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ALTA 2020 In-Situ Recovery Conference

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INFORMATISATION SYSTEMS FOR ISR MINES

By

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ABSTRACT

In-situ recovery (ISR) transfers hydrometallurgical processing of mineralised bodies to the subsurface to directly obtain solutions of commodities. As a result, there is little surface disturbance. For ISR to be successful, however, deposits need to be permeable. Furthermore, commodities need to be readily amenable to dissolution by leaching solutions over a reasonable period, with an acceptable consumption of leaching reagents.

ISR is a “hidden” extraction process and development of an informatisation system allows the process to be more predictable and controlled. Informatisation systems are used at various ISR mines, including Beverley, Kazatomprom and others.

In 2010, the Strategic Conceptual Project was developed for informatisation of all ARMZ Holding mines, including the Dalur and Khiagda ISR uranium mines. The strategic directions were developed by two teams over the last nine years (Seredkin, Solodov, Boytsov, 2016).

The methodology for geological / resource modelling of sandstone-type deposits for extraction by ISR was developed by CSA Global (Seredkin, 2018). The methodology was based on modelling morphological elements of roll front mineralisation (noses, wings, residual parts), horizons / interbeds of impermeable sediments, the variability of permeability, and estimation of grade-thickness parameters for mineralised bodies. The resulting geological / resource models allow the preparation of the mine schedule and cash flow model for the ISR project, in addition to an assessment of the economic sensitivities.

Software for modelling hydrodynamic, physico-chemical and operation models/parameters was developed by the National Research Nuclear University with methodological support from ARMZ Holding (Seredkin, Solodov, Boytsov, 2016). This software includes the following modules: geological modelling based on operation wells, collection of initial operational data, hydrodynamic and physico-chemical modelling (core module), and economic analysis and forecast.

The module for geological modelling allows a quick update of the geological model based on the exploration grid after obtaining data from operation wells.

The module for the collection of initial operational data allows the creation of a database for the primary data at regular periods from wells, pipes and the plant. The data includes the volume of leaching and pregnant solutions, concentration and consumption of leaching reagents, and concentration of uranium and other components.

The module for physico-chemical modelling allows the preparation of an operating model for each period of the ISR process based on the geological model and operational data database.

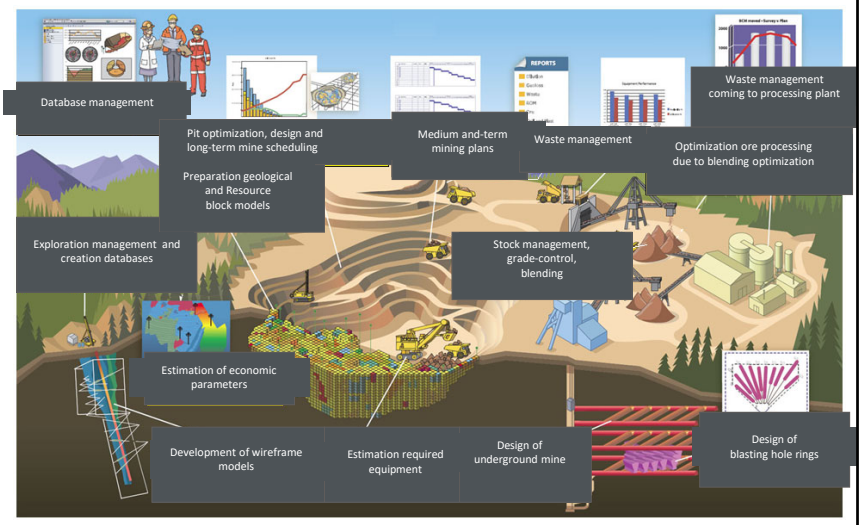
The economic analysis and forecast modules are focused on forecasting the ISR process and making informed decisions to optimise injection/pumping solutions, and concentrations of leaching reagents.

In summary, an informatisation system has been developed for modelling and optimisation of the ISR process, which includes emerging technologies similar to big data and artificial intelligence.

Keywords: *in-situ recovery, informatisation, hydrodynamic modelling, physico-chemical modelling, forecast, big data, artificial intelligence.*

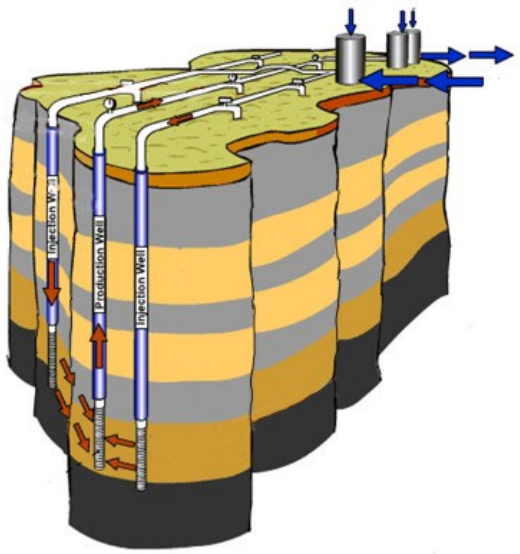
Informatisation for mining industry

The mining industry has developed software packages for the most operations for conventional mining



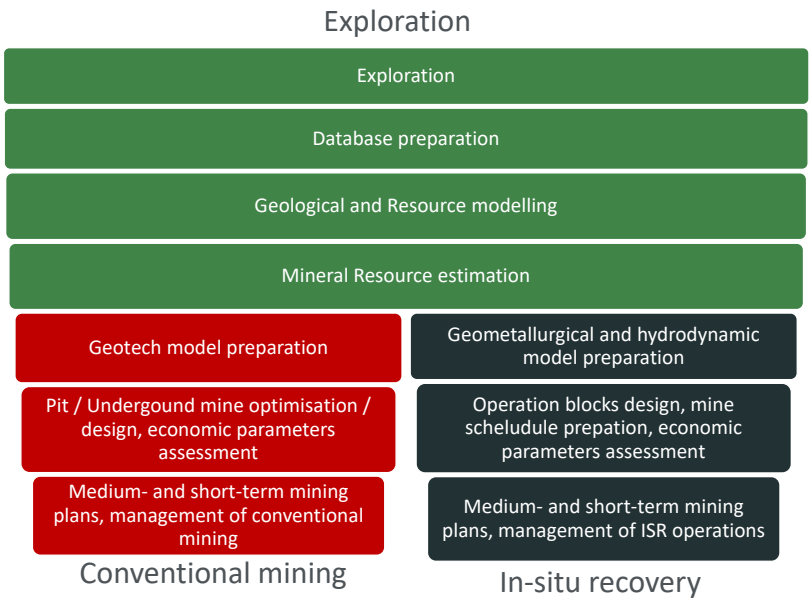
Features of in-situ recovery (“ISR”)

- Feature of ISR is "hidden" mining, extraction of metals using grids of operational wells.
- Direct and visual control of operations is impossible in ISR.
- ISR is a complex process due and depends on hydrogeology and geometallurgy.
- Existing industrial software does not cover all ISR requirements.



Comparison conventional mining and ISR

- Exploration, geological and resource studies are the same for conventional mining and ISR projects for informatisation systems.
- Mine design and operation / mining studies are very different.



Companies developing software for ISR operations

Software for ISR projects is being developed in the uranium industry due to share of ISR in uranium production exceeds 50%

4

Overview of informatization systems in this presentation based on Kazakhstan and Russian experience

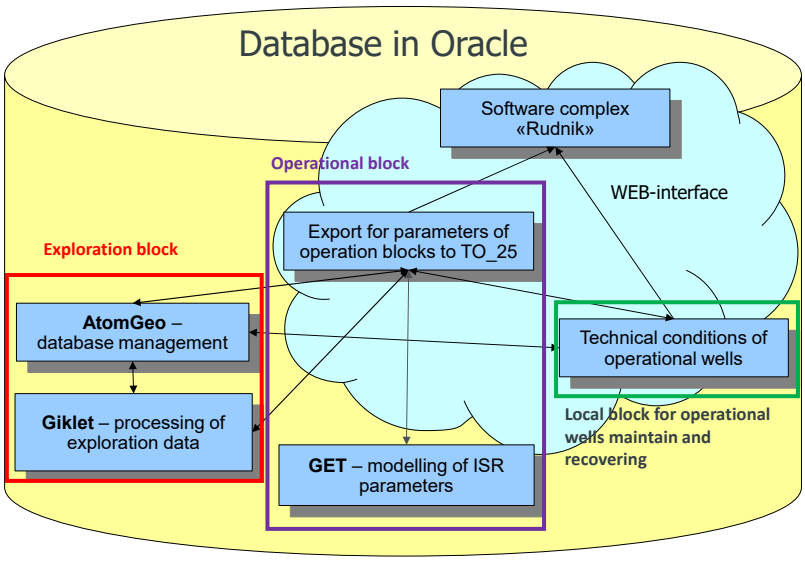
Reference: Seredkin, Noskov, Boytsov, Solodov. Implementation of informatisaton systems for ISR mines. MINEX-Kazakhstan, 2018

Software system "Rudnik"

This software system has been developed in Kazatomprom since 1998.

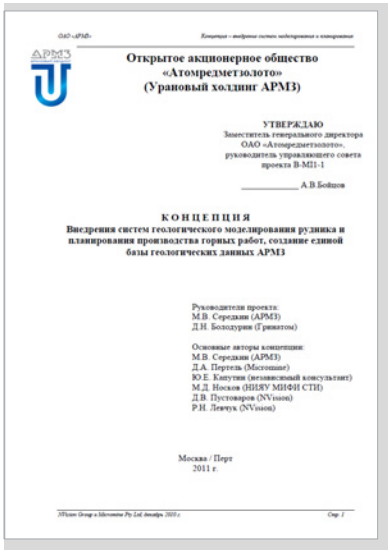
Exploration and operation information is stored in an Oracle database.

This is complemented by supporting software which is focused on certain concretic tasks.



Software system “Seversk” (Rosatom)

- The team at National Research Nuclear University “MERHI” are developing integrated software complex for ISR since the beginning of 2000 for Dalur.
- ARMZ Holding prepared a structured detailed strategy for developing this system.
- Further systematic developing of ISR system for Dalur and Khiagda is realising this strategy.



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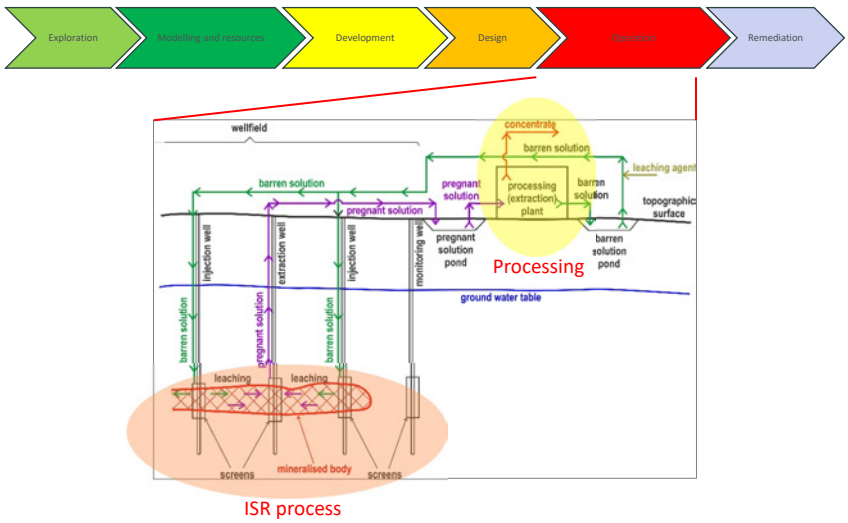
Д.В. Пустоваров (NVision)
Р.Н. Левчук (NVision)

Москва / Перт
2011 г.

ISR project stages

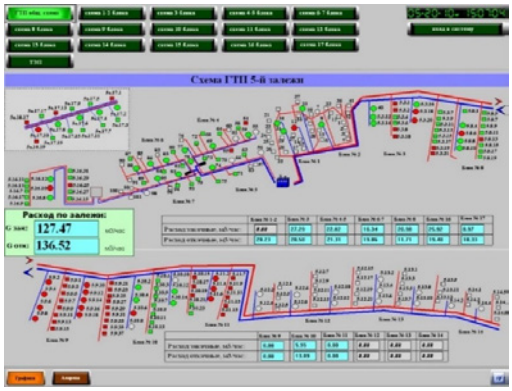
- All stages of ISR projects are covered by software systems.
- The main focus of software systems is on the operation stage as core these systems including ISR process and processing of pregnant solutions.

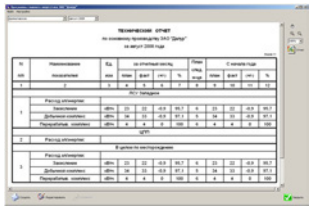


Software system “Seversk” (Rosatom) Operation Module

Exploration | Modelling and resources | Development | Design | **Operation** | Remediation

- The operational data collection and storage module collects and stores operational / geometallurgical information in operation collection module.
- This information is visualised and analysed, and then used to prepare daily, weekly and monthly reports.



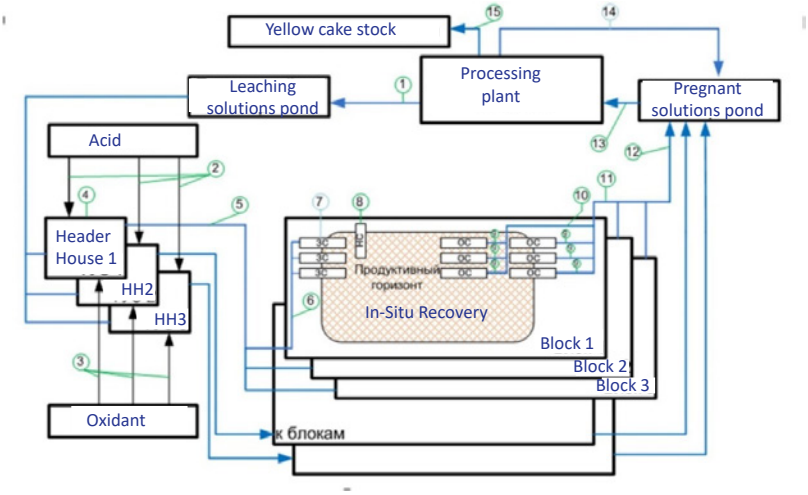


Seredkin et al., Minex Kazakhstan, 2018

Software system “Seversk” (Rosatom) Operation Module

Exploration | Modelling and resources | Development | Design | **Operation** | Remediation

Information is collected from different points in the mine for estimation of full mass-balance of processing pregnant solutions and production of final product

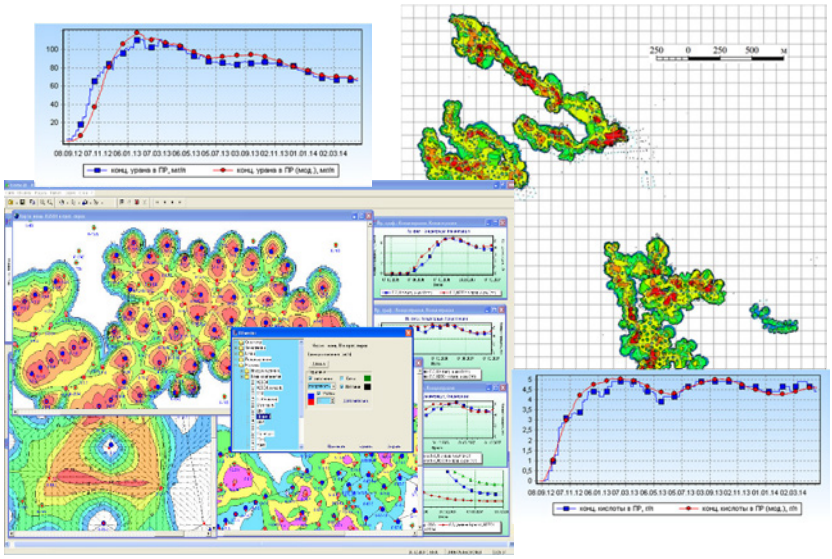


Seredkin et al., Minex Kazakhstan, 2018

Software system “Seversk” (Rosatom) Operation Module

Exploration | Modelling and resources | Development | Design | **Operation** | Remediation

- The geometallurgical module is the core of an ISR software system.
- The main purpose of operation of leaching and physico-chemical interaction processes of leaching solution with geological substrate based on real operation parameters.

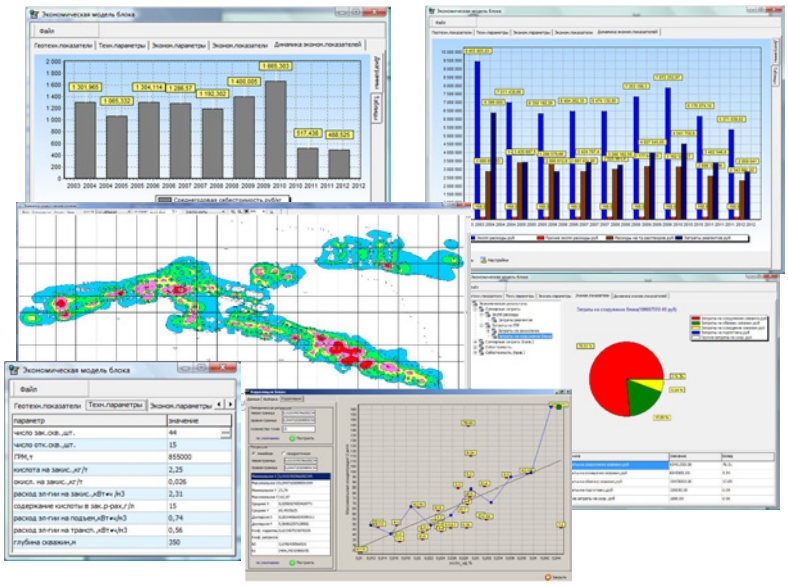


Seredkin et al., Minex Kazakhstan, 2018

Software system “Seversk” (Rosatom) Operation Module

Exploration | Modelling and resources | Development | Design | **Operation** | Remediation

An economic assessment module for an ISR operation returns economic parameters, a cash flow model, and initial information for the optimisation of ISR processes.

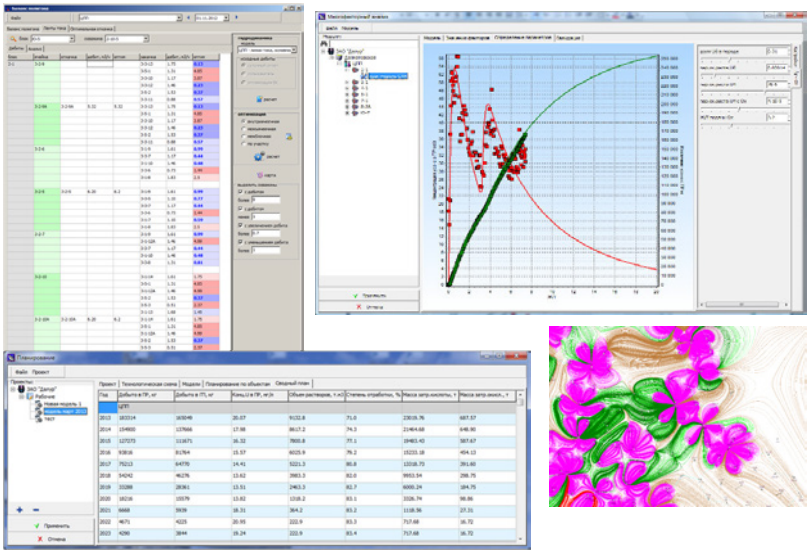


Seredkin et al., Minex Kazakhstan, 2018

Software system “Seversk” (Rosatom) Operation Module

Exploration | Modelling and resources | Development | Design | **Operation** | Remediation

- The operation module for the optimisation of operational blocks and regime of ISR, is based on the geometallurgical module, the operational data collection module and the economic module.
- This module returns options for the most effective operation for each block.



Seredkin et al., Minex Kazakhstan, 2018

Software system “Seversk” (Rosatom) Operation Module

Exploration | Modelling and resources | Development | Design | **Operation** | Remediation

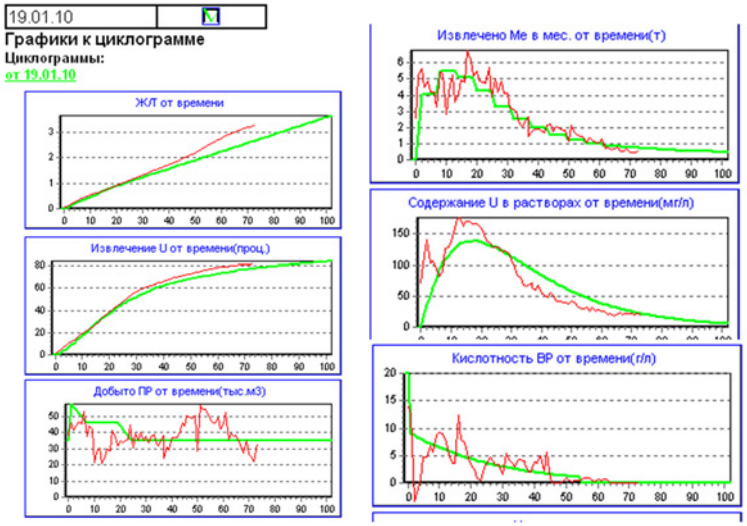
- All operation modules are integrated across the Dalur mine.
- Their software system is self-learning and in future may be used for operation of wells without an operator.

Seredkin et al., Minex Kazakhstan, 2018

Software system “Rudnik” Operation Module

Exploration | Modelling and resources | Development | Design | **Operation** | Remediation

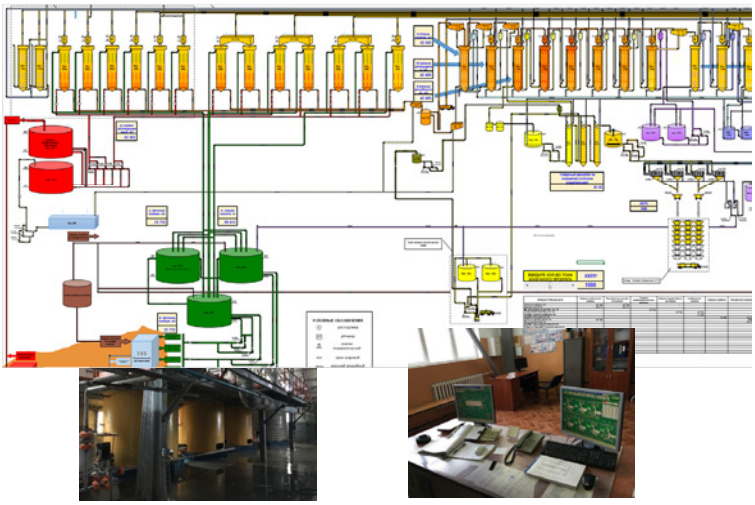
- The operation module in the Software system “Rudnik” is simpler and allows users to prepare and analyse real parameters of an operation blocks based on collected operation data for different periods of block operation.
- This analysis allows users to optimise parameters of operation blocks.



Software systems on Processing Plants

Exploration | Modelling and resources | Development | Design | **Operation** | Remediation

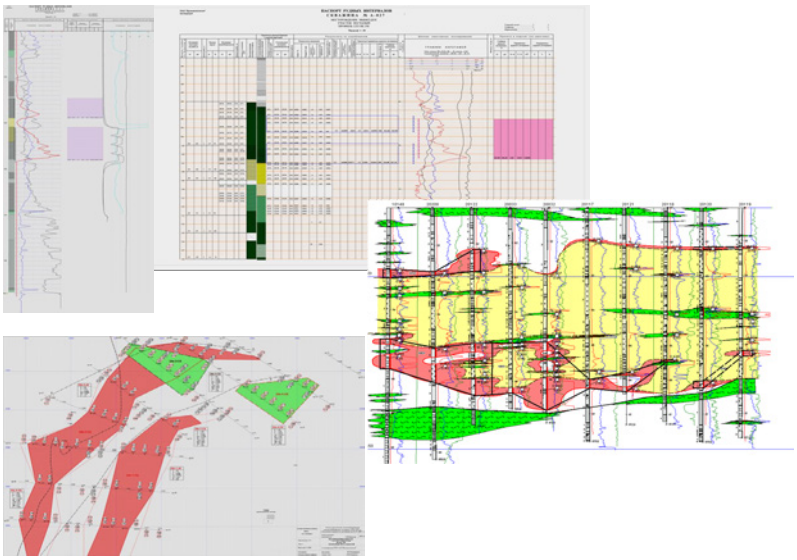
- Processing plants on ISR mines are operated by special software as standard approach.
- Operator may change reagent feeding, resin reloading, order new reagents, identify challenges and much more.
- This system may be integrated with an operation system for ISR blocks.



Software system “Rudnik” Geological Module

Exploration | Modelling and resources | Development | Design | Operation | Remediation

The geological module is focused on processing initial data, estimation mineralised intervals based on geophysical logging, preparation lithological section and Mineral Resource estimation by polygonal method.

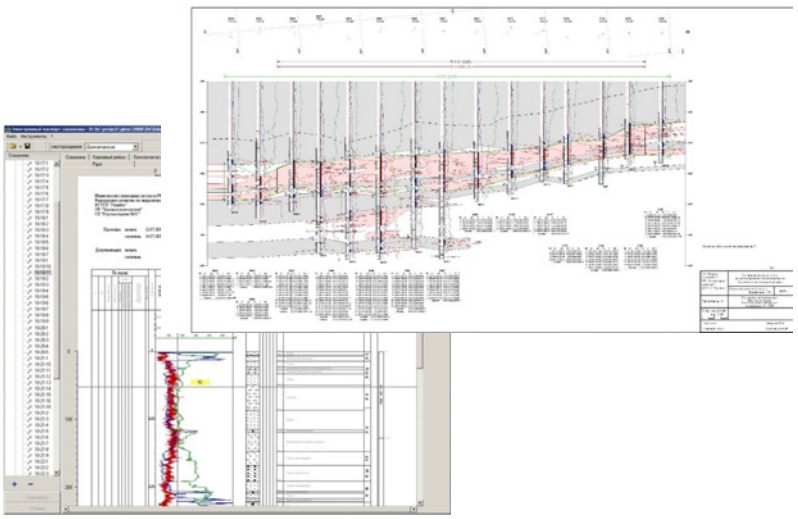


Seredkin et al`., Minex Kazakhstan, 2018

Software system “Seversk” (Rosatom) Geological Module

Exploration | Modelling and resources | Development | Design | Operation | Remediation

The basic geological module of the Software system “Seversk” is similar to the “Rudnik” system.

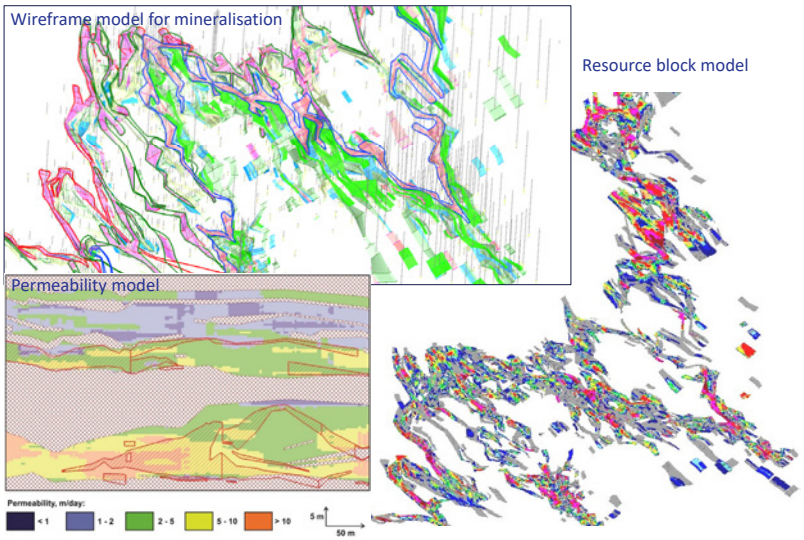


Seredkin et al., Minex Kazakhstan, 2018

Conventional mining software geological modules

- Conventional mining software is the best option for geological / resource modelling instead of the built-in geological modules in ISR software systems.
- 3D block models may be integrated with ISR software systems.

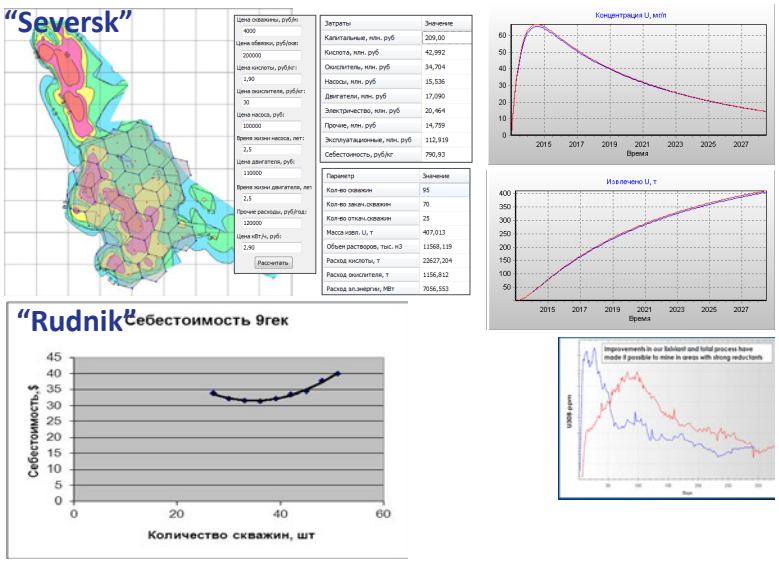
Exploration | Modelling and resources | Development | Design | Operation | Remediation



Development of ISR projects using ISR systems

The design module of both systems “Rudnik” and “Seversk” is used to estimate the grid and configuration of operational wells, expected geometallurgical parameters of operational blocks, and the estimation of economical parameters for proposed blocks.

Exploration | Modelling and resources | Development | Design | Operation | Remediation

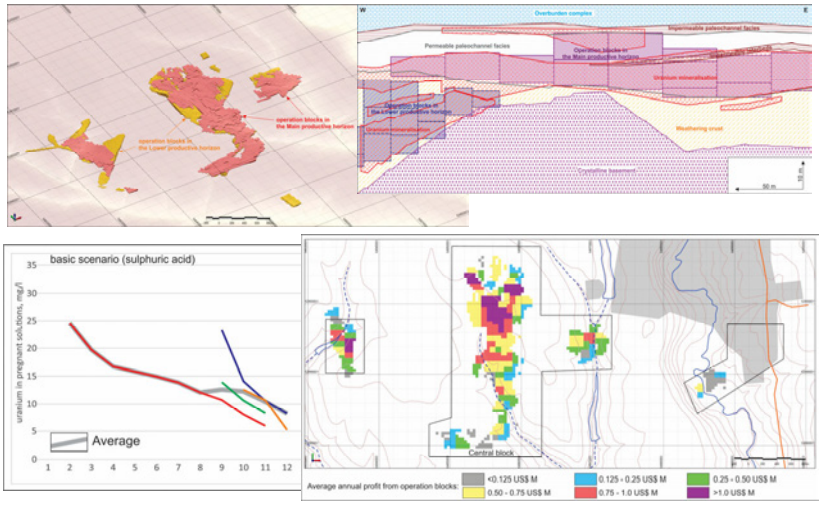


Seredkin et al., Minex Kazakhstan, 2018

Conventional mining software Development ISR projects

Conventional mining software can be used for development of ISR projects particularly for estimation economic parameters for each cell including cost of cell construction, operation cost, revenue and final profit.

Exploration | Modelling and resources | Development | Design | Operation | Remediation



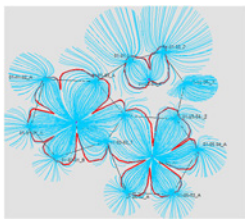
Hydrodynamic modelling in conventional software

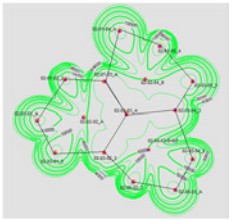
Modflow is a cheap alternative to ISR software systems for hydrodynamic modelling on pre-development and development stages.

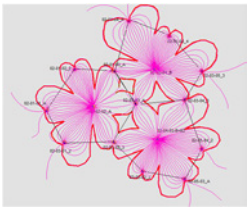
Exploration | Modelling and resources | Development | Design | Operation | Remediation

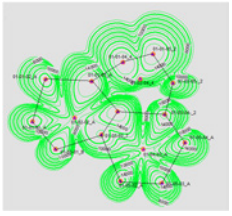
Hydrodynamic of leaching solutions

Distribution of sulphate ion



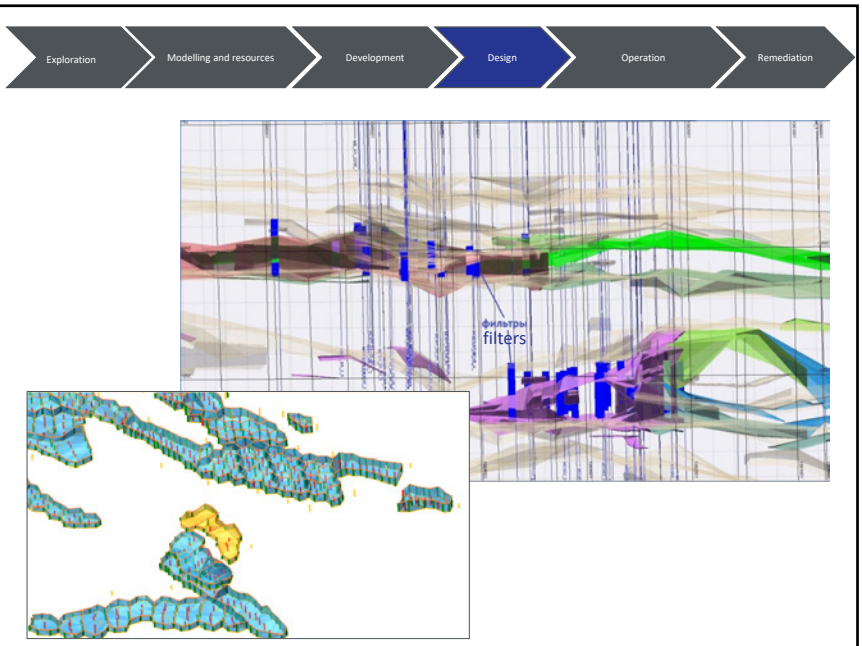






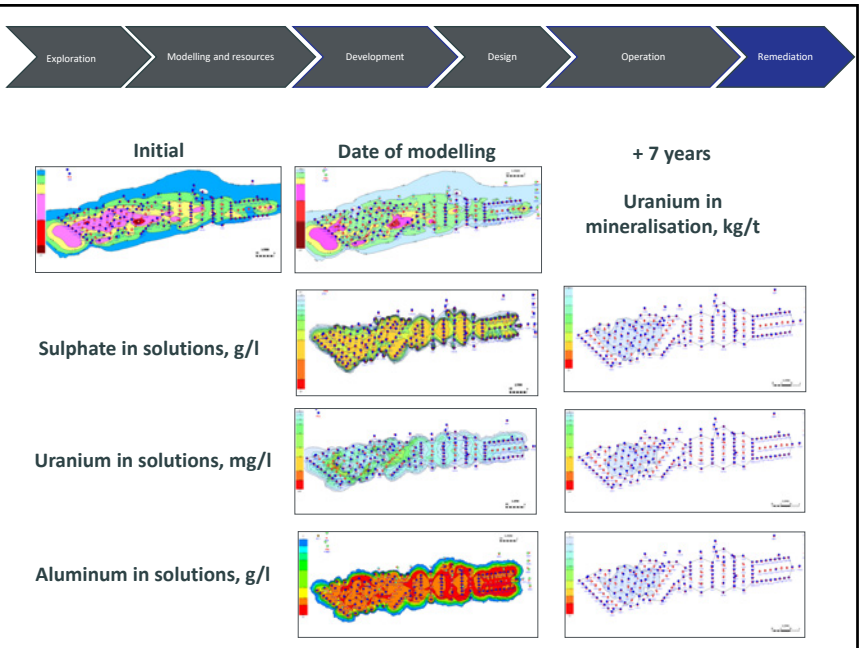
Using software for design operation blocks

- 3D models prepared for exploration holes are useful for properly designing of operation blocks and filter (screen) setting.
- Whereas ISR software systems “Rudnik” and “Seversk” use the 2D maps for operation wells and not the best option for designing operation blocks.



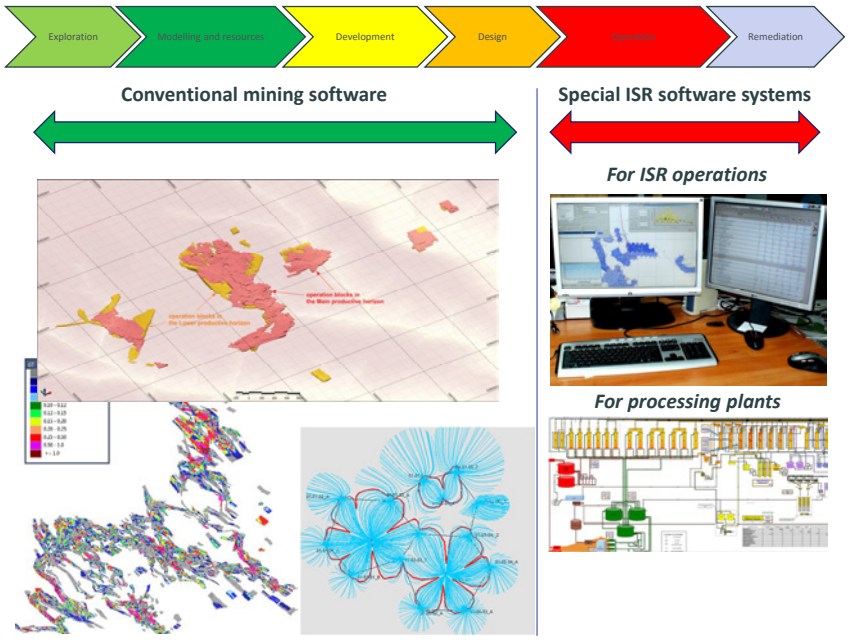
Software system “Seversk” (Rosatom) Remediation Module

Modelling of the evolution of solutions based on thermodynamic properties of the most common technogenic minerals, together with hydrodynamic modelling, allows the prediction of the composition of underground waters over certain time periods.



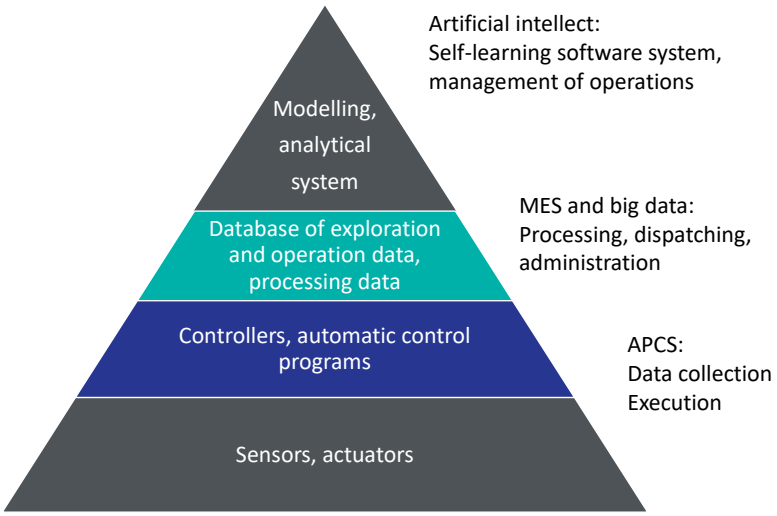
General approach for using software for ISR projects

- Software systems for an ISR operation are well-developed for using on ISR mines already .
- However information systems prepared for conventional mining are cheaper and better for early stage of ISR projects that involve exploration to development and design.



Hierarchy in ISR software systems

- Software systems for an ISR operation may be developed to self-learning system based on operation data.
- This system may manage ISR and processing operations with minimal personnel.



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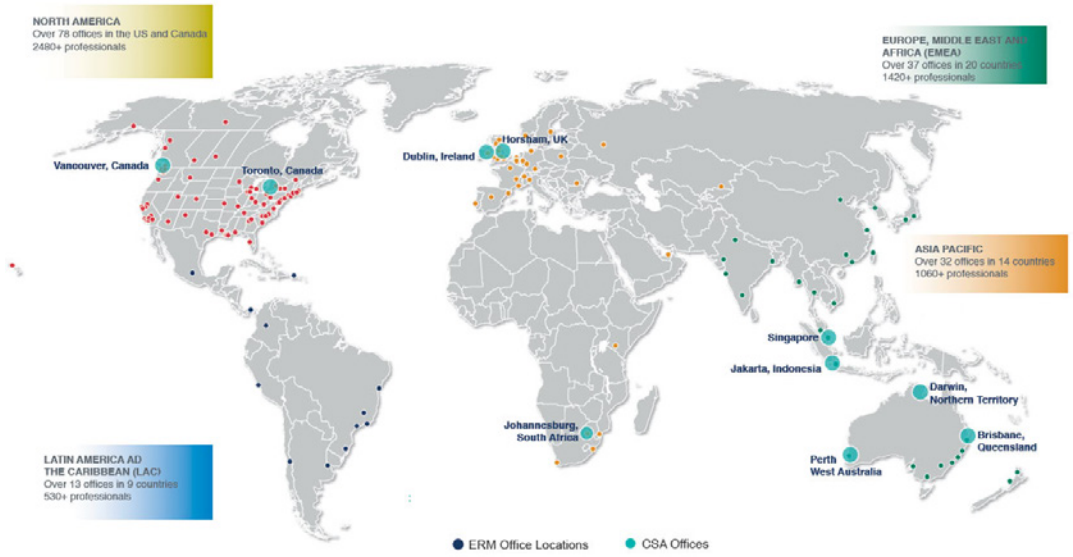

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