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© T. Hrebeniuk[1], L. Shaidetska[1], V. Bronytskyi[1], E. Shukurlu[1]
[1] National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, Ukraine

ASSESSMENT OF MINERAL RESOURCES FOR YUKON'S GOLD MINING DISTRICT USING GIS TECHNOLOGIES

© Т.В. Гребенюк[1], Л.В. Шайдецька[1], В.О. Броницький[1], Е. Шукюрлю[1]
[1] Національний технічний університет України «Київський політехнічний інститут імені Ігоря Сікорського», Київ, Україна

ОЦІНКА МІНЕРАЛЬНИХ РЕСУРСІВ ЗОЛОТОВИДОБУВНОГО РАЙОНУ ЮКОНА З ВИКОРИСТАННЯМ ТЕХНОЛОГІЙ ГІС

Purpose. To was to develop a methodological approach to the assessment of mineral resources of the Yukon gold mining region using modern geoinformation technologies (GIS).

The methodology used: 3D modeling of mineral deposits.

Results. A visualization of a mineral map was created using a geoinformation model of the deposit. A cartographic analysis of the Yukon gold mining region was performed, including a detailed location of deposits and potential mining areas. A mineral resource distribution model was formed for the assessment of gold reserves using GIS technologies.

Originality. The scientific novelty lies in the integration of multidimensional data and high-tech algorithms to create visually understandable models of mineral distribution. This contributes not only to more effective planning of mining operations, but also provides the opportunity to take into account environmental factors for more sustainable management of natural resources. In addition, the proposed methodology can be adapted for different types of minerals and geographical conditions, which makes it a universal tool in geological exploration and reserve assessment. This opens up new prospects for the use of GIS technologies in the mining industry.

Practical value. Thanks to the use of multidimensional data analysis, it is possible to minimize the risks of errors and optimize the mining process, reducing the costs of drilling and exploration. In addition, the detailing of underground structures allows you to take into account environmental factors, choosing mining areas with minimal impact on nature. The versatility of the method ensures the possibility of its adaptation to the extraction of various minerals and conditions, which makes it an important tool for the development of the modern mining industry. The implementation of this approach will contribute to sustainable management of natural resources and increasing the environmental responsibility of the industry.

Keywords: *minerals, geoinformation systems, 3D modeling, visualization, maps, coordinates, ecology, landscape disturbance.*

Introduction. The main goal is the identification and spatial placement of mineral deposits. During the planning of mining operations, strategic decisions are made to manage product quality and optimize production efficiency. In addition, the analysis of potential risks and determination of ways to minimize them to ensure the stability of production is carried out.

The discovery of gold deposits in the Yukon occurred at a time when there was an acute shortage of gold in all the developed countries of the world [1]. During the gold standard, when paper money was tied to existing gold reserves, a sudden decline in gold production in the late 19th century caused the price of gold to rise sharply relative to paper money, causing it to flow out of circulation. This led to the Panic of 1893 and 1896, when unemployment and financial instability spread amid economic depression.

The main driver of Yukon's economy in the 19th century was the mining industry, which proved to be crucial for the development of the region. There are rich deposits of such minerals as lead, zinc, silver, gold, copper and asbestos. The beginning of the economic development of the Yukon Territory relates to the famous "Gold Rush" (fig. 1).

Fig. 1. Prospectors in the mine, 1898

Mining operations began with cleaning the surface of vegetation and debris, after which the opening of the mine was carried out. If the mine looked promising, it was dug to the full depth of the alluvial cover to the rocks where the gold was most often contained. The process of drilling a vertical mine required careful control in order not to miss possible gold veins and to adjust the search direction in a timely manner.

Only 40,000 people now live in Canada's smallest and westernmost federal territory, the Yukon. Commonly called the Yukon, this territory covers more than 183,000 square miles and includes 1,368 mountains. The Yukon is known as Canada's last frontier and contains some of the country's most majestic snow-capped peaks, alpine tundra, and subalpine lakes [2].

Relevance of research. A thorough analysis of the generalized geological and geophysical data of the region under consideration was performed.

Literature sources indicate that the initial drilling program was completed in 1983, consisting of four drill holes totaling 3,264 feet at previously untested depths of 500 to 750 feet. Larger drilling was subsequently carried out in 1984 and 1986. Downhole electromagnetic surveys were performed in conjunction with the drilling, effectively extending the prospect for ore that occurs to its current maximum vertical depth of 2,250 feet.

The following investigations have made it possible to estimate the useful resources, namely the presence of gold-bearing ores in the Watson Lake mountain area, southeastern Yukon, Canada. Gold-bearing ores were discovered in several areas.

Ground geophysical research conducted in 1988 on an area of 2,500x2,900 m in the northern part made it possible to obtain data on polarization, resistivity, and magnetic parameters. In June 1994, an on-board electromagnetic survey was carried out, which made it possible to obtain data on the resistivity of rocks [3]. The following studies were carried out with the help of a magnetometer, it was an on-board magnetic and radiometric survey in 1995 and carried out cartographic works.

In July 2011, electromagnetic studies were conducted to assess the potential of gold-bearing ores, which required significant efforts and financial costs.

In response to the growing need for accurate and reliable data on geological formations and mineral deposits, geophysical surveys and 3D modeling are becoming increasingly important in geological science and industry. These methods not only provide a more detailed understanding of the structure of the earth's crust and its components, but also play a key role in identifying mineral deposits, assessing available resources, and planning mining operations [4].

For more efficient search for minerals with a reduction in material resource costs, the use of the Surfer software is suggested. This program is publicly available and convenient. It allows you to create maps that visually and compactly reproduce the features of the terrain's relief, its geoecological condition, and represent the features of the flow of underground water. Surfer was developed specifically for surface analysis and modeling, mesh generation, landscape rendering, and much more. Thanks to the ability to adjust any parameters, this tool allows you to create a truly wide variety of 3D maps [5–9].

Creating detailed maps has never been so easy and fast. Thanks to the powerful interpolation capabilities of the program, you can get extremely accurate surfaces with high-quality graphics. An intuitive interface makes the program accessible even to those users who have not previously had experience with it. For example, to adjust any parameters of the map, it is enough to simply double-click on its surface and set the necessary values.

Presentation of the main material of the study with a full justification of the scientific results obtained. The article proposes a new modeling technique using a 3D grid of HYZS data, which determines the concentration of minerals in the soil, and allows you to visualize deposits under the surface (fig. 2, 3).

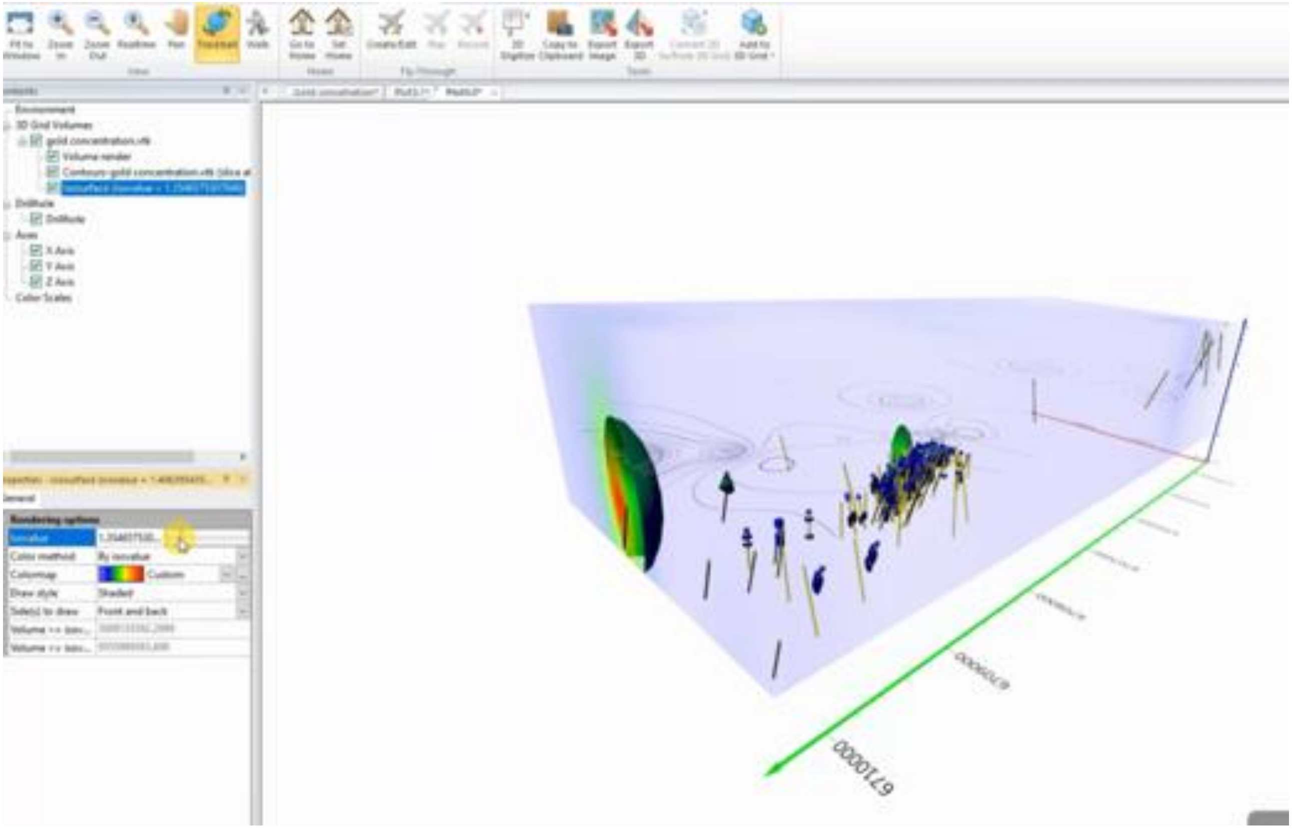

Fig. 2. Red shows the highest concentration of gold in the area

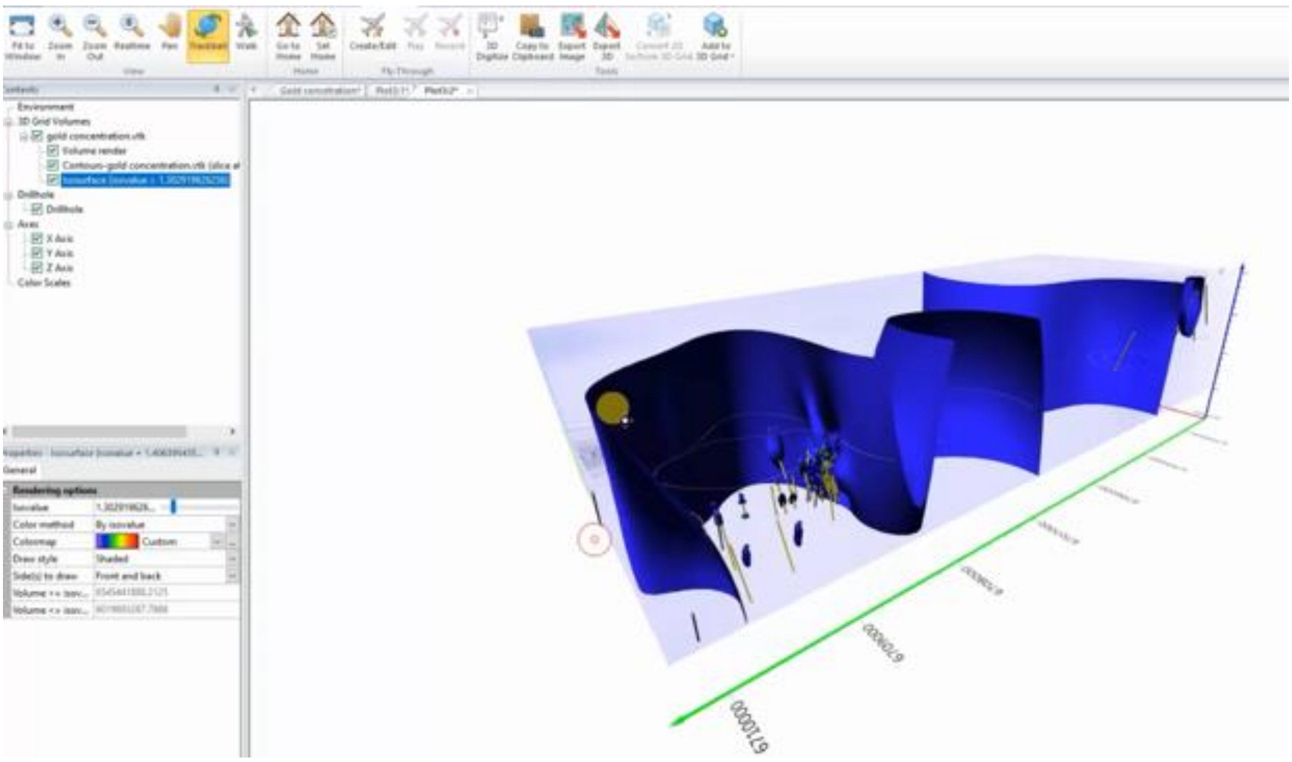

Fig. 3. Value of gold concentrations on the site

First, a set of data on HYZS coordinates was saved. To do this, click Home – Grid Data on the upper ribbon of the panel to open the grid data dialog box (fig. 4).

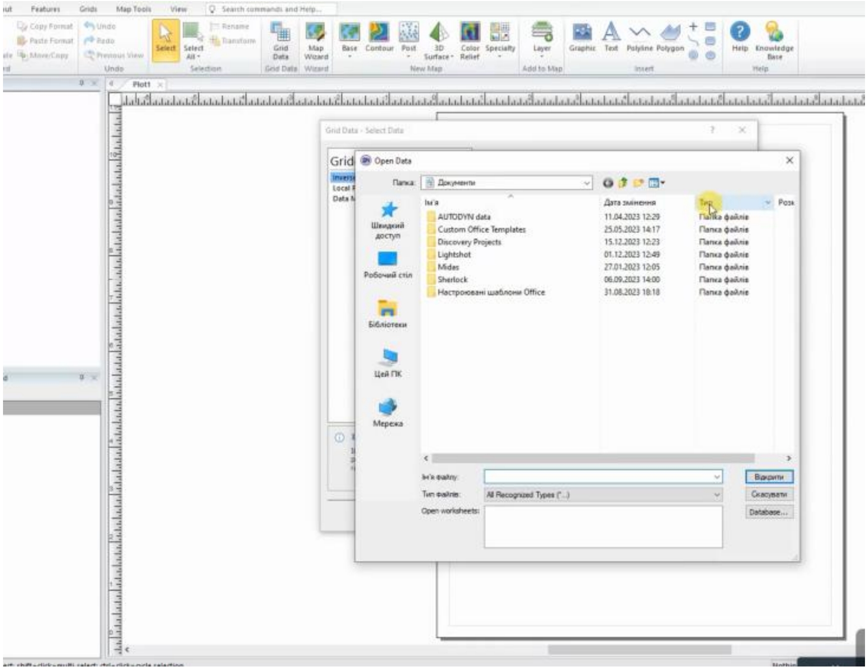

Fig. 4. Grid Data dialog box

To do this, in the grid data dialog, select the new XYZ data type and the 3D evaluation parameters that must be filled. Next, you need to choose one of the three classification methods, download our data set by clicking the Browse button. This data set contains gold mineral concentrations at the corresponding depth values (fig. 5). After setting the appropriate columns from our data table to the appropriate variables and then clicking Next.

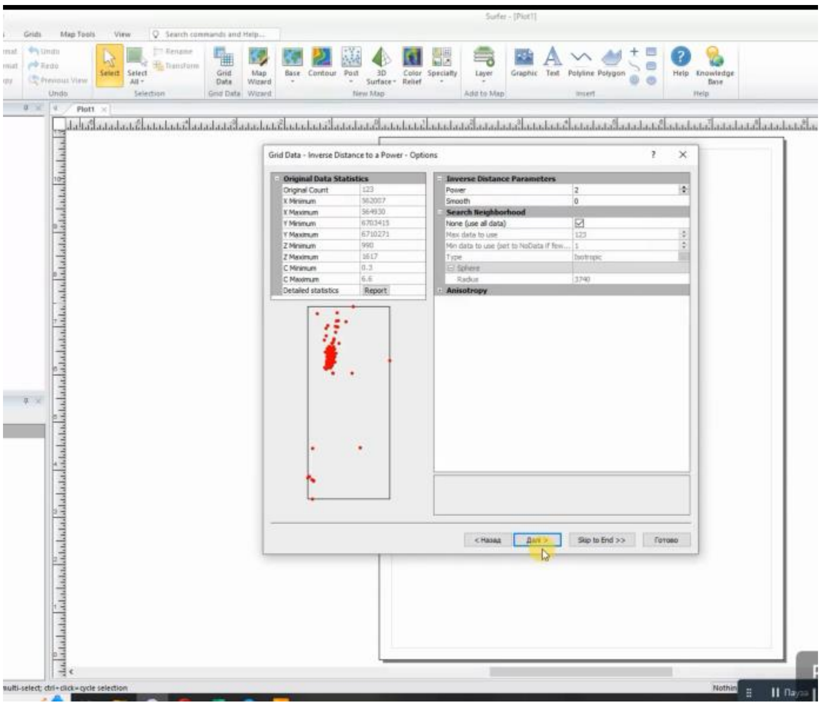

Fig. 5. Dialog window for assigning the parameters for displaying the concentration of the substance on the screen

In the second dialog box, you can fine-tune the final mesh result by applying anisotropy or limiting the search area. On the final mesh output page, select the type of 3D Surface map, and optionally change the geometry of the mesh. All 3D meshes are saved in vtk file format. After setting the save location for the vtk file and completing the evaluation process, we add a 3D mesh, as any of the following Surfer mesh based map types will convert our data to the selected map type and save a vtk file that can be used to create a wide variety of 3D visualizations (fig. 6). By moving the Z coordinate slider, you can visualize deposits below the surface.

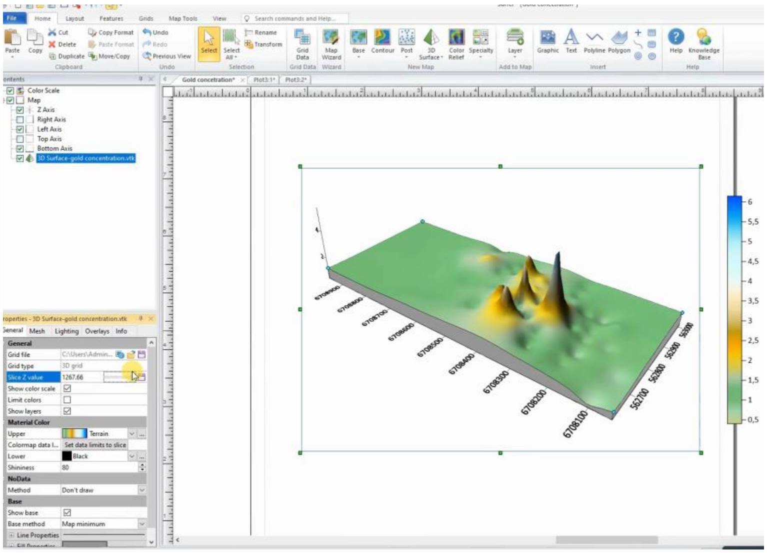

Fig. 6. Visualization of the deposit

The next step is to create another type of map – a contour map (fig. 7). By clicking Home – Contour on the top ribbon, you can select the saved vtk format file and open it. 3D Grid data type. With the help of methods of three-dimensional visualization, adding surfaces, combining map types, a complete figure of the final report was created.

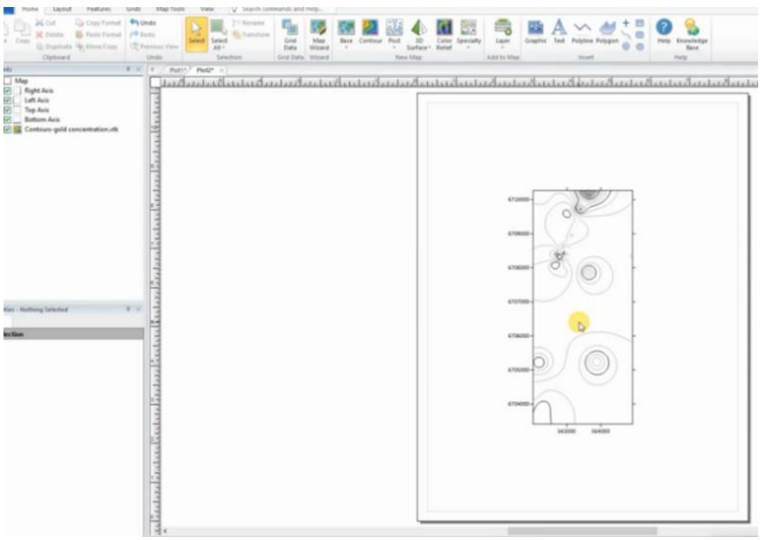

Fig. 7. Contour map of gold concentration

The next step was to add a well map. After selecting the contour map, press Home – Add to Map – Layer – Drillhole and Browse to select the data table. After selecting the required table, the Survay borehole inclination data was loaded. Also added Interval and Point tables. After loading all the data, clicking Finish and created our wells layer (fig. 8). To view the results in 3D view, open the 3D view by selecting Map and clicking Map Tools.

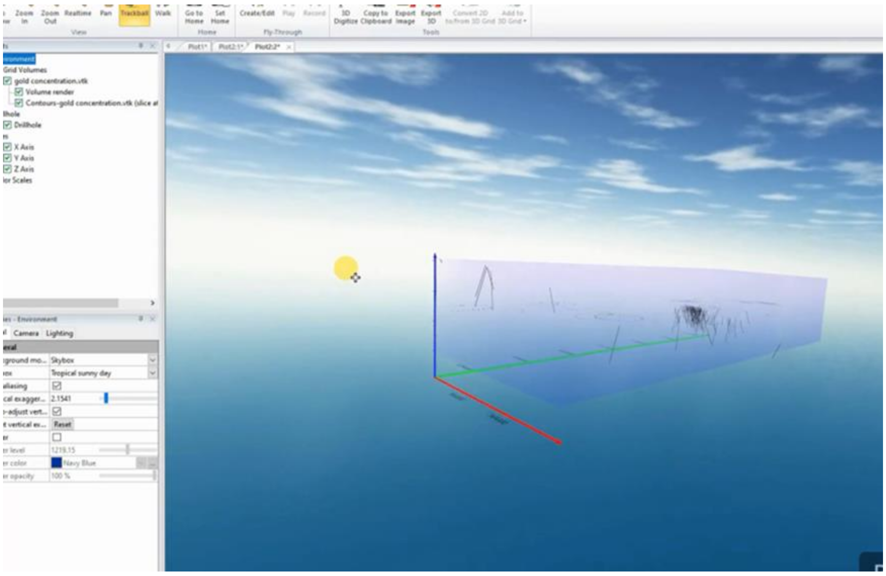

Fig. 8. Concentration of gold by wells

To display the points, you need to check the Show points checkbox in the Drillhole properties window. We can also set the character frequency of the point to be displayed, change the Sizing method and Color. It is also possible to display wells as Drillhole Intervals. In this way, the wells will look completely different, even if we use the same parameters as in the Points tab.

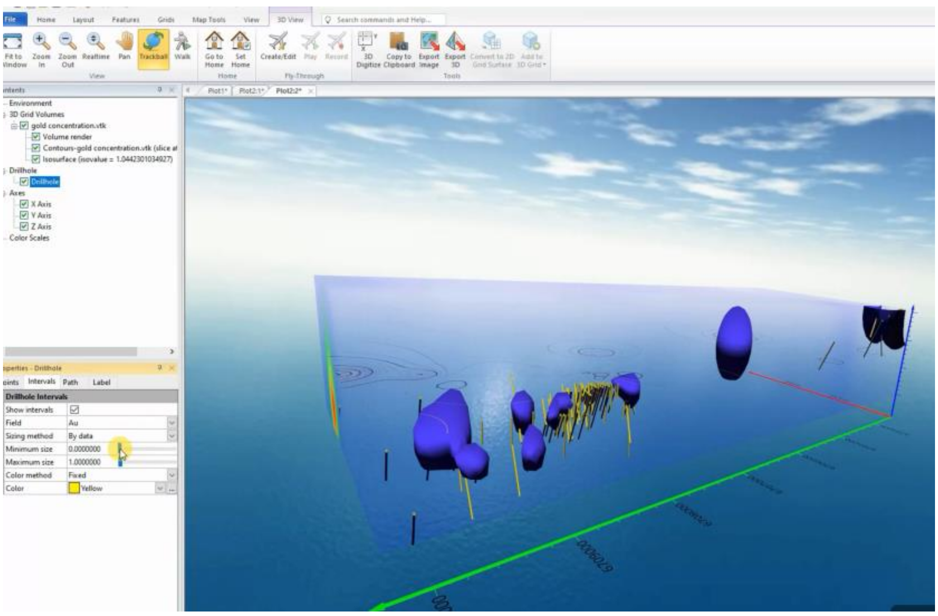

Fig. 9. Gold concentration along with 3D view of wells

The last method of viewing wells in 3D is Drillhole Paths (see. fig. 9). Well trajectories can be displayed even if Interval and Point data are not imported.

Conclusions. As a result of the conducted research, it can be concluded that the modeling technique using 3D is extremely convenient and easy to use. It allows you to effectively visualize complex geological structures and mineral deposits, which helps to improve the understanding of their structure and distribution. Thanks to the use of 3D models, researchers can obtain more accurate and detailed data, which contributes to the improvement of geological modeling processes and the identification of new promising objects for further study and extraction of minerals. Thus, the use of 3D modeling turns out to be an important tool in modern geology and mining, which allows for a more efficient and accurate analysis of geological objects.

Therefore, an innovative modeling technique using a 3D XYZ data grid is proposed, which allows determining the concentration of minerals in the soil and visualizing deposits below the surface. This approach opens new opportunities for accurate analysis of geological formations and resource extraction planning. The use of the 3D grid of XYZ data allows you to effectively study the structure of the soil and the location of useful deposits, which is important for the development of the mining industry and the assessment of natural resources. This new technique paves the way for more accurate analysis and prediction of deposits, contributing to the efficient use of natural resources and the preservation of the environment.

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АНОТАЦІЯ

Мета. Розробити методологічний підхід до оцінки мінеральних ресурсів золотодобувного району Юкону з використанням сучасних геоінформаційних технологій (ГІС).

Методика, яка використовувалась: 3D моделювання покладів корисних копалин.

Результати. Створено візуалізацію карти корисних копалин з використанням геоінформаційної моделі родовища. Виконано картографічний аналіз золотодобувного району Юкону, включаючи детальне розташування родовищ та потенційних зон видобутку. Сформовано модель розподілу мінеральних ресурсів для оцінки запасів золота за допомогою технологій ГІС.

Наукова новизна. Наукова новизна полягає в інтеграції багатовимірних даних та високотехнологічних алгоритмів для створення візуально зрозумілих моделей розподілу корисних копалин. Це сприяє не лише ефективнішому плануванню робіт з видобутку, але й забезпечує можливість врахування екологічних факторів для більш сталого управління природними ресурсами. Крім того, запропонована методика може бути адаптована для різних типів корисних копалин та географічних умов, що робить її універсальним інструментом у геологічній розвідці та оцінці запасів. Це відкриває нові перспективи для використання ГІС-технологій у сфері видобувної промисловості.

Практичне значення. Завдяки використанню багатовимірного аналізу даних можна мінімізувати ризики помилок і оптимізувати процес видобутку, зменшуючи витрати на буріння та дослідження. Крім того, деталізація підземних структур дозволяє враховувати екологічні фактори, вибираючи зони видобутку з мінімальним впливом на природу. Універсальність методики забезпечує можливість її адаптації до видобутку різних корисних копалин та умов, що робить її важливим інструментом для розвитку сучасної видобувної промисловості. Впровадження цього підходу сприятиме сталому управлінню природними ресурсами та підвищенню екологічної відповідальності галузі.

Ключові слова: *корисні копалини, геоінформаційні системи, 3D моделювання, візуалізація, карти, координати, екологія, порушення ландшафтів.*