Modern geographic information system make it possible to convert any spatial objects, phenomena, processes of the real world into digital format, i.e. in the form of a digital map, and save information about them in a database.

The most illustrative form of representing the peculiarities of underground water (UW) distribution and formation are hydrogeological maps.

Hydrogeological maps characterize the distribution, conditions and occurrence depth, qualitative and quantitative components of UW, as well as thickness, filtration parameters of water-bearing and water-resistant formations shall be made based on the results of hydrogeological studies with the use of geological, geomorphological, hydrological and other information. Requirements to the geological maps are given on the website of the Committee for Geology and Subsoil Use, including in the Instruction for the making and preparation for publishing the sheets of the Republic of Kazakhstan state geological map with the scale of 1:200 000; methodological guideline for the compilation of series legends of the State GeolMap–200 [4]. Effective requirements to the making of hydrogeological maps are stated in the Instruction for the making and preparation for publishing of sheets of the state hydrogeological map of Kazakhstan with the scale of 1:200000 approved by the Order of the Committee for Geology and Subsoil Use of the Ministry of Energy and Mineral Resources of the Republic of Kazakhstan dated 09.11.2004 No. 143-п. [5] and also in Stratigraphic Code, SNiP RK 1.02-18-2004 and GOST 21.302-2013 [6]. Specialized publications devoted to hydrogeological databases (DB) and GIS give the main requirements to their architecture and provisioning. These include compliance with DB standardization rules - uniqueness of tables, avoidance of data redundancy and duplication. Unified requirements to hydrogeological maps must underlie the works of structuring the geodatabase and creation of a special style in ArcGIS.

Survey methods: system analysis, spatial analysis, GIS-technologies and geoinformation methods of displaying hydrogeological surveys; cartography integration.

Results. Hydrogeological maps reflect the results of hydrogeological surveys: state of groundwater, main types of rocks and water bodies, types of UW by hydraulic properties, interaction with surface waters, geochemical types of UW regime, as well as exogenous processes caused by UW activities [7].

These data should be laid on hydrogeological maps, taking into account the rules of their graphic design dictated by the specialized literature and GOSTs which are relevant for the Republic of Kazakhstan and neighbouring countries, and they can be conventionally combined into sets of classes. Each class in ArcGIS has its subtypes which in their turn are divided into domains [8].

1. Information about the set of classes of objects "Horizons and complexes (hydrogeological units)" shall include the following classes of objects:
- Horizons and complexes (polygons),
- Borders of various aquiferous complexes (lines).
- Borders of various degrees of mineralization aquiferous complexes (lines).
- Borders of UW chemical composition
- Isopachytes (thickness of aquiferous horizons)
- Isolines of depths of aquiferous horizons top
- Isolines of depths of aquiferous horizons bottom
- Horizons and complexes occurring above the first from surface persistent by area units (lines)
- Horizons and complexes occurring below the first from surface persistent by area units (lines)

2. Information about the set of classes of objects "Hydrodynamics" shall include the following classes of objects:
- Direction of ground water flow (lines)
- Hydroisohypses (lines)
- Hydroisopiestics (lines)
- Ground water pinchout (lines)
- Class of objects UW dividing range (lines)
- Groundwater recharge at account of infiltration and inflow of precipitations (lines)
- Groundwater recharge at account of infiltration and inflow of surface water (lines)
- Groundwater recharge through tectonic faults (dots)
- Sites of water vapor intense condensation and its value, mm/year (polygons)
- Groundwater discharge at account of plants transpiration (lines)
- Sites of UW discharge into lakes and rivers (lines)
- UW discharge areas (traverses)
- Borders of suberimposed depressions or saddles that are drainage systems of mineral or thermal water (lines)
- Borders of sites of UW intense evaporation (lines)
- Sites of hidden discharge (dots) (UW flow-over from one aquiferous object to another through lithological windows)
- Isolines of long-time annual average underground water runoff module (lines)
- Head intensity (lines)

3. Information about the set of object classes "Tectonics" includes the following object classes:
- Fractured zones (lines)
- Fractured zones (polygons)

4. Information about the set of classes of objects "Hydrogeological zoning" includes the following object classes:
- Hydrogeological zones (polygons)
- Hydrogeological zones (table)
- Borders of hydrogeological zones (lines)

5. Information about the set of object classes "Sections" includes the object class "Section lines".

6. Information about the set of object classes "Water points – natural and artificial water- and gas showings" includes the following object classes:

- Hydrogeological wells (dots)
- Groups of wells (dots)
- Well clusters (dots)
- Water-absorbing wells (dots)
- Springs object class (dots)
- Groups of springs (dots)
- Mines (dots)
- Shafts/pits (dots)
- Group capping of shafts/pits (dots)
- Dry gas jets (dots)

7. Information about the set of classes of objects "Fields, resources, UW use, intake structures" includes the following object classes:

- UW fields and resources (polygons)
- Water-supply wells (dots)
- Groups of water supply wells (dots)
- Karizes and water-intake galleries (radial wells) (dots)
- Mineral water use points (dots)

8. Information about the set of object classes "Indicators and processes having hydrogeological importance" includes the following object classes:

- Fresh water lenses (polygons)
- Fresh water lenses (dots)
- Leakage water sites (dots)
- Borders of flooded buried valleys (lines)
- Flooded alluvial cones (dots)
- Swelling hummocks of "mii" type (lines)
- Borders of permafrost rock (lines)
- Spots of permafrost rock (dots)
- Isolines of permafrost rock thickness (lines)
- Hydroisotherms (lines)

9. Information about the set of object classes "Numbering" includes the object class "Numbering by nomenclature (polygons)".

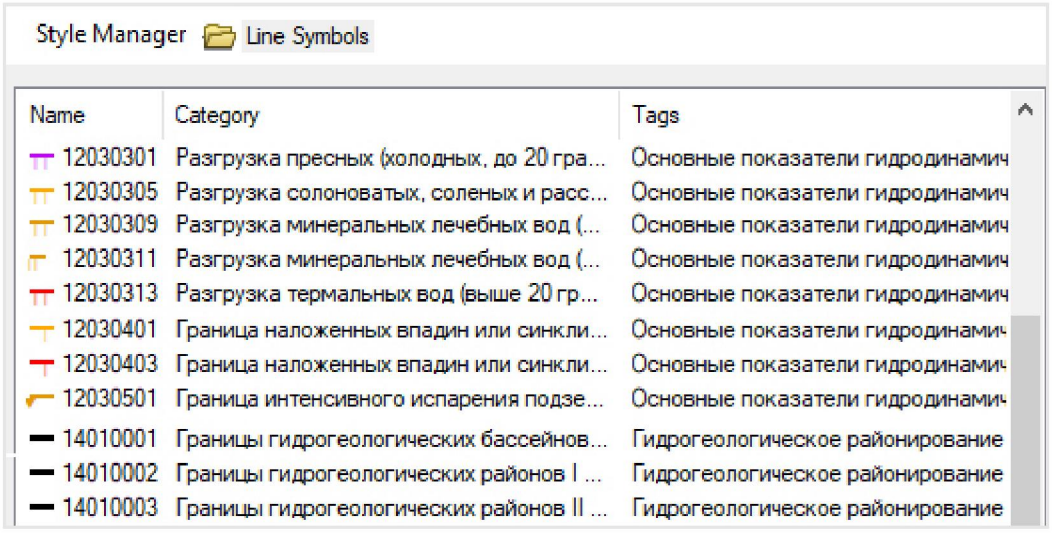
The file of styles "Hydrogeology.style" was created in ArcGIS, version 10.4.1, and contains 863 polygonal, linear and point conventional signs, as well as the styles for designing letterings on maps, headings, subheadings and legend elements [9]. The elements of the file of styles are presented in figure 1.

The library of the "Hydrogeology" style contains both conventional symbols prescribed by the 2006 instruction and "obsolete" designations of objects used in hydrogeological maps of the Soviet period.

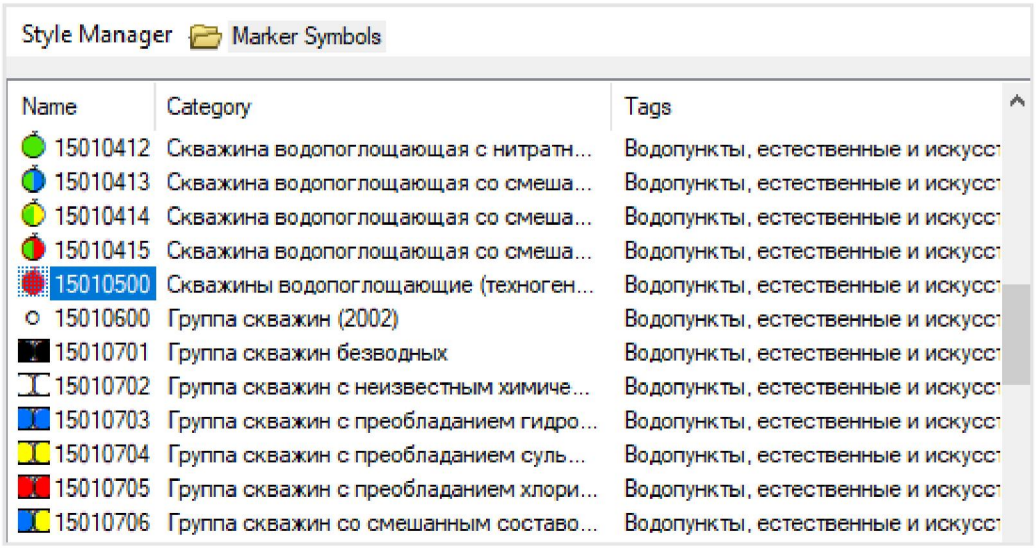
Table 1 give examples of some differences between up-to-date and "outdated" using conventional symbols and designations.

When creating point conventional signs and some types of hatching of the "Hydrogeology" style file, standard font markers of ESRI type were used. Other point conventional signs, some types of pattern and processes/objects displayed on the maps as dotted linear signs are created in ArcGIS Style Manager by combining the elements of standard font markers: ESRI AMFM Electric, ESRI Cartography, ESRI Caves 1, ESRI Default Marker, ESRI Dimensioning, ESRI Geology, ESRI Geology USGS 95-525, ESRI IGL Font22, ESRI IGL Font23, ESRI NIMA VMAP1&2 PT, as shown in figure 2.

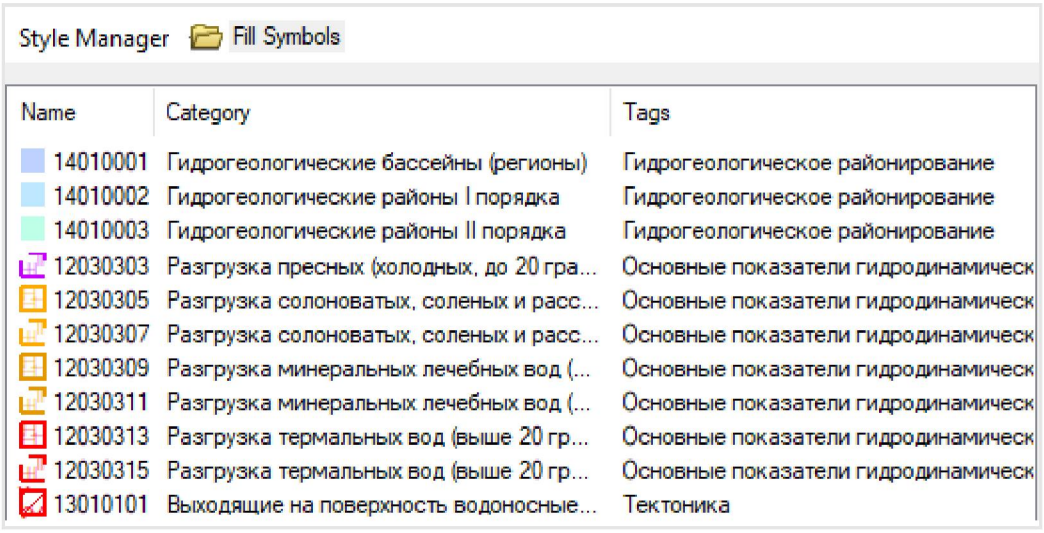
All cartographic objects of the Hydrogeology style file in ArcGIS have unique codes assigned, as shown in figure 3.



a)



b)



c)

Figure 1 – Style "Hydrogeology":
a) linear objects; b) dotty objects; c) polygonal objects

Table 1 – Present-date and outdated notation conventions on maps

Objects or phenomena drawn on maps	Notation conventions on Soviet maps	Notation conventions in accordance with the Instruction 2006
Tectonic faults	(aquiferous fault) (non-aquiferous fault) (fault hydrogeological value of which was not figured out)	(cropping out aquiferous water-absorbing) (cropping out aquiferous water-discharging) (cropping out aquiferous water-conducting) (cropping out water-resistant) (cropping out hydrogeological unexplored)

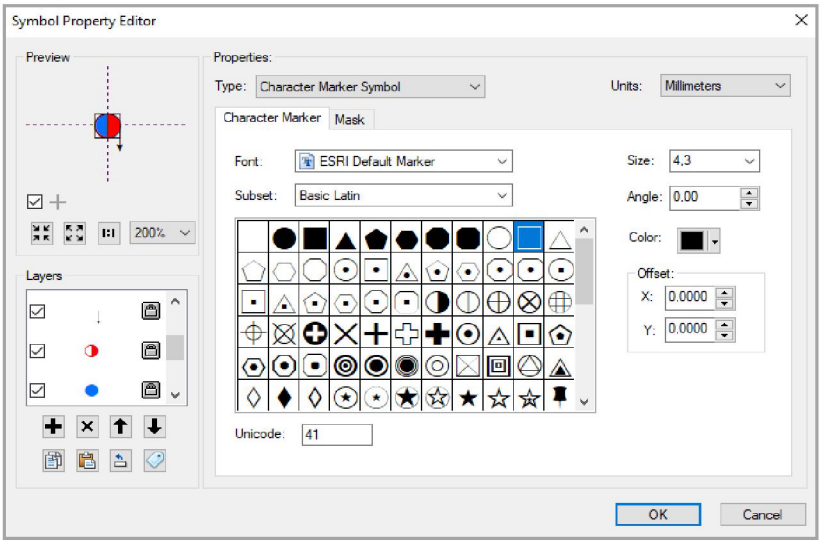


Figure 2 – Symbols creation editor

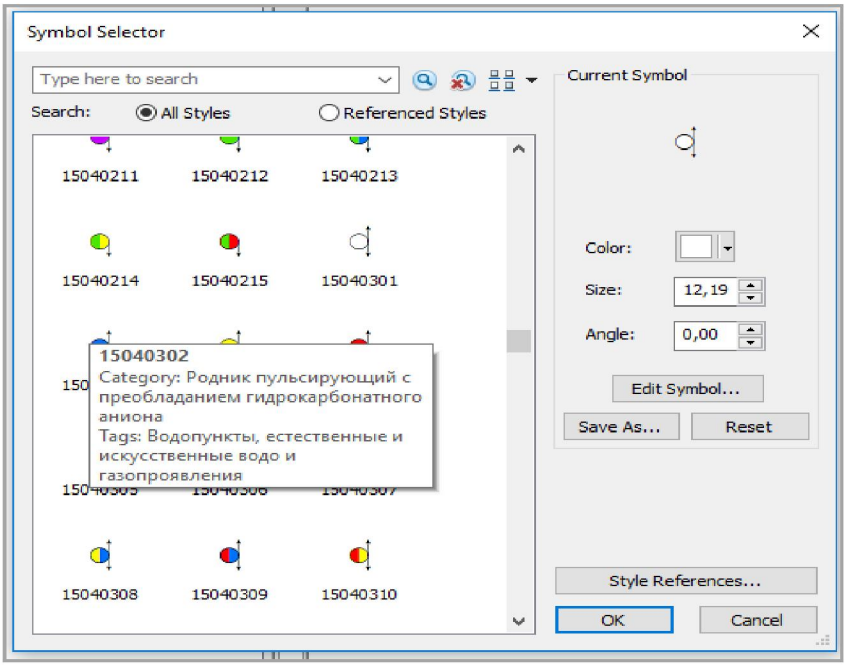


Figure 3 – Conventional symbols of "Pulsating springs" group

The unique codes of conventional signs applied in the style file correspond to the developed classifier and the geodatabase used in the sub-types and domains. The classifier is represented by an eight-digit numeric code in which each pair of characters consistently reflects information about thematic affiliation of its element, category of object, its subcategory, and the last two characters determine the unique nature of the element within the subcategory. As a result, when working with a hydrogeological map, if there is a need to show a certain class of data using conventional signs, the subtypes or domains of the attribute fields of the geodatabase with the file of styles "Hydrogeology.style" are automatically compared using the unique codes of its elements.

Conclusion. Structurization of the "Hydrogeology" style of cartographic objects in ARCGIS, use of its graphical interface and conventional signs of hydrogeological information together with a classifier and a set of attribute data, contributes to the uniformity of the digital information presented in the ArcGIS environment, which will allow specialists from a wide range of organizations using in their activities cartographic information related to hydrogeology, utilization of the technology for effective spatial analysis and data storage, and also ensure continuity archived and current cartographic information.

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ArcGIS-ДЕ ГИДРОГЕОЛОГИЯЛЫҚ ЗЕРТТЕУЛЕР НӘТИЖЕЛЕРІН ЦИФРЛАНДЫРУ

Аннотация. Кеңістіктік деректердің тұтастығын цифрландыру, біріздендіру, дамыту және қолдау мақсатында мемлекеттік геодезиялық қамтамасыз ету жүйесін жаңғырту, бірыңғай координаттар жүйесінде және деректердің бірыңғай құрылымдары бойынша карталар жасау қажет. №AP05131239 жобасы аясында геоақпараттық жүйелер көмегімен гидрогеологиялық карталарды құрылымдау бойынша ғылыми-әдістемелік негіз әзірленуде, гидрогеологиялық тақырыптағы шартты белгілер жинағы құрылды. Қазақстан Республикасында цифрлық гидрогеологиялық карталарды ресімдеудің бірыңғай әдістемесінің жоқтығына байланысты, гидрогеологиялық нысандарды біріздендіру проблемасын шешудің әдістемелік тәсілдерін әзірлеу маңызды болып табылады. Карта парақтарының сериясын құру және оларды бірыңғай шартты белгілері бар ArcGIS бағдарламалық өнімінде жұмыс істегенде пайдалану, сонымен қатар Орта Азияның басқа да елдерінде де өзекті мәселе. Бұл мақалада ArcGIS ортасында картографиялық деректердің "Гидрогеология" стилін құрылымдау кезеңі баяндалады.

Түйін сөздер: ГАЖ, цифрландыру, гидрогеология, картография, геодеректер базасы, карта.

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ЦИФРОВИЗАЦИЯ РЕЗУЛЬТАТОВ ГИДРОГЕОЛОГИЧЕСКИХ ИССЛЕДОВАНИЙ В ArcGIS

Аннотация. С целью цифровизации, унификации, развития и поддержания целостности пространственных данных необходима модернизация системы государственного геодезического обеспечения, создание карт в единой системе координат и по единым структурам данных. В рамках проекта №AP05131239 разрабатывается научно-методическая основа по структурированию гидрогеологических карт с помощью геоинформационных систем, создана библиотека условных знаков гидрогеологической тематики. Разработка

методических подходов к решению проблемы унификации гидрогеологических объектов важна в виду отсутствия единой методики оформления цифровых гидрогеологических карт в Республики Казахстан. Создание серии листов карт и использование их при работе в программном продукте ArcGIS с едиными условными обозначениями также актуально и в других странах Средней Азии]. В данной статье освещается этап структурирования стиля «Гидрогеология» картографических данных в среде ArcGIS.

Ключевые слова: ГИС, цифровизация, гидрогеология, картография, база геоданных, карта

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