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Further Discussion On Digital Twin Of Solid Mineral Deposits And Of Subsoil Use - Challenges And Recommendations

Trinh Quoc Vinh (corresponding)[1] , Dinh Tran Ngoc Huy, MBA (corresponding)[2] , Sergey Yakutseny (corresponding)[3]

[1]Gubkin Russian State University of Oil and Gas: Moscow, RU .

[2]Banking University HCM city Vietnam – GSIM, International University of Japan, Niigata, Japan.

[3]Gubkin Russian State University of Oil and Gas: Moscow, RU.

ABSTRACT
A digital twin is "a system consisting of a digital reservoir model and two-way information links with a field and (or) its constituent parts."
The paper aims to figure out What are background and challenges of digital twin? By using descriptive method for primary model, synthesis methods and process analysis and analysis of difficulties and discussion, This study finds out that: The primary model is created at the initial stage of geological exploration of the deposit. Then, as geological exploration is carried out, it is refined and saturated with additional data, it serves to determine the resources and reserves of minerals, and to calculate the conditions. Also, it is necessary to develop modules for technological processes, technical-economic and organizational-economic processes.

Keywords: Digital Twin, Challenges, Recommendations, Solid Mineral Deposits, Digital Twin Of Subsoil Use.

1. Introduction

Sevin et al (2021) stated that Systems for transport and processing of granular media are challenging to analyse, operate and optimise. In the mining and mineral processing industries, these systems are chains of processes with a complex interplay among the equipment, control and processed material. The material properties have natural variations that are usually only known at certain locations. Therefore, we explored a material-oriented approach to digital twins with a particle representation of the granular media. In digital form, the material is treated as pseudo-particles, each representing a large collection of real particles of various sizes, shapes and mineral properties. Movements and changes in the state of the material are determined by the combined data from control systems, sensors, vehicle telematics and simulation models at locations where no real sensors could see. The particle-based representation enables material tracking along the chain of processes. Each digital particle can act as a carrier of observational data generated by the equipment as it interacts with the real material. This make it possible to better learn the material properties from process observations and to predict the effect on downstream processes. We tested the technique on a mining simulator and demonstrated the analysis that can be performed using data from cross-system material tracking

Next, Kalidindi et al (2022) pointed Digital twins are emerging as powerful tools for supporting innovation as well as optimizing the in-service performance of a broad range of complex physical machines, devices, and components. A digital twin is generally designed to provide accurate in-silico representation of the form (i.e., appearance) and the functional response of a specified (unique) physical twin.

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Research questions:

Question 1: What are previous studies on digital twin model?

Question 2: What are background and challenges of digital twin?

2. Previous studies

We summarize in below table:

Table 1 – Summary of related studies

Authors	Year	Content, results
Boschert and Rosen	2016	Digital twin refers to a comprehensive (physical and functional) description of a system, which includes all the most-useful information, over the lifecycle phases. It is an emerging representation of cyber-physical systems and has attracted increasing attention very recently. Through this concept, a digital representation of the system under study is developed. The level of the complexity applied in the digital twin is a function of the computational infrastructure and collected data. Nevertheless, this concept opens the way to real-time monitoring and

		synchronization of real-world phenomena with virtual counterparts
Kalidindi et al	2022	offers a new perspective on how the emerging concept of digital twins could be applied to accelerate materials innovation efforts. Specifically, it is argued that the material itself can be considered as a highly complex multiscale physical system whose form (i.e., details of the material structure over a hierarchy of material length) and function (i.e., response to external stimuli typically characterized through suitably defined material properties) can be captured suitably in a digital twin. Accordingly, the digital twin can represent the evolution of structure, process, and performance of the material over time, with regard to both process history and in-service environment. This paper establishes the foundational concepts and frameworks needed to formulate and continuously update both the form and function of the digital twin of a selected material physical twin. The form of the proposed material digital twin can be captured effectively using the broadly applicable framework of n-point spatial correlations, while

		its function at the different length scales can be captured using homogenization and localization process-structure-property surrogate models calibrated to collections of available experimental and physics-based simulation data.
Lari et al	2022	**presented** NSZD includes partitioning, biotic and abiotic degradation of LNAPL components plus multiphase fluid dynamics in the subsurface.
Tao et al	2018	In addition to mimicking the physical products, the in-silico analogues offer unprecedented potential for consistent change management, allowing the optimization of intentional or unintentional product evolution over time. Therefore, within this context, a digital twin can be defined as a high-fidelity in-silico representation closely mirroring the form (i.e., appearance) and the functional response of a specified (unique) physical twin. Digital twins have thus far been used in the manufacturing and performance evaluation of complex engineered physical systems (e.g., turbine engines)

(source: author synthesis)

3. Methodology

Authors have used qualitative and analytical methods, descriptive method for primary model, synthesis methods in this paper. Moreover, this paper used process analysis and analysis of difficulties and discussion.

4. Main findings

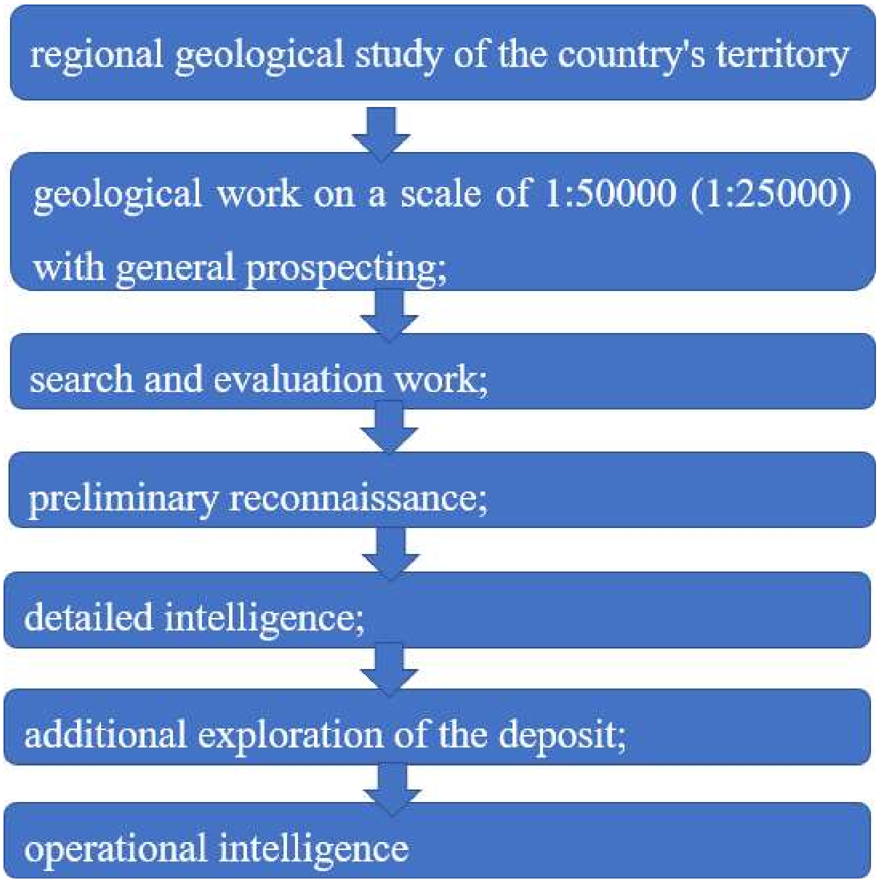
4.1 Background of digital twin

DeFilipe et al (2022) pointed The immense advances in computer power achieved in the last decades have had a significant impact in Earth science, providing valuable research outputs that allow the simulation of complex natural processes and systems, and generating improved forecasts. The development and implementation of innovative geoscientific software is currently evolving towards a sustainable and efficient development by integrating models of different aspects of the Earth system. This will set the foundation for a future digital twin of the Earth. The codification and update of this software require great effort from research groups and therefore, it needs to be preserved for its reuse by future generations of geoscientists. Here, we report on Geo-Soft-CoRe, a Geoscientific Software & Code Repository, hosted at the archive DIGITAL.CSIC. This is an open source, multidisciplinary and multiscale collection of software and code developed to analyze different aspects of the Earth system, encompassing tools to: 1) analyze climate variability; 2) assess hazards, and 3) characterize the structure and dynamics of the solid Earth. Due to the broad range of applications of these software packages, this collection is useful not only for basic research in Earth science, but also for applied research and educational purposes, reducing the gap between the geosciences and the society. By providing each software and code with a permanent identifier (DOI), we ensure its self-sustainability and accomplish the FAIR (Findable, Accessible, Interoperable and Reusable) principles.

The primary model is created at the initial stage of geological exploration of the deposit. Then, as geological exploration is carried out, it is refined and saturated with additional data, it serves to determine the resources and reserves of minerals, and to calculate the conditions.

Each stage of exploration

Figure 1 – long **exploration process**



(source: made by authors)

4.2 Challenges

Trinh Quoc Vinh, Y.Sergey Pavlovich, Dinh Tran Ngoc Huy (2022) mentioned Creating digital models is a discrete process. That is, there is no (but it is necessary!) A single platform. A chaotic mass of models that are inconsistent in type, type and form of presentation of these models is used. **A digital twin is needed to study the object, evaluate the deposit, identify the most favorable deposits in the dynamics of production changes, the ability to try out a new method / rate / volume of production in digital, and not directly on the object; the possibility of calculating the volume of rock production with high accuracy (especially for PPI) in order to prevent unscrupulous actions to artificially underestimate the indicators of extracted raw materials.**

5. Discussion and conclusion

When developing a model for the functioning of a mining enterprise, a group of enterprises, it is necessary to develop modules for technological processes, technical-economic and organizational-economic processes.

Then, Digital threads open multiple new avenues for fostering innovation and improving the in-service performance of a wide range of products. A necessary feature of the digital threads is that they encompass both the in-silico activities (e.g., model-based or virtual engineering) and the physical activities (e.g., measurements made during the different stages of manufacturing, testing, and operation of the product) conducted in the PLM. An important outcome from the deployment of digital threads is that they have opened new opportunities for the creation and use of in-silico analogues to the physical product. The recent advances in digital and sensor technologies (Mei et al., 2019).

Next, The integration of geological and geophysical data and generation of models that simulate different geological processes, may lead to digital models of certain aspects and/or processes of the Earth system, with the ultimate aim of building a digital twin of the Earth. Digital twins combine continuous observation, modeling and simulation of certain aspects of the Earth system, resulting in accurate predictions for possible scenarios (Bauer et al., 2021)

Then, Beloglazov et al (2020) pointed According to the top-priority trends and challenges in the mineral sector, and as per the mining science strategy, it is highly critical to arrange enhanced control, prediction and safety of production objects and their functioning for the preservation of automation sustainability. Improved control of databases, regulatory bonds, management, logistics and principles of sustainable development in mining makes it possible to reduce technological deviations and accidents at large mining and processing plants. Most procedural violations and accidents in surface and underground mines occur because of the unskilled actions of process flow operators. Damage in this case can be considerable, especially as compared with the expenses connected with qualitative training and persistent development of personnel engaged with supervisory control and data acquisition for the efficient operation of SCADA-systems within the automation framework of mining and processing plants. Definition of digital systems and their interrelation with multilevel automated control can be incorrect. The review of new principles can awaken interest in the conceptual assessment of digitalization processes using such notions as: numerical models, simulator, and artificial intelligence. Often applied formulations and principles of a digital model are substituted without justification of functional connections. On the other hand, a digital system today can be assumed as robotic lines and other numerical models and smart technologies, for instance, machining stations with numerical program control. It is necessary to define the practical significance of conceptual modifications and digital transformation regarding objects of the mineral sector, using Big Data; to understand how a digital twin can influence a changeable process situation; to provide prompt prediction; to eliminate an accident; and to preserve the physical balance in the whole production system. Such intelligent and flexible productions particularly need computerbased simulators and digital twins based on technologies of Industry 4.0–extended and virtual reality on the basis of digital twins. Digital twins allow maximal simulation of real-life activity of process flow operators. The skills acquired by personnel after such simulation training enable operators to master the optimized procedure for functioning in emergency situations in mineral mining and processing.

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Conflicts of interest

There is no conflict of interest

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