Modern American Journal of Engineering, Technology, and Innovation
ISSN(E): 3067-7939
Volume 01, Issue 03, June, 2025
Website: usajournals.org

THE APPLICATION OF ARCGIS IN THE GEOLOGICAL ANALYSIS AND ENVIRONMENTAL MANAGEMENT OF THE POTASSIUM DEPOSIT

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Abstract:
The present article explores the application of ArcGIS software in the geological modelling, resource assessment and environmental monitoring of the Tepakuton potassium deposit in Uzbekistan. The integration of diverse geospatial datasets, encompassing borehole data, structural geology, topography, and environmental baselines, has been demonstrated to enhance the understanding of complex salt-bearing formations. The study demonstrates how Geographic Information System (GIS) technologies improve exploration planning, subsurface visualization, and environmental risk mitigation. The results obtained demonstrate the value of ArcGIS in supporting sustainable and efficient underground potassium mining at the Tepakuton site.

Introduction

During mineral deposit exploration, a significant volume of geological data is collected, including core logging, sampling results, and geophysical and geochemical survey outcomes. These data are essential for constructing geological maps and cross-sections, estimating reserves, and conducting further geological analysis. Prior to the introduction of computer technology, such data were processed manually, requiring substantial time and effort. With the advent of computers, especially personal computers and specialized software, the accumulation and processing of geological data have become significantly more efficient.

Today, digital modeling plays a central role in systematizing, analyzing, and visualizing geological information. It enables accurate reserve estimation,

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mineral quality assessment, and geological-economic evaluation of deposits. Common modeling approaches include geoinformation, analytical, and block modeling. Geoinformation modeling, supported by software such as ArcGIS and ArcView, focuses on map creation and spatial data visualization. Analytical modeling is used for constructing geological maps and cross-sections based on borehole data. Block modeling involves dividing the deposit into uniform blocks, with interpolation methods applied to evaluate ore characteristics within each block.

These digital approaches facilitate the design and management of mining operations, providing comprehensive geological models that support decision-making. As a result, modern mineral exploration increasingly relies on advanced software tools and digital technologies to enhance the accuracy and efficiency of geological investigations[1-14].

Materials and methods

Potassium is an essential nutrient for agricultural production, and its extraction from underground evaporate deposits plays a critical role in global fertilizer supply. The Tyubegatan deposit, situated in southwestern Uzbekistan, represents a pivotal resource within the nation's burgeoning mining sector. In consideration of the geologically complex nature of the salt-bearing strata in the area and the location's designation as being of environmental sensitivity, there is a necessity for the employment of advanced digital tools to facilitate safe and sustainable development. The present article investigates how ArcGIS software is utilized for geological modelling, resource estimation, and environmental monitoring of the Tyubegatan deposit[4].

The Tyubegatan deposit is located within the South Tien Shan fold system and is composed of thick sequences of sylvinite, carnallite, and halite, often interbedded with argillaceous layers. The deposit is located at depths of 300–600 meters, exhibiting folding and faulting patterns that influence ore continuity and mining feasibility. The accurate spatial modelling of this subsurface structure is of vital importance for the effective planning of mining operations and the effective prevention of potential hazards. Conventional geological methodologies are

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being complemented by digital geoinformatics approaches, notably through the utilization of ArcGIS.

A unified geodatabase was constructed in ArcGIS using borehole logs, geological maps, seismic profiles, and Digital Elevation Model (DEM) data. Arc Map and ArcGIS Pro were utilized in the georeferencing of historical maps and their alignment with contemporary survey data. The stratigraphic information was categorized and visualized using symbology tools, while spatial interpolation methods such as Kriging and IDW were employed to estimate ore grade and thickness. The resulting isopach and isoline maps provide an accurate spatial mineralization of potassium mineralization across the Tyubegatan field [3,4].

The Arc Scene and ArcGIS Pro 3D Analyst extensions facilitated the generation of three-dimensional block models of the deposit. Borehole data were utilized to construct cross-sections and fence diagrams, thereby illustrating the vertical and lateral variation of potassium-bearing layers. These models facilitate the visualization of fault zones, synclines, and anticlines by geologists and mining engineers, thereby aiding in the identification of structurally stable zones for shaft sinking and chamber excavation. The integration of fault plane data facilitates a more comprehensive risk assessment of geotechnical instability. It is imperative to acknowledge the close proximity of the deposit to agricultural lands and settlements, thus underscoring the necessity for comprehensive environmental monitoring to be a fundamental component of the project development process. The application of satellite imagery (Landsat, Sentinel-2) and ArcGIS was utilized to map vegetation indices (NDVI), surface water bodies, and land-use changes over time. The implementation of buffer analysis and overlay techniques has enabled the identification of zones susceptible to surface subsidence or brine leakage. Arc Hydro tools were utilized to model surface runoff and drainage patterns, thereby guiding the placement of mine infrastructure to minimize environmental disturbance.

Results and Discussion

ArcGIS Network Analyst was instrumental in the design of transportation and utility corridors to facilitate connectivity between the mining site and regional infrastructure. The implementation of route optimization measures resulted in a

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significant reduction in both land disturbance and construction costs. Furthermore, proximity analysis was employed to identify safe zones for waste storage, ventilation shafts, and emergency response access. The utilization of Geographic Information Systems (GIS) in hazard mapping, particularly in the context of karst collapse or brine migration, has been identified as a pivotal element in the development of risk mitigation strategies.

The primary challenge in implementing ArcGIS for Tyubegatan is the digitization of legacy data and the limited access to high-resolution imagery in certain areas. Nevertheless, sustained investment in remote sensing and surveying technologies is enhancing data availability. The integration of ArcGIS with artificial intelligence and real-time monitoring systems is expected to further enhance operational efficiency and environmental compliance soon [3].

Conclusion

The utilization of ArcGIS in the Tyubegatan potassium deposit exemplifies its efficacy in integrating geological, structural, and environmental data into a unified spatial framework. Through the utilization of advanced cartographic techniques, three-dimensional modelling, and risk assessment tools, ArcGIS facilitates data-driven decision-making processes in the domain of potassium mining. The application of this technology at Tyubegatan serves as a paradigm for digital transformation in Uzbekistan's mining sector, underscoring the pivotal role of geospatial technologies in facilitating the sustainable development of mineral resources.

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