Intelligent Digital Rock Modeling

Vladimir Berezovsky[1], Evgeny Osipov[2], Olga Yufryakova[1], Yunfeng Bai[1]

[1]Applied Mathematics and High Performance Computing, Northern (Arctic) Federal University, Russia

[2]Dependable Computation and Communication group, Luleå University of Technology, Sweden

v.berezovsky@narfu.ru

Background

The context of the project is mathematical, computational and cognitive challenges in the Digital Rock Modeling (DRM). DRM implies using virtual or reconstructed digitized pore space and mineral matrix of natural rock to numerical simulating various physical processes in this digital object to obtain such macroscopic rock properties as permeability and porosity, to analyze reservoir characterization. The project is focused on following key issues:

- Efficient digital rock models and methods for extraction of rocks macroscopic properties from it;
- Natural language proceedings to extract data from geophysical survey reports;
- Image processing and associative reconstruction;
- Machine learning for model tuning;
- Open rock modeling infrastructure;
- High-Performance computing in modeling, simulation, visualization and data analysis.

The focus of the project is well-aligned with trends in Digital Rock Analysis and e-Core technology, that promise to address challenges of integration of intelligent data analysis into digital rock modeling to accurately and efficiently predict oil and gas reservoir characteristics using high-performance computing technology.

Methods

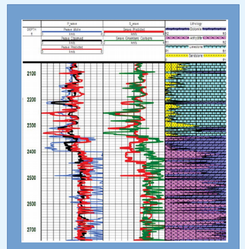
Molecular dynamics simulations using HPC for 3D rock microstructure construction and fluids permeability estimation.
Brute-force search accompanied by HPC for model simulations is used to train multilayer neural network to identify the correspondence between model parameters and geophysical survey and well logs data.

Assumptions

Having enough data from geophysical survey reports, adequate rock model and using artificial intelligence methods it can be possible to predict oil and gas reservoirs behaviors.

Assets

NArFU have a strong research record in computational methods for the digital rock simulation to predict the main permeability and porosity parameters of the oil and gas reservoirs.
LTU have a strong research record in machine learning and artificial intelligence.
NArFU have a considerable high-performance facility.

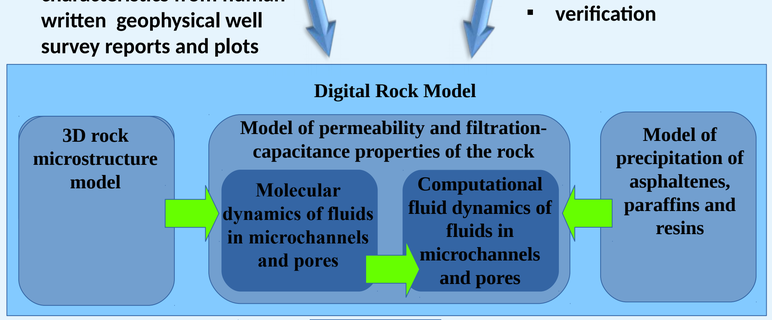


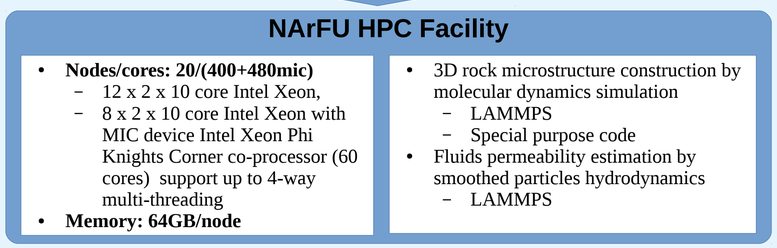
Log surveys processing

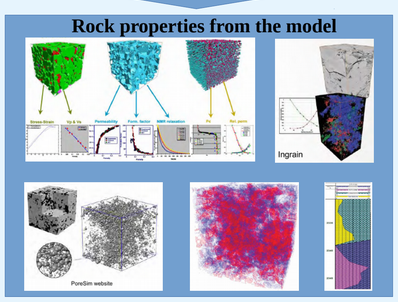
- extraction rock characteristics from human written geophysical well survey reports and plots

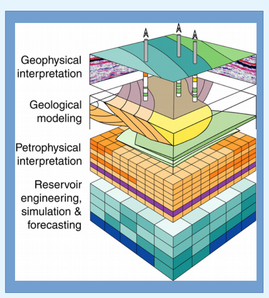
Laboratory examinations

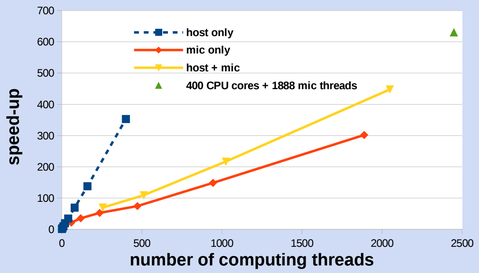
- intelligent data acquisition and assimilation
- verification











Performance of special purpose code for molecular dynamics building of rock microstucture on hybrid HPC with many-integrated core (mic) co-processors.

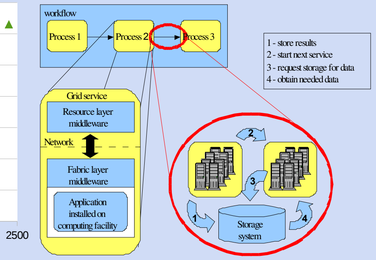


Diagram of modeling workflows implementation.

Results & Output

1. prototype of the intelligent infrastructure for digital rock modeling with several capabilities,
2. extraction foremost rock characteristics from human written geophysical well survey reports,
3. intelligent data acquisition and assimilation for the model,
4. verification of obtained from the model macroscopic properties.

Outlook

1. Open source infrastructure
2. Added chemistry
3. Verification of prognostic capabilities
4. Producing human-written like reports
5. Visualization
6. Reconstruction of rock based on geological data
7. Grid services

References

1 I. Belozerov, V. Berezovsky, M. Gubaidullin, A.Yuriev. Model of core microstructure terrigenous oil and gas reservoirs. Proceeding of V Scientific-Practical conference "Tyumen 2017: Geoscience is the key to rational development of mineral resources", URL:http://earthdoc.eage.org/publication/publicationdetails/?publication=87662, DOI:10.3997/2214-4609.201700081

2 V. Berezovsky, M. Gubaydullin. Modeling of the microstructure of a clastic oil and gas reservoir rock using molecular dynamics simulation. 16th International Conference on Geoinformatics - Theoretical and Applied Aspects, 2017. URL:http://earthdoc.eage.org/publication/publicationdetails/?publication=89508, DOI:10.3997/2214-4609.201701837

3 D. Kleyko, E. Osipov, R. W. Gayler, Recognizing permuted words with Vector Symbolic Architectures: A Cambridge test for machines.2016 In : Procedia Computer Science.

The Russian Foundation for Basic Research (RFBR) project No. 16- 29-15116
The Swedish Foundation for international Cooperation in Research and Higher Education (STINT) Initiation grant IB2017-7008
All models has been simulated used NArFU HPC facilities