

# **The First Application of Quantum Computing in the Exploration and Production Industry**

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## **Abstract**

We wish to showcase the first application of adiabatic quantum computing to solving seemingly simple, yet very challenging, optimization problem in subsurface imaging, known as residual statics estimation (RSE). The objective is to explain, how we arrived at the combination of the quantum technology, use-case, and the successful implementation thereof. We also wish to show what the future of this technology might bring to the exploration and production industry.

The field of quantum computing features two computing paradigms: a programmable circuit-model and quantum annealing. While the first is still in its infancy, and neither a large enough fault-tolerant machine, nor an algorithm to address a business need, have been demonstrated to date. A second approach can boast a 5000-qubit purpose-built quantum annealer, which uses quantum mechanics to determine solutions to complicated non-convex optimization problems. We convert the problem of stack power optimization into a hardware graph of a Quadratic Unconstrained Binary Optimization (QUBO), encode it onto a quantum computer and let it settle into its (quantum) ground state where the solution to the original problem is encoded.

Near surface in the desert environment features very strong wave propagation velocity heterogeneities and local anomalies such as wadis, karsts or sand dunes/sabkhas. Due to seismic resolution limit, the resulting temporal shift are difficult to estimate by conventional means, giving raise to unexplained residual statics, which in turn blur and distort the seismic image.

We demonstrate how a computationally complex combinatorial optimization problem of RSE can be implemented and ran on a quantum annealer. To accomplish that we first state the RSE problem as a stack power (or trace alignment) maximization. The latter then needs to be discretized and a solution space is chosen, such that the problem is converted to a so-called Quadratic Discrete Model. The discrete values are then represented by a set of binary variables, which later become the QUBO qubit states. This process requires the introduction of a constraint implemented with a Lagrange multiplier. We show some examples of this approach applied to simple noisy synthetics and to the SEAM Arid model dataset. We show that the quantum computer can align nearly 200 traces, and when supported by a classical computer, then number can be further increased to handle industry relevant problem sizes.

This is the first application of quantum computing to problems in the E&P business. There have been two attempts of solving toy problems in geoscience reported on before. The very first results pertaining to this work have been presented at the EAGE 2022 conference. This talk includes work conducted since Jan 2022 which was not shown elsewhere.