

Superdeep Scientific Drilling - Lessons Learned for the Development of Modern Drilling Technologies

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Background

Superdeep Scientific Drilling is known as a specific tool for Earth's crust investigations since the 1960s. Simultaneously in the USA and USSR relevant programs were started. The goal was to obtain information on the nature and properties of rocks and formations deep in the Earth crust.

The depths of 18 superdeep wells completed in FSU and Russia within 1961-2006 ranged from 5,000 m to the Kola well record of 12,262 m. More than 130000 m actually drilled in 9 different geological regions. The average well depth is 6987 m. Two of these wells will be analyzed in this paper.

Kola SG-3 Technique and Technology

The concept of SG-3 drilling was based on the three main principles:

1. 214 mm pilot borehole drilling with 100 % core sampling;
2. Using hydraulic downhole motors - turbodrills;
3. Using aluminum drill pipes.

Principles #2 and 3 were based on the fact that light alloy drill pipes and turbodrills were successfully used in the USSR oil industry. The available commercial turbodrills had a variety of properties, which guaranteed proper selection for SG-3 drilling. The R&D focused on design of a coring tool for the expected drilling conditions. Several types of core bits and core barrels were developed and tested along with pilot borehole deepening. Continuous efforts to find the optimal combination of core bit performance and core recovery rate were not always successful. Challenging borehole conditions required a new and innovative approach to BHA design and tool selection for each run.

The second phase of drilling when SG-3 crossed a depth of 7,000 m required new drill pipes and turbodrills. High-strength and temperature resistant light-alloy drill pipes were designed. A reduction-gear temperature resistant turbodrill was implemented. A new drilling mud system stable at high volumes and capable to efficient cuttings removal from the super-long open borehole has been developed. The 245 mm casing running technology was capable of reaching the record depth of 8,770 m. These major developments not only allowed to reach the record depth of 12,262 m but also significantly expanded opportunities and improved drilling efficiency in the country.

Krivoy Rog SG-8 new coring concept

Part of the Kola SG-3 strategy was an additional test borehole named "Sputnik". Testing of a new method of Drilling Without Pulling Pipes was performed. DWPP is based on internal flash aluminum drill pipes and retrievable coring and drilling assemblies. Tests were completed in 1978, however using the DWPP drill string in the existing open hole of SG-3 proved to be impossible. It was decided to use a new method at Krivoy Rog SG-8, featured super hard rocks and many expected geological complications. The principle #1 of the SG-3 concept was modified for SG-8 drilling:

1. Pilot borehole drilling down to the depth of 1000 m with a standard mining type rig and wireline coring technology, follow by the main borehole drilling with a RTB vertical drilling system.
2. 132 mm pilot boreholes up to 25 m long coring with retrievable system and subsequent reaming/drilling with the BHA providing verticality.

It became evident that scientific borehole drilling should not be seen as a short-term project but rather as a long-term downhole geo-laboratory. Lessons learned provided a solid basis for concept realization with proper advanced planning before well construction.

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