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Assessment of Geothermal Resources Potential in Regions of Russia, Using GIS Technologies

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ABSTRACT

Russia, due to its unique geographical location, has a significant potential of renewable energy resources. Geothermal resources are available in Kamchatka, the Kuril Islands (Sakhalin region), Krasnodar region, and the Republic of Dagestan.

The implementation of geothermal energy projects requires an assessment of feasibility and efficiency of local geothermal resources use for energy power supply in the particular regions. To tackle this issue, a large amount of data should be processed. It should address the necessity and possibility of geothermal resources use within the particular territory, energy infrastructure, energy balances, description of geothermal fields, etc. Use of GIS-technologies is an effective tool to solve this complex problem.

A common characteristic of the data on geothermal resources in Russia is its fragmentation and inaccessibility. The GIS database "Renewable energy sources of Russia" was developed by the Laboratory of Renewable Energy Sources (Faculty of Geography, Lomonosov Moscow State University) and the Joint Institute of High Temperatures of the Russian Academy of Sciences. It is focused on serving a wide range of stakeholders: professionals, students, investors, regional governments, commercial structures etc. This paper presents an attempt in structuring information on geothermal resources based on the particular region of Russia, the assessment of resource potential and the experience of geothermal resources mapping.

1. INTRODUCTION

There are some locations in Russia, compared with the European countries, USA and others, where geothermal and other renewable energy resources could find a wide usage: centralized power supply systems cover only 1/3 of the Russian Federation territories (**Figure 1**); for 70 % of the territory with a population of about 20 million people, the power supply of consumers is carried out mainly by means of independent power installations working on expensive imported liquid fuel or using local resources (coal, wood fuel, peat, etc.); only about 50 % of the cities and about 35 % of rural settlements are connected to the gas network. Further, some consumers, including some of those who are located in a zone of centralized power supply, prefer their own electro- and heat supply sources in the existing economic circumstances, and this in some cases results in irrational use of organic fuel and a deterioration of the ecological system (Fortov and Popel, 2011).

Figure 1: Types of energy supply in Russia (Fortov and Popel, 2011).

The Russian Federation has a considerable potential of renewable energy resources. The geothermal resources of Kamchatka, the Kuril Islands and the Northern Caucasus have the highest potential in Russia.

The implementation of geothermal energy projects requires an assessment of feasibility and efficiency of local geothermal resources use for energy power supply in the particular regions. Wide amount of data should be attracted to solve this problem. It should address the necessity and possibility of geothermal resources use within the particular territory, description of geothermal fields, energy balances, energy infrastructure, etc. Therefore, it is necessary to use the analysis tools that allow collecting these data sets and convert them. Use of GIS-technologies is an effective tool to solve this complex problem.

2. THE WORLD EXPERIENCE OF GEOTHERMAL RESOURCES GIS-MAPPING

Presently geoinformation mapping is widely used in the world to assess the geothermal resources potential. Static and interactive maps are used for geothermal resources assessments in many countries. In recent year, they have used geoinformation tools that allow analyzing and making predictions.

Maps of geothermal resources are different in terms of territory coverage:

- global (example: Distribution of the world's geothermal energy production by country http://geothermal.marin.org/geomap_1.html);
- national (example: Geothermal Map of North America http://smu.edu/geothermal/2004NAMap/2004NAmap.htm);
- regional (example: Map of Oregon geothermal data http://www.oregongeology.org/sub/gtilo).

Also, maps of geothermal resources are classified by content into the following groups:

- maps of geothermal energy projects location (example: US Geothermal Projects and Resource Areas http://geoheat.oit.edu/dusys.htm);
- maps of hydrothermal deposits and promising deep geothermal systems (example: Locations of Identified Hydrothermal Sites and Favorability of Deep Enhanced Geothermal Systems of the United States http://www.nrel.gov/gis/geothermal.html);
- maps of the temperature distribution at depth (example: Thermal Springs in the United States http://maps.ngdc.noaa.gov/viewers/hot_springs).

Geothermal energy resources with different levels of detail and a range of data are presented in a number of GIS maps. For example, the maps which show existing and developing geothermal power plants, geothermal resource potential estimates and other information related to geothermal power are represented in GIS maps that were made by National Renewable Energy Laboratory of U.S.A. GIS “Renewable energy sources of South Korea”, which map the geothermal energy resources of that country, was developed by Korea Institute of Energy Research (kredc.kier.re.kr/kier_eng/index.asp). The map creating options for any given area within a state indicating the optimal points for the construction of heat pumps is available in GIS “Renewable energy atlas of Vermont” http://www.vtenergyatlas-info.com/geothermal. The map is accompanied by an indication of the assessment methodology and input data sources for the calculations.

Questions of geoinformation mapping of geothermal energy resources are also considered in the paper Rafikova and Teterina (2011).

The following problems are relevant in terms of mapping and development of GIS on geothermal energy:

1. obtaining an assessment of geothermal resources potential. Data is often not publicly available because of its commercial nature and other reasons. Furthermore, now high costs of exploration drilling make it difficult to conduct such research. This means that for the geothermal assessment for Russia it is optimal to assess only those areas where real promising customers of that energy are situated. In many cases, the results of extensive previous research and suspended wells can be used in assessments.
2. definition of geothermal energy resources characteristics which are in demand in both the designing objects, and in the conduct of simple estimates for ordinary customers in GIS.

3. FEATURES OF DATA ON GEOTHERMAL RESOURCES IN RUSSIA

The complication of the mapping and introduction of geothermal energy resources data to GIS is explained by their fragmentation and inaccessibility. Usually geological maps and their explanatory notes are not publicly available in Russia.

The most important general works on modern Russian geothermal energy, including the resource base, are the works of Povarov and Tomarov (2006). The subject of Russian territory zoning in terms of geothermal resources reserves was developed by Belousov, Postnikov, Melnikov and Belousova (2005). A detailed overview of methods for assessing the geothermal resources potential is presented in this paper.

Conditions of various types of geothermal sources formation, methods of their stocks assessment, physico-chemical properties of the North Caucasus region thermal water, and scientific and technical problems of geothermal resources development are considered in the monograph of Alhasov (2008). Particular attention is paid to forecast resources of geothermal fields in promising Russian regions. The subject of different geothermal resources using technologies in economic activities are also covered in detail there. The Russian thermal resources geochemistry problems are thoroughly discussed in the monograph of Kononov (1983).

The richest and most mastered Russian region in terms of geothermal fields use is Kamchatskiy krai. The wide range of geothermal resources using aspects in this region is fully reflected in the work of Sugrobov (1976). The results of the Kamchatka thermal water balneological characteristics study are discussed in the work of Lodis and Semenov (1993). Wide range of field survey results conducted on the Kamchatka peninsula territory are represented in the work of Piip (1937).

A more detailed literature review on the Russian geothermal resource is given in the paper of Teterina and Rafikova (2011).

4. GIS “RENEWABLE ENERGY SOURCES OF RUSSIA”

As it was mentioned, the geothermal resource data in Russia are fragmented and difficult to access, so any person or company (specialists, investors, management organizations, etc.) must have tools that allow them to assess the primary estimates of resources, project profitability, potential environmental impacts of the project work. To create such kind of tool, the geoinformation system “Renewable energy sources of Russia” has been developed by the Laboratory of Renewable Energy Sources (Lomonosov Moscow State University, Faculty of Geography) and the Joint Institute of High Temperatures of the Russian Academy of Sciences since 2010. It has become one of the first GIS-projects on renewable energy in Russia. The following data are currently presented on the site of the project www.gis-vie.ru:

- maps of solar, wind and bioenergy characteristics distribution, maps of some technical characteristics (for example, a probability of hot water supply loading by means of solar water-heating installations of set capacity);
- information on objects and projects of renewable power in Russia with a short description (**Figure 2**);
- tables with characteristics of bio- and geothermal energy sources;
- procedures of some renewable energy characteristics calculations;
- the atlas of solar energy resources for the Russian Federation territory;
- etc.

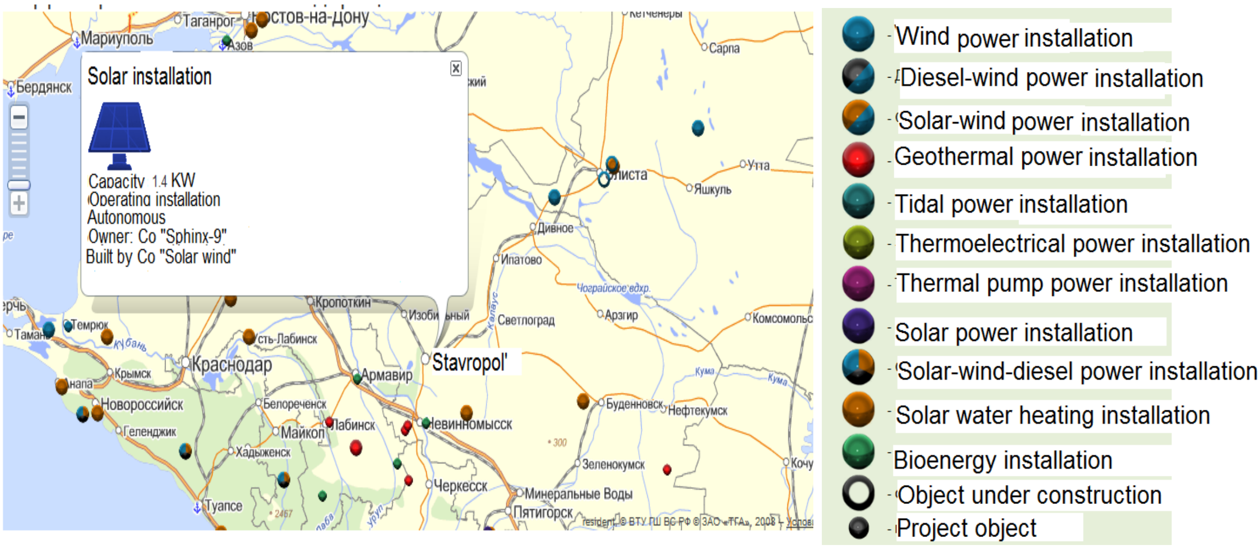

Figure 2: Objects and projects of renewable power in Russia. Screenshot of GIS "Renewable energy sources of Russia".

More information on this GIS project can be found in the article Kiseleva, Rafikova and Shakun (2012).

On geothermal energy the following data are presented in this GIS:

- a map of geothermal power plants and heat pump systems (both projected systems and those already in service are mapped);
- characteristics of geothermal fields that are situated in Russian regions and that have greatest thermal water potential: Kamchatka, the Kuril Islands, the North Caucasus (characteristics of the geothermal fields functioning, geochemical and energy characteristics, special features of geothermal fields location, etc.).

In addition, the authors have compiled a series of geothermal fields location maps and their significant characteristics for the richest region of Russia - the Kamchatka peninsula (**Figures 3, 4, 5**). Because of objective failure and inaccuracy of the fields location data, the problem of mapping was solved in fully by digitizing various existing thematic maps and analysis of the available descriptions fields.

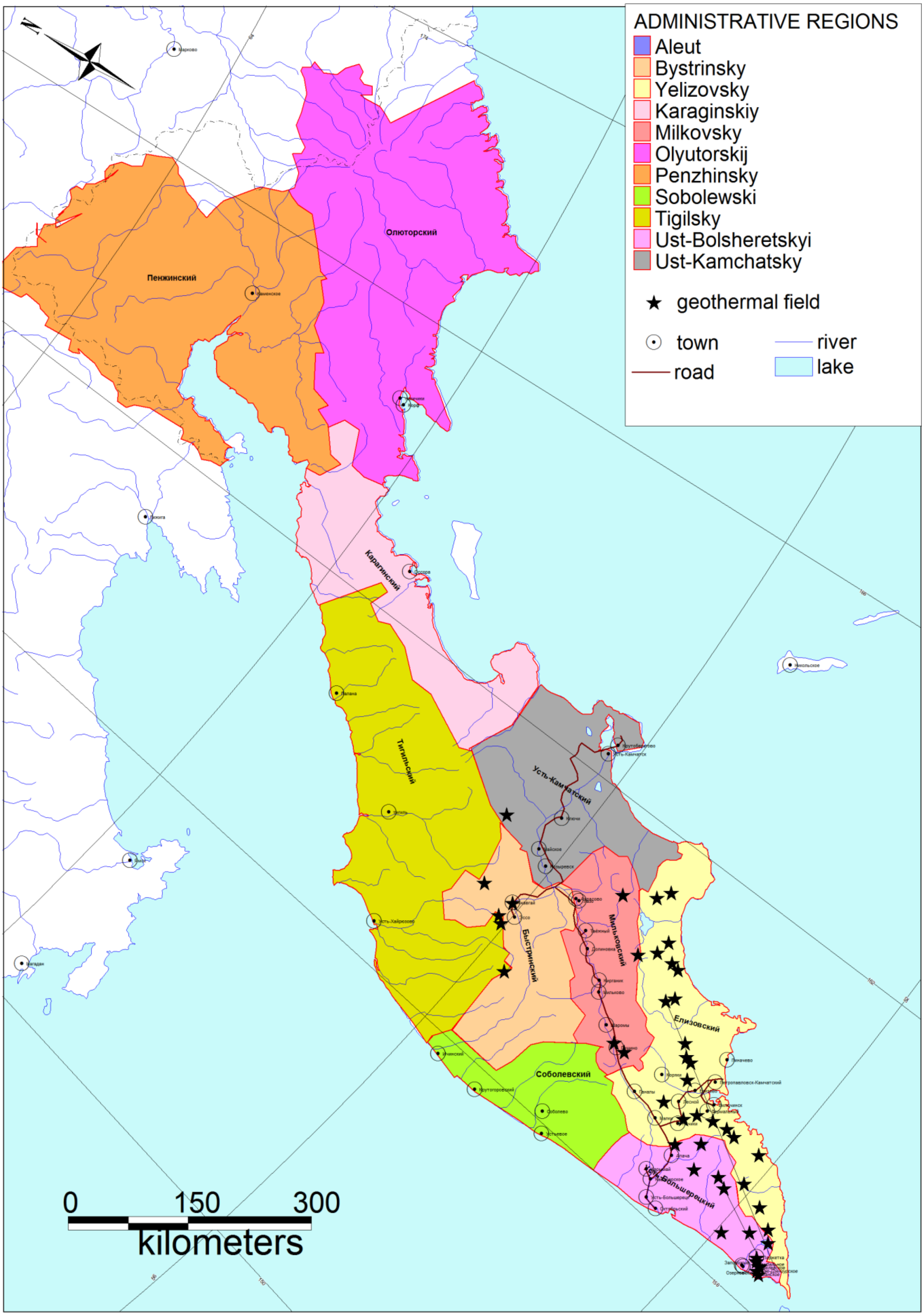

Figure 3: A map «Location of geothermal fields in Kamchatka».

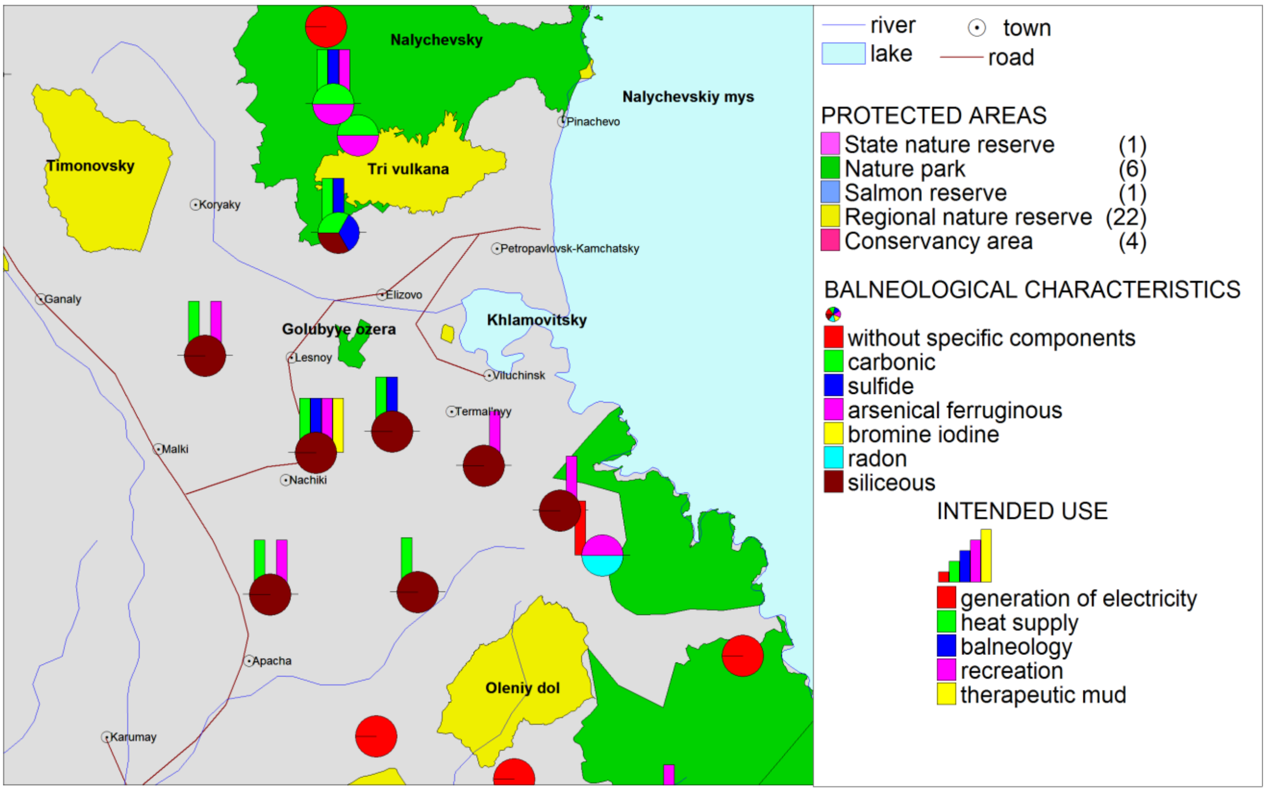

Figure 4: Fragment of a map «Intended use and balneologic characteristics of geothermal fields in Kamchatka».

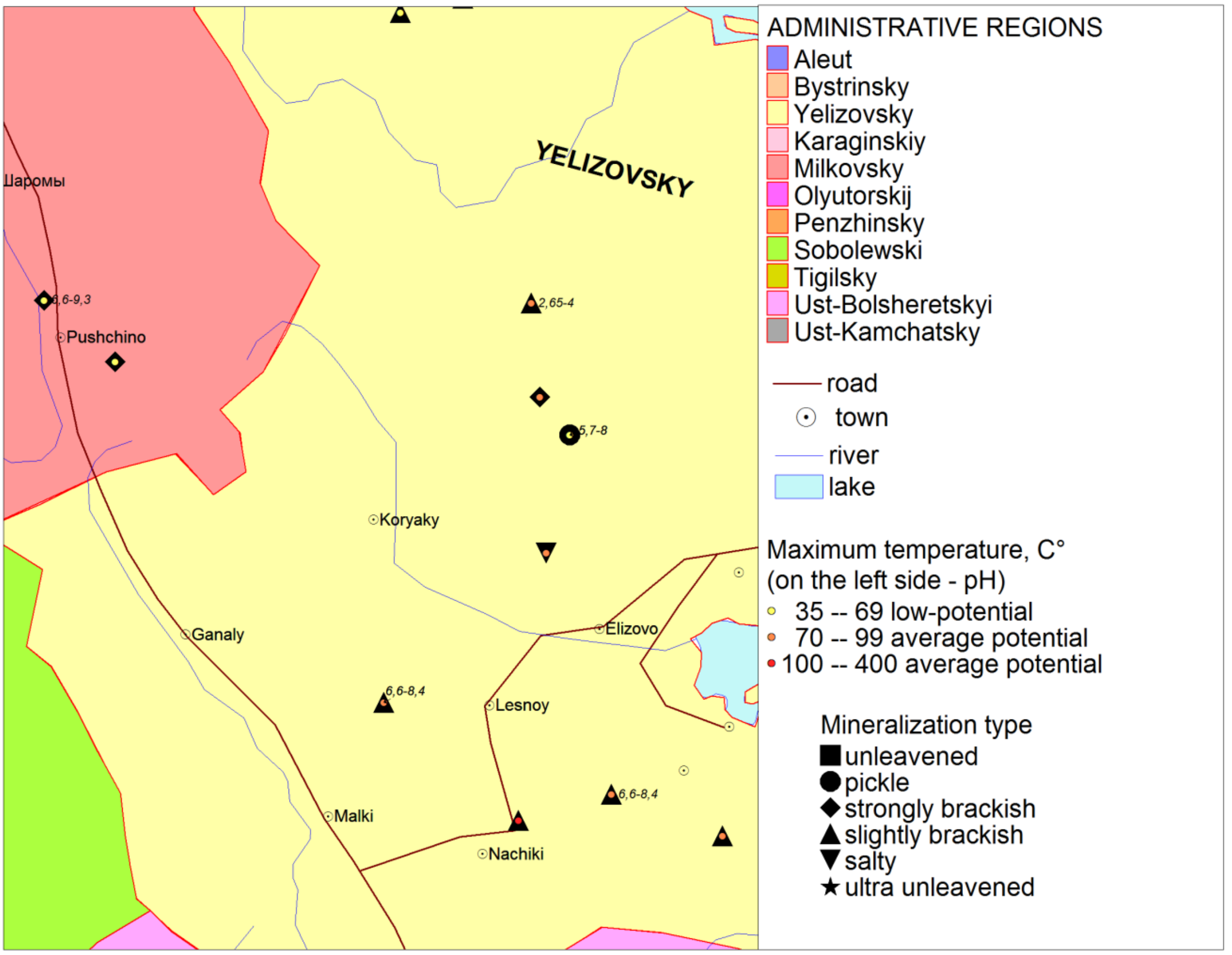

Figure 5: Fragment of a map «Physical and chemical characteristics of geothermal fields in Kamchatka».

The developed maps can be the basis of regional spatial planning in the energy field. It should be noted that the development of renewable energy is usually observed in Russia nowadays at the regional level through regional programs and local regulations and laws.

The next step in the course of more accurate and detailed region estimates could be an analysis of the potential customer distribution, their distance from the prospective geothermal energy objects, forecasting demand. It is possible to start more expensive large-scale research after that.

Some ways to optimize the use of natural resources of Kamchatka through development of geothermal resources are presented in the paper Teterina, Kiseleva and Nefedova (2011). In particular, the possibility of utilizing the Kamchatsky Krai village Ozernovsky geothermal resources was shown in order to optimize the use of natural resources and the improvement of social conditions.

5. CONCLUSION

In Russia, installing renewable power in the territories of independent power supply, is promising and appealing. For geothermal energy development, the most promising Russian regions are Kamchatka, the Kuril Islands and the Northern Caucasus.

The potential estimates of geothermal resources have to be based on drawing up and thorough analysis of multi-scale dynamic cartographic materials. Geoinformation mapping and GIS are the most widely available and accurate tools for geothermal energy development at this stage of Russian renewable energy progress.

GIS "Renewable energy sources of Russia ", which is publicly available, provides information about the different characteristics of geothermal resources for the most promising Russian regions. On this basis, the user can carry out preliminary assessments of the prospects of these resources for the production of heat, electricity and other purposes.

The maps compiled by the authors are the primary stage of Kamchatka geothermal resources regional estimates which is one of the most promising regions for the geothermal energy development.

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