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Typification of engineering and geological conditions of the city territory using GIS

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ABSTRACT: The relevance of the study is due to the rapid growth of construction of buildings and structures in large cities of the Republic of Kazakhstan over the past thirty years. An engineering-geological assessment of the area is necessary to support the decision-making process on the location of structures, as well as to ensure that the construction of facilities is carried out with less negative environmental impact, accompanied by a reduction in danger and damage to both construction, society, and the economy. As a result, it is necessary to systematize and analyze previously obtained data using modern geoinformation systems (GIS). The relevance of the introduction of GIS in geotechnical research is due to the fact that geoinformation systems and technologies allow creating, storing, analyzing, processing and providing the consumer with spatially distributed information, where the main means of communication for visualizing geotechnical data are special geotechnical maps, so how modern GIS have a wide arsenal of basic methods of spatial analysis that can and should be used to solve the problems of typification of engineering-geological conditions. The results of this work demonstrate the ability of GIS technologies to analyze engineering and geological conditions and zoning development areas according to the types of bases and foundations in such cities of Kazakhstan as Astana and Pavlodar.

1 INTRODUCTION

The formation of an information engineering-geological model of the terrain is the main task of engineering-geological research. This kind of model should contain in an analytical or synthetic form all the data necessary to solve problems related to the placement of building complexes and structures, assess the impact of engineering and geological measures on the natural environment and plan measures for its transformation. At the present stage of development, engineering-geological maps of zoning are used for this purpose, supplemented by engineering-geological sections, an explanatory note, and various tables. The methodology of creation of maps of engineering-geological zoning, developed in the main theoretical positions of N. Nikolaev & F. Savarensky (1939), I. Popov (1951, 1969), is based on consistent zoning of the studied territory on the area, increasingly homogeneous in terms of engineering and geological conditions [Tsotsur 1976].

Zoning is the main tool for flexible regulation in cities when planning urban development, which is a sustainable form of control over the use of land in settlements. Construction zoning of urban space is the division of the residential area of the city into zones with different number of storeys. One of the main goals of construction zoning is the correct placement of the main types of buildings in the city, considering the relief and engineering-geological conditions, the most economical use of the territory both in new construction and in the reconstruction of residential areas. To take into account engineering-geological factors in zoning, it is necessary to know the history of the

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development of the territory in the anthropogeny and the current state of the rocks, the main engineering-geological features of the territory that have been created throughout the history of its geological development. Today, the study and use of natural resources, rational economic development, environmental protection, and monitoring, making practical decisions related to the geological environment are impossible without reliable information support [Kozlovskii 2010].

Since the beginning of the twenty first century, there has been a tendency to use digital materials in working with paper primary sources. The problems of the accumulation, processing and storage of geological engineering information should be addressed through the introduction and improvement of automation processes and computer facilities and their subsequent development.

2 BASES OF CONSTRUCTION OF THE GEOINFORMATION DATABASE

GIS in engineering-geological surveys is considered, first, as a means of processing spatial data of the geosystem for obtaining new knowledge and presenting them in the form of special geotechnical maps. According to several authors, the introduction of formal procedures in cartographic work makes it possible to automate the daily and labor-intensive stages of mapping, thereby freeing up time for experimentation and creativity in the field of cartographic modeling and map design [Dyshlyuk et al. 2015].

GIS capabilities applicable in engineering and geological surveys:

- input, accumulation, storage and processing of digital cartographic and geotechnical information;
- construction of thematic maps based on the obtained data, reflecting the current state of the geosystem;
- study of the dynamics of changes in the geotechnical situation in area and time;
- construction of graphs, tables, diagrams;
- modeling the development of the geotechnical situation in various environments and studying the dependence of the state of the geosystem on engineering and geological conditions, characteristics of foundations and construction objects;
- obtaining comprehensive assessments of the condition of construction facilities based on various data [Alibekova 2009].

The development of the "Geoinformation Database program" provides for the collection of geotechnical survey data with its own inherent format that expands the concept of communication of databases [Zhussupbekov & Alibekova 2013].

The main management system of the Geoinformation Database program (DIG-system) has a hierarchical structure consisting of two levels and including the main functions:

1) general management function; 2) input control data function; 3) function of data extraction and processing; 4) data augmentation function.

The first level of the hierarchical structure is responsible for the general management function, which provides general management and organization of the graphic process. The second hierarchical level includes functions that perform preliminary processing of source information and provide organization of the graphic process.

The initial information used in the program is divided into the two main sections:

1. Constant datasets (local data base), included directly in program text (for example, a city map, coordinates and characteristics for obtaining graphic files) (Figure 1).
2. Initial data, prepared directly by the user from the materials of engineering and geological surveys and entered during the execution of the program (Figure 2).

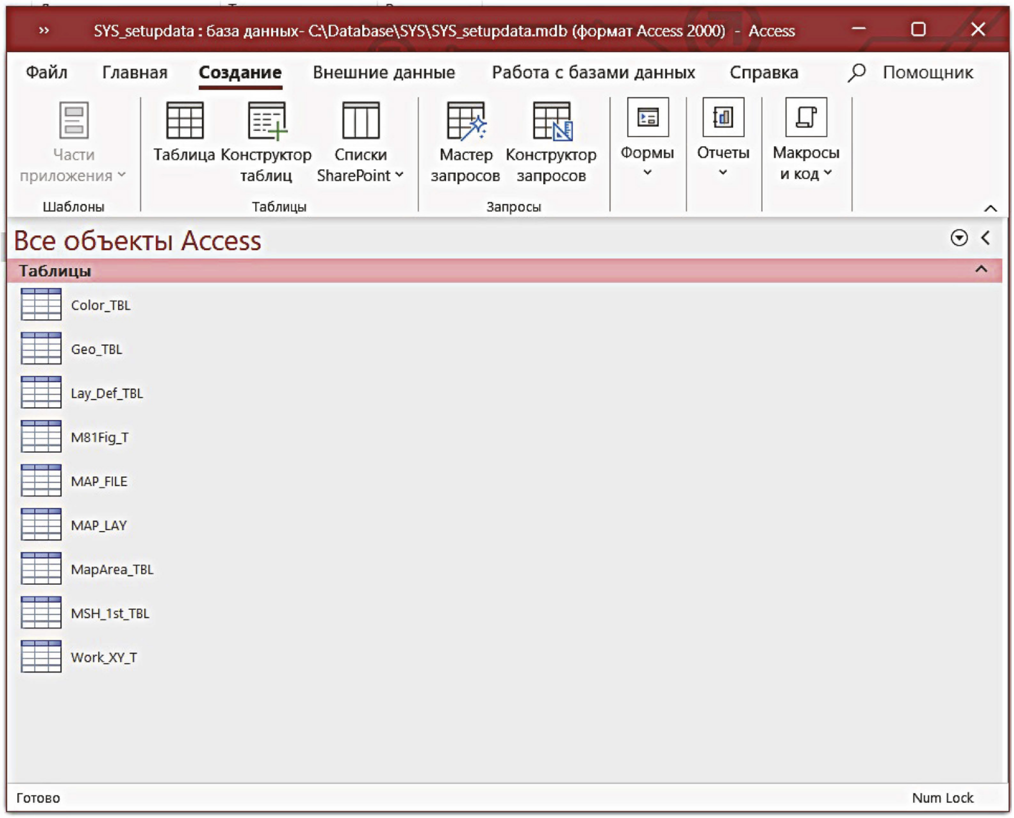

Figure 1. Local data base.

3 TYPIFICATION OF ENGINEERING AND GEOLOGICAL CONDITIONS IN KAZAKHSTAN USING GIS

3.1 *Geoinformation system for Astana*

Astana is a city in the north–east of Kazakhstan, which in 1997 received the status of the capital of the Republic of Kazakhstan and is one of the youngest capitals in the world. For less than 30 years, a modern Euro-Asian-style city has grown up on the site of a provincial town in the middle of the steppe, with skyscrapers, original architectural structures, broad avenues, and spacious areas. The super-accelerated pace of design and construction of the young capital of Kazakhstan requires targeted study, forecasting and management of geological aspects of both existing and planned buildings and structures.

In 2008, the program “Geoinformation Database of Astana” was created for the first time to evaluate engineering and geological studies of Astana (Figure 3), which allowed analyzing regional soil conditions before a detailed study. On the territory of Astana there are six main engineering-geological elements (EGE), diverse in origin and age (Figure 4) [Zhussupbekov et al. 2012].

In addition, with the help of the program “Geoinformation Database of Astana”, special geotechnical zoning maps were created by types of foundation and optimization of the lengths of driven piles for buildings of the 2nd (normal) level of responsibility, taking into account the type of foundation (Figure 5) [Zhussupbekov et al. 2012].

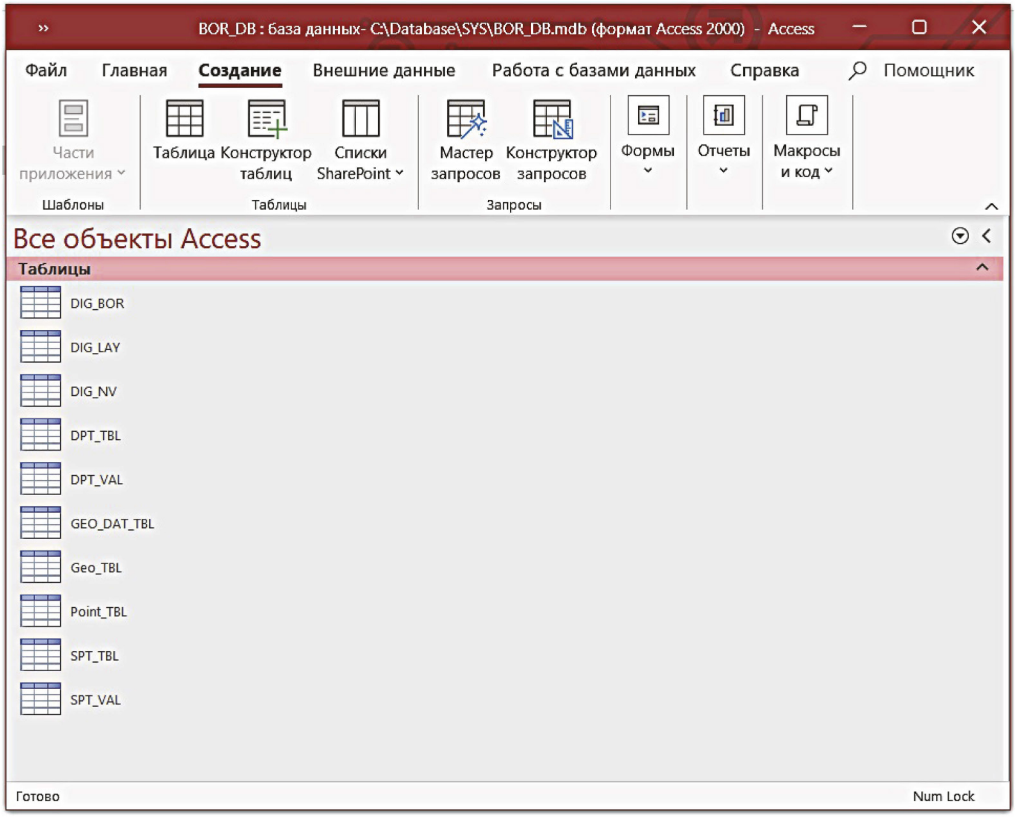

Figure 2. Source data base.

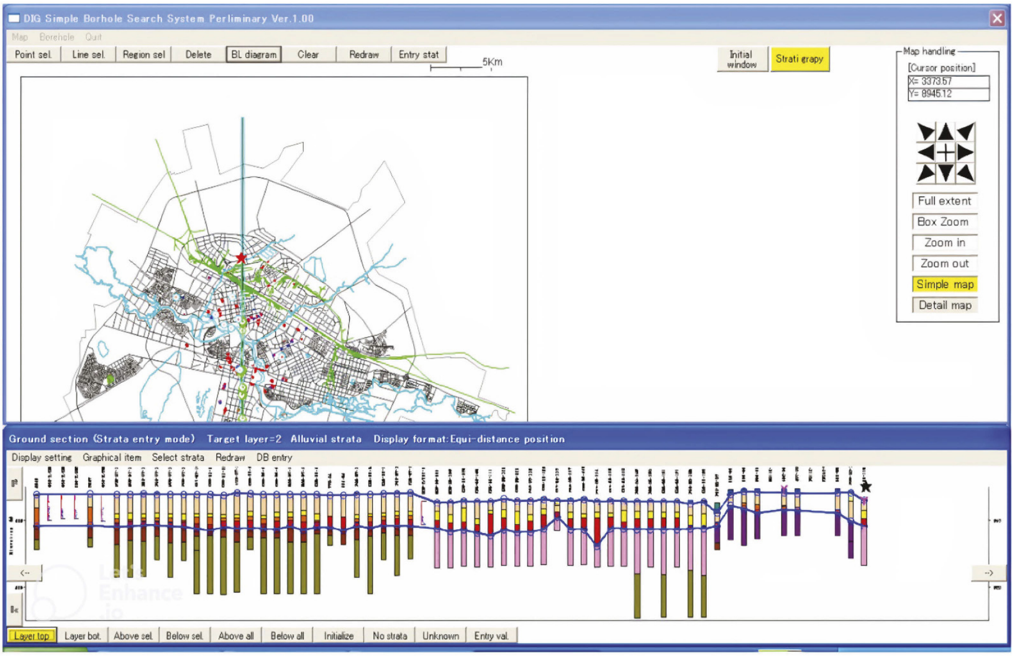

Figure 3. General view of the program "Geoinformation database of Astana".

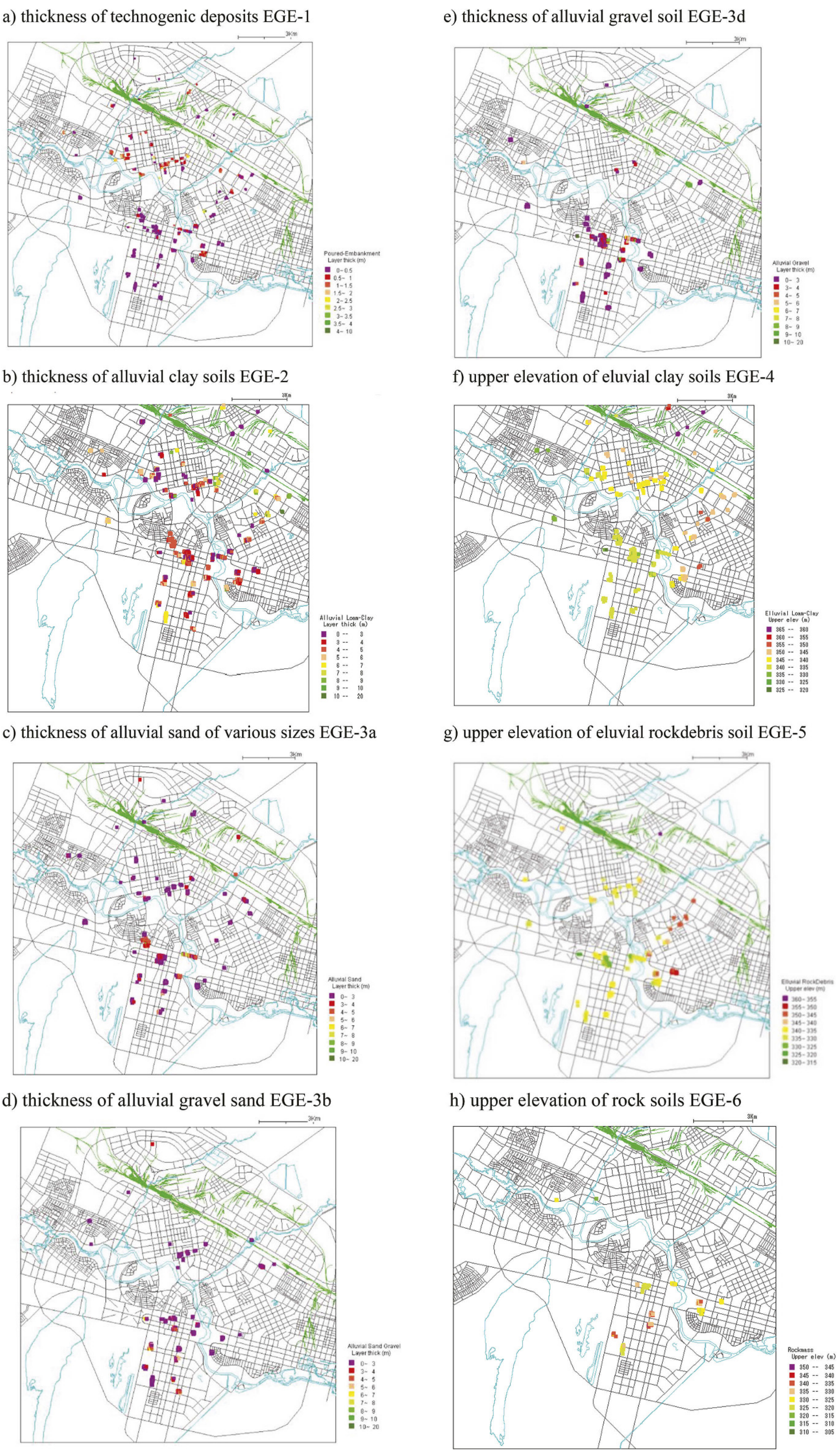

Figure 4. Engineering and geological maps of Astana.

a) geotechnical zoning map by type of foundation

b) geotechnical zoning map for optimizing the lengths of driven piles

Figure 5. Special geotechnical maps of Astana.

3.2 *Geoinformation system for Pavlodar*

Pavlodar is the center of industrial and cultural development in the Republic of Kazakhstan. It is located 450 km northeast of national capital Astana.

In 2022, for the evaluation of engineering and geological research in Pavlodar, the program “Geoinformation Database of Pavlodar” was created for the first time (Figure 6), which also made it possible to analyze regional soil conditions before a detailed study.

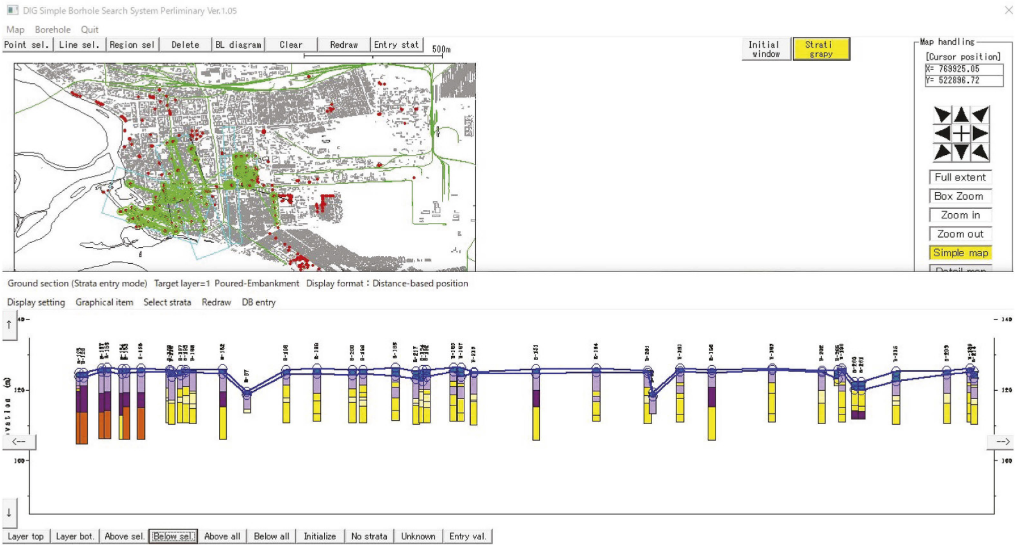

Figure 6. General view of the program “Geoinformation database of Pavlodar”.

With the help “Geoinformation Database of Pavlodar” geotechnical conditions of the city territory were analyzed five main engineering-geological elements (EGE) were identified [Abisheva 2021] and special geotechnical maps of the occurrence of soils of alluvial-deluvial deposits and lacustrine-alluvial deposits of Neogene age were built in Figure 7:

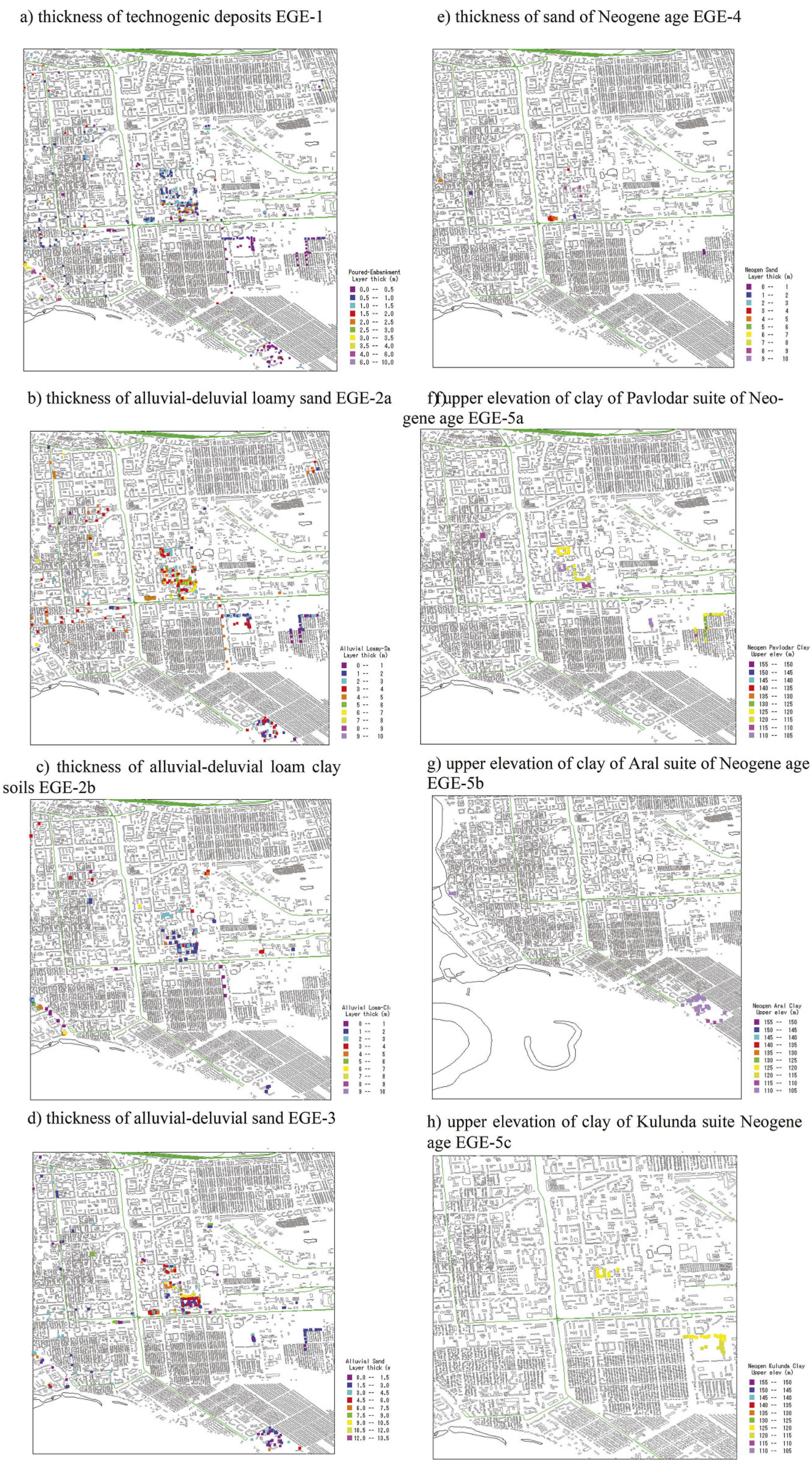

Figure 7. Engineering and geological maps of Pavlodar.

4 CONCLUSIONS

The results of the study suggest that the engineering and geological conditions of the two cities are different. The territory of Astana is represented by a diverse complex of soils, such as loams with interlayer of sandy clay loam and clays, gravel sands, medium-sized sands, silty soils, clays with lenses and layers of sandy loams, gravelly sands and gravel soils, as well sandstones, which are inter bedded with siltstones and mudstones. At the same time, it should be emphasized that groundwater in the undeveloped territories of the capital is at a depth of 5 m, and in most of the built-up areas at a depth of 0 to 2 m. From what has been said, it becomes obvious that most of the city's territory is in a flooded state, which is one of the reasons for the use of pile foundations in the construction. In turn, subsidence soils are most common in the territory of the city of Pavlodar, where the specific soil is a swelling sandy loam, from solid to fluid consistency. The groundwater of the above-floodplain terraces of the city's territory lies at a depth of 1 to 11 m, most often at a depth of 3 to 5 m.

As a result of consideration of this issue, it was found that with the help of special geotechnical maps obtained as a result of the development of geoinformation databases for the city of Astana and Pavlodar, it is possible to quickly obtain the necessary information for the purpose of substantiation when solving problems of industrial and civil construction, namely, typification of engineering-geological conditions and planning of urban development. These data not only systematize already known information, but also significantly accelerate the processing and analysis time for creating new projects, as well as significantly reduce the time and cost of exploration and design work.

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