

Victor Osipov

Abstract

An ambitious research project was implemented at the Sergeev Institute of Environmental Geoscience of the Russian Academy of Sciences in collaboration with the Moscow Geological and Geodetic Trust during 2008–2009 according to the decision of the Moscow Government. The project implied the compilation of 12 thematic geological large-scale maps for the Moscow territory to a scale 1:10,000. This work was based on the digital processing of more than 85,000 boreholes drilled in the city in different years, among which 13,000 deep boreholes penetrated in the Carboniferous deposits. This is a pioneer work in Russia, because apart from the digitizing and analysis of a great volume of drilling data, it implied theoretical and methodical studies based on modern geoinformational techniques. The resultant combined map of engineering geological zoning was based on the integration of data on the structural-geodynamic, geomorphological and geological structure, hydrogeological conditions, distribution of natural hazards and geological processes and phenomena. The map proceeds from the principle of consistent typological division of the territory into four taxonomic levels, using the index method naming of taxa of different rank. The performed complex analysis of engineering geological conditions permitted us to distinguish three degrees of complexity for construction, which should be taken into account at the early stages of designing subsurface and surface urban engineering structures.

Keywords

Large-scale mapping • Drilling data • Engineering geological zoning • Geohazards • Urban area

2.1 Introduction

In March 2007, the Moscow Government issued the decision “About compilation of thematic geological large-scale maps for the Moscow territory”. During 2008–2009 the project was performed under the guidance of GUP Mosgorgeotrest (Moscow Geological and Geodetic Trust) with the scientific and methodical support by the Sergeev Institute of Environmental Geoscience RAS. More than 85 thousand borehole records from the Moscow geological database were

analyzed, 25 thousand of them having been digitized. On the basis of data generalization and processing (without any additional survey), 12 specialized large-scale maps were compiled for the territory of Moscow: Structural and geodynamic map; Map of facts; Carboniferous deposits; preQuaternary deposits; Quaternary deposits; technogenous deposits; Hydrogeological map; Map of podol’sko-myachkovskii aquifer protection; karst and karst-suffosion hazard; landslide and waterlogging hazard; seismic microzoning; and the resultant synthetic Map of engineering geological zoning. All maps are informationally interrelated. The total volume of work covered more than 700 standard map sheets of A0 size.

The work of this kind has been performed in Russia for the first time; it is an innovative research, because apart from the analysis of huge data volume, it implied the development

V. Osipov (✉)
Sergeev Institute of Environmental Geoscience, Russian Academy
of Sciences, Ulanskii per, 13, bld. 2, Moscow, 101000, Russia
e-mail: direct@geoenv.ru

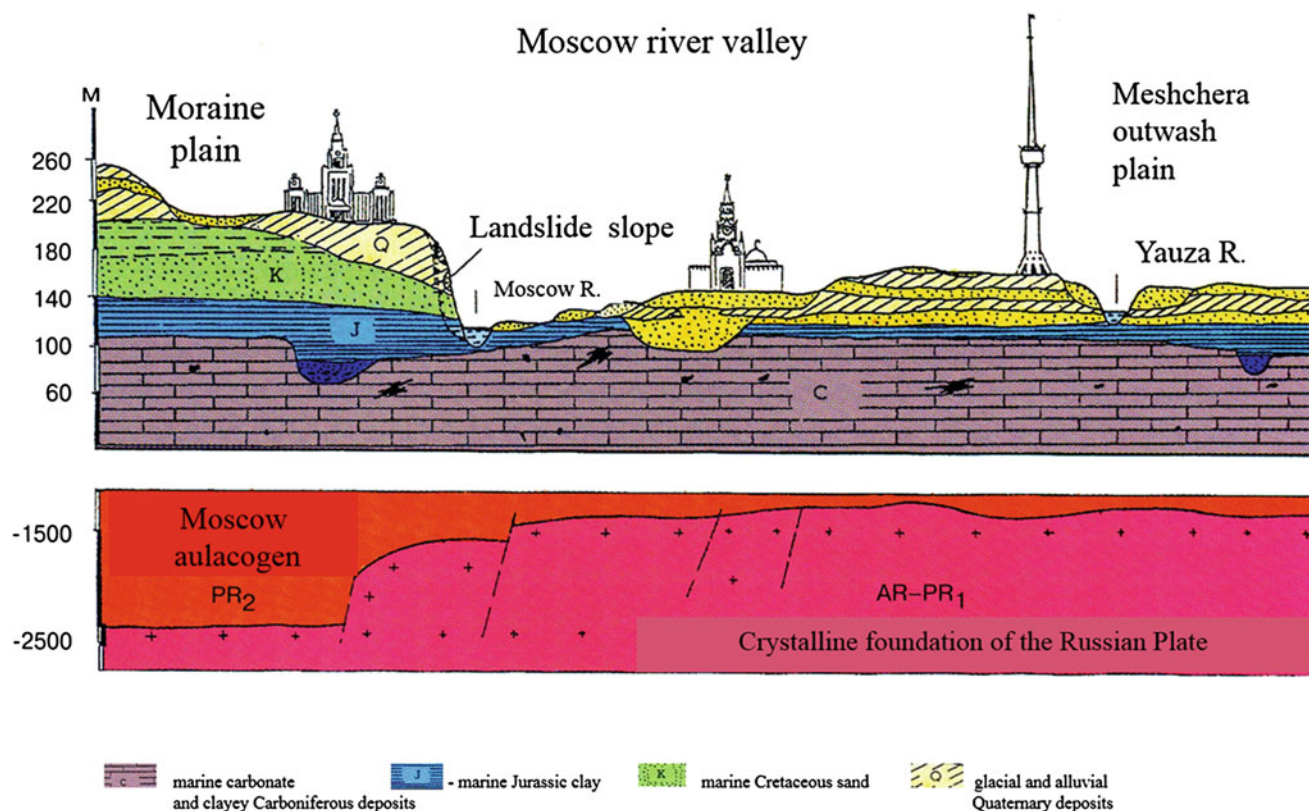


Fig. 2.1 Schematic geological cross-section of Moscow territory

of theoretical and methodological fundamentals implemented on the basis of the newest achievements in fundamental science with the application of up-to-date GIS techniques.

It appears impossible to describe the content of all maps compiled in a small report. Therefore, let us dwell on the principal features of geological structure of Moscow revealed in the course of this work.

2.2 Geoenvironmental Conditions of Moscow Territory

2.2.1 Geological Structure

Within the Moscow territory, the upper part of lithosphere to a depth of 150 m is composed of three series of rocks from the bottom upward: (a) carbonate-clay deposits of Carboniferous age; (b) Mesozoic clayey-sandy deposits of Jurassic and Cretaceous age; (c) Quaternary deposits (Fig. 2.1) (Moscow. Geology and the city 1997). As a result of mapping, the geologic large-scale maps of Carboniferous, pre-Quaternary and Quaternary deposits have been compiled for the first time. These maps formed the basis of Moscow

territory zoning by the engineering geological conditions, which is acute in particular in connection with high-rise and subsurface construction.

2.2.2 Modern Geodynamics

For the first time, the structural geodynamic map of Moscow has been built, that shows the neotectonic structures imprinted in modern topography (Makarov 1997). These structures form two groups of blocks undergoing either relative submerging or uplifting (Fig. 2.2). It is important that the boundary zones between blocks do not represent classic tectonic faults, as no discontinuities appear at the contacts between blocks due to small amplitudes of displacement. Scores of geological cross-sections have been built. None of them has registered either vertical or horizontal displacements or rupture of the Earth's crust. However, on the contacts between blocks in places of stress concentration, there are the zones of elevated fracturing, which play an important part in the geological conditions of territory. Various exogenous processes, intense erosion, various geochemical anomalies (high concentrations of radon, hydrogen, etc.) are confined to these zones.

Fig. 2.2 Geodynamic map of Moscow

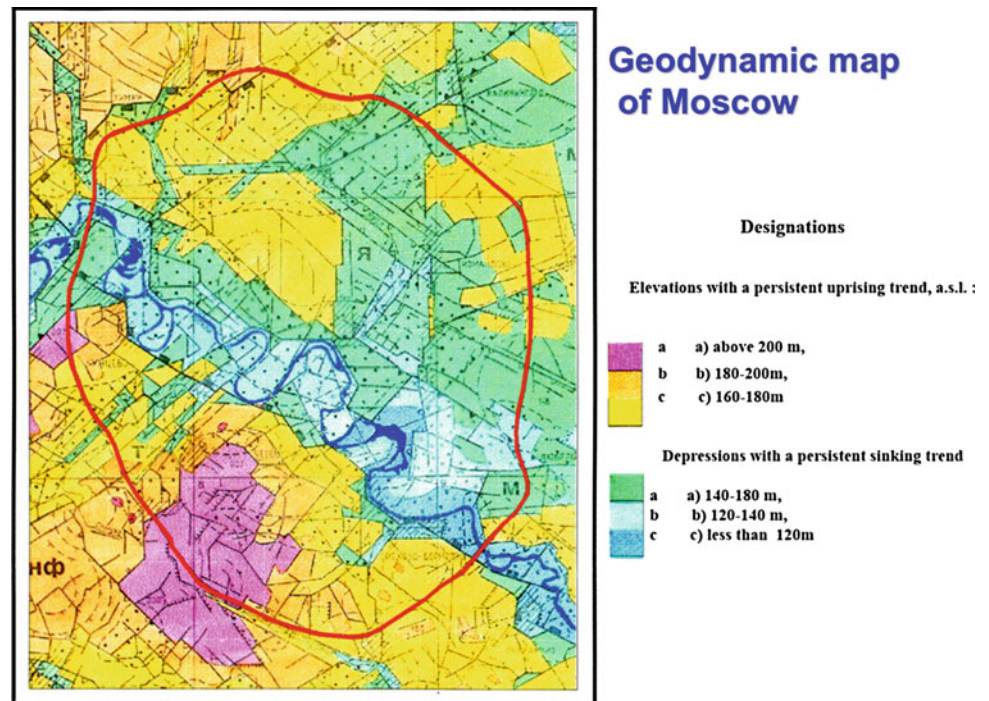
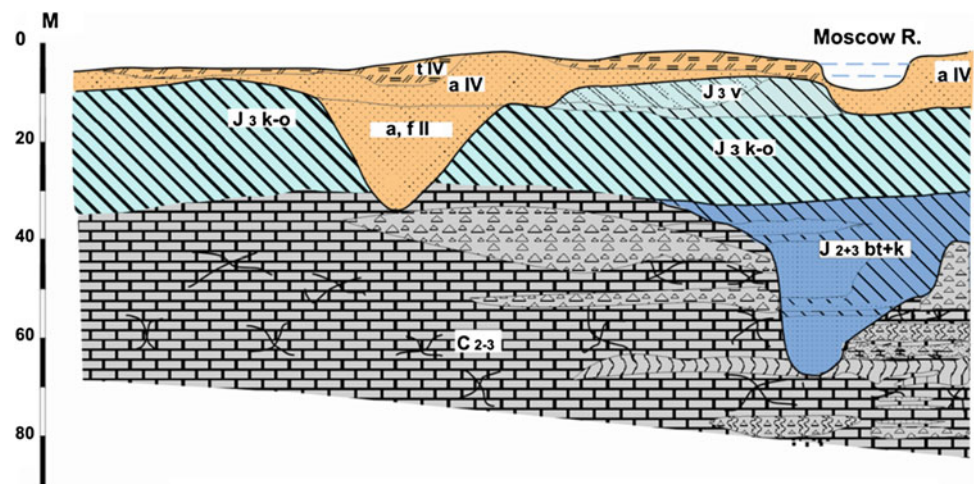


Fig. 2.3 Geological cross-section across the Moscow river valley from Grebnoi canal to Serebryani Bor district



2.2.3 Seismicity

The Moscow area belongs to seismic regions, where no strong destructive earthquakes can occur. However, the high-rise construction demands performing the seismic microzoning, because the coincidence of the own vibrations of high-rise buildings and the low-frequency seismic oscillations may produce resonance. As a result of seismic microzoning, four seismicity zones have been distinguished within the Moscow area ranging in intensity from 4 to 5.5 (MSK-64). This proved once again that the intensity of local earthquakes in Moscow cannot exceed 4. The centers of earthquakes that are registered in Moscow are located mainly in the Vbranch zone (Romania).

2.2.4 Ancient Erosional Channels

Two continental stages existed in the geological history of Moscow territory: the first one lasted since late Carboniferous till middle Jurassic epochs, and the second one lasted during the entire Cenozoic era until the Quaternary period. Both continental breaks were accompanied by the formation of ancient relief with deep erosional channels (Fig. 2.3).

For the first time, using the 3D modelling, the ancient topography was mapped that existed in the Moscow area more than 1 billion years ago. The erosional channels are well pronounced in these models (Fig. 2.4). These buried erosional channels give birth to problems upon driving deep tunnels in limestones. The buried erosional channels are

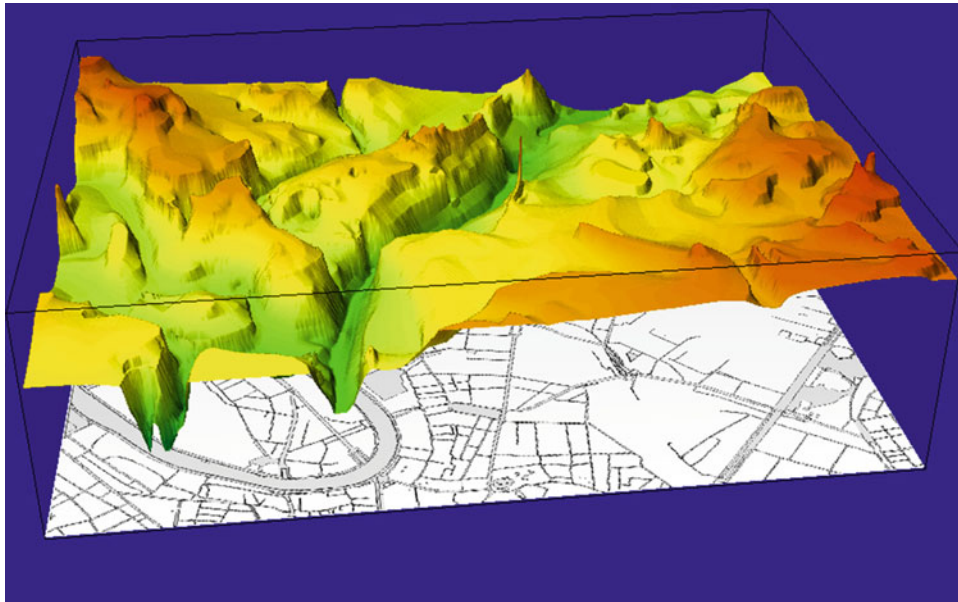


Fig. 2.4 A 3D model of preQuaternary deposits roof in the central part of Moscow

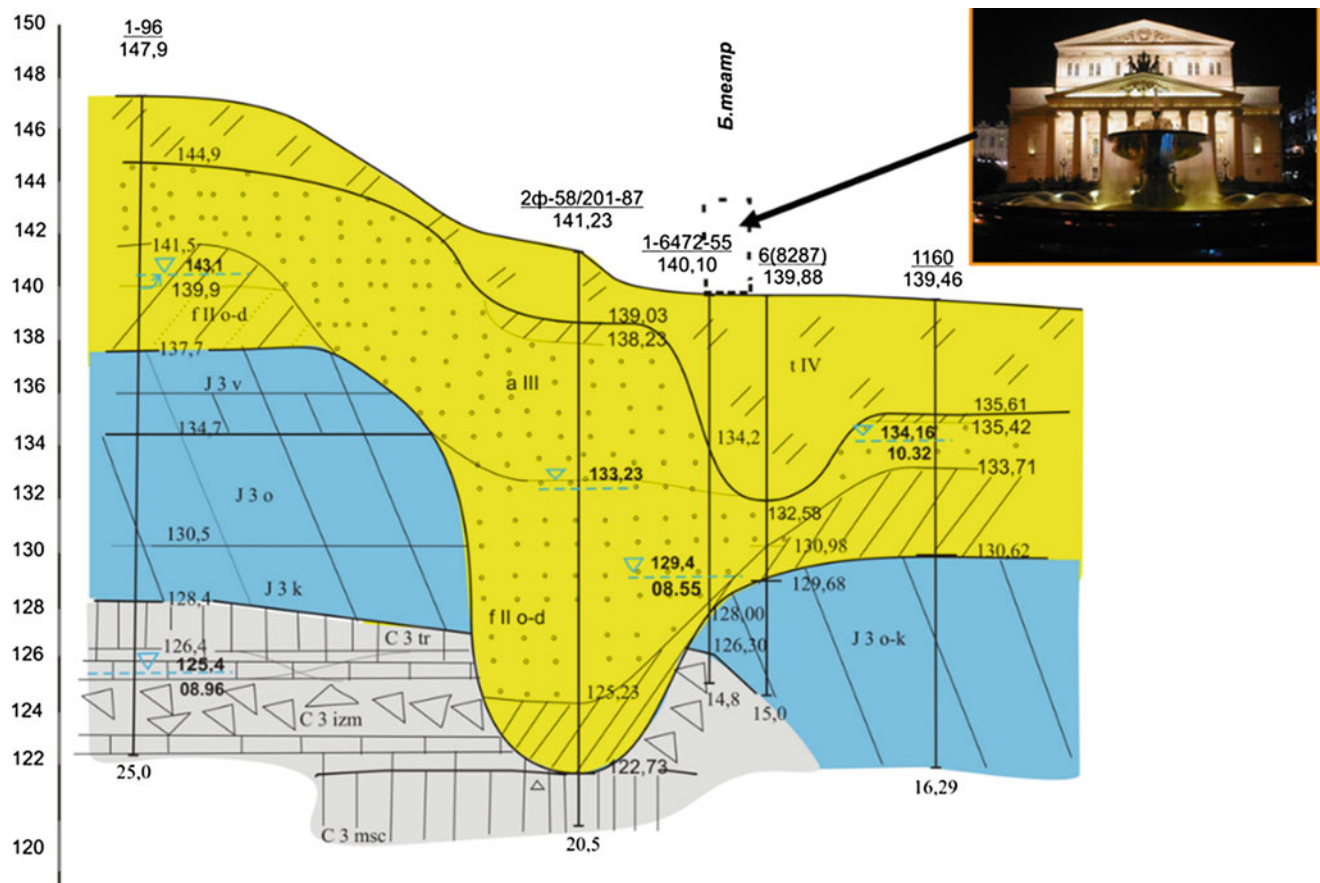


Fig. 2.5 “Hydrogeological window” in the area of Bolshoi Theater (the centre of Moscow)

The first map shows the development of waterlogging and landslides. The following areas are distinguished: permanently waterlogged areas, where the groundwater table occurs at a depth of less than 3 m (14 % of Moscow territory); seasonally or temporarily waterlogged areas, where groundwater level occurs at a depth of up to 5 m (14 % of Moscow territory), and not waterlogged area (72 %).

Landslides mainly develop in the Moscow river valley; 15 landslide sites are distinguished on the river banks.

Karstification of rocks and formation of karst-suffosion sinkholes represent the greatest hazard. A special map for assessing this hazard was compiled. By the degree of these processes development, the Moscow territory was subdivided into hazardous, potentially hazardous and nonhazardous sites. The ratio between the areas of three categories is the following: (a) by the karstification of rocks: hazardous sites—2 %; potentially hazardous sites—77 %; and nonhazardous sites—21 %; (b) by the formation of modern karst-suffosion sinkholes: hazardous—1 %, potentially hazardous—16 % and nonhazardous—83 %.

2.3 Engineering Geological Zoning of Moscow Territory

The resultant map of engineering geological zoning in essence summarizes the entire information shown in the above-mentioned maps. In the map, above 3,600 sites of engineering geological massifs are distinguished, each of them having been indexed in a certain way. The code index encompasses the entire information about the site (geodynamic position, geomorphology, geological structure, hydrogeological conditions, and developed geohazards) (Fig. 2.6). All designations in figures and letters are deciphered in the map legend. This map provides at once the general idea about the geological conditions typical to the certain area, which permits making timely expert assessment of geoenvironment status.

On the basis of compiled analysis of all engineering geological conditions, the map allows us to make the preliminary assessment of the distinguished engineering geological conditions. The complex engineering geological conditions are colored in red (11 %), moderate conditions are colored in yellow (45 %) and simple conditions are shown in green (44 %) (Fig. 2.6). From practical viewpoint, the map of engineering geological zoning is the most important document, which should be taken into consideration upon working out the General Plan of Moscow urban development, upon district and detailed planning, as well as upon solving other problems in urban development (Osipov 2001).

2.4 Conclusion

The study of geological structure of Moscow territory and its large-scale engineering geological zoning gives the most valuable data for rational planning and use for construction. The zoning permits experts to obtain the preliminary data on the geological structure and hydrogeological conditions of the site under development and the adjacent areas. It also permits revealing the presence of geohazards, and allows to determine preliminarily the necessity of engineering protection, and to elaborate the program of detailed engineering geological study.

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