Active Earth

Down the Kola Well

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Editor's Note: *Releases dealing with technical developments in the USSR are occasionally received from the Press Office of the USSR Embassy in Canada. This article is presented here as an interesting summary of the Kola Superdeep Drilling Project in the Soviet Union. (Received May 1990).*

Production of minerals begins with geology. Today, you have to go deeper and deeper for them, including three to four kilometres for oil and gas. To determine the geological situation and placement patterns, even deeper wells have to be drilled, prospecting and technical means improved, and proven superdeep drilling methods and new basic knowledge applied.

Geology shows the evolutionary process geochronologically, making it possible to document geological and biological events and establish the chronology of rock stratifications in the Earth's laminated envelope. The effort to produce a far-flung system of superdeep wells in the Soviet Union will help develop mineral occurrence and thickness evaluation methods and establish when the Earth was born and how it developed and became laminated with a crust, mantle and nucleus.

Superdeep drilling will look into so far inexplicable geological phenomena, such as crustal shifts of scattered chemical elements; ore, oil, and gas concentrations; the nature of volcanism and earthquakes; geochemical zones with high or low content of elements and ensuing disease incidence; and mechanical stress and temperature fields and their dynamics.

A Telescope Looking Into The Earth

Twenty years ago, the unique Uralmash-15000 rig designed to drill 15,000-metre wells was put to work on the Kola Peninsula, where the granite-layer crystalline rock lies near the surface.

By the time the Kola project got started, the Soviet Union had several deep wells — Aralsorskaya (6806 m) in the Caspian lowlands, Shevchenkovskaya (7520 m) in the Carpathian region, Burunnaya (7510 m) in the Northern Caucasus and others. The deep drilling experience was there, but a special rig was needed. Instead of a rotary-type drill, a turbodrill was chosen and a pipe-string pulling-and-running system designed. For lightness, the string was made of aluminum alloys (a steel string would inevitably have broken under its own weight), minimizing the string presure on the walls and reducing the wear on the pipes, casing and walls several times over. With a lighter string, the ground-level hoists' load rating was reduced. On 25 May 1970, the first ever drilling into crystalline rock started.

The Kola well is not unlike a telescope. The 40 m wide shaft is encased in 720 mm steel pipes to prevent cave-in. To a depth of 2000 m, the walls are protected by two-layer (245 mm and 325 mm) piping. After this, the solid rock begins, for which no strengthening is required.

Lack of geological and geophysical information told on drilling. For example, nobody could foresee that, at a depth of 11,000 m, the pressure would be 1200 atmospheres and the temperature 200 °C. Mechanisms failed. Impromptu decisions had to be made and drilling technology improved. Crystalline rock, believed to be crushed at 500 RPM, could only be crushed at depths not exceeding 7.5-8 km. Special low-speed turbine engines and sample-taking methods had to be developed.

By May 1990, the well (1 m at its top and 20 cm at its lower end) reached a depth of 12,124 m and was included in the Guinness Book of Records.

The First Surprises

Soviet scientists were the first to look 12 km into the crust and prove, or disprove, many traditional geological modes. The "sole" of the sedimentary-volcanic formations turned out to lie at 6800 m instead of 4700 m as was earlier believed. The basalt layer expected at 7000 m has not been discovered. Nor has the radioactivity forecast come true, and radiation only increases with depth, owing to the rising percentage of radioactive uranium, radium, thorium, *etc.*

Rock compaction and the speed of elastic-vibration spread do not increase sharply with depth. In the 4500-8000 m interval lies a low-speed zone, which is crucial for building new crust and mantle models.

The temperature dynamics were unexpected. Instead of the expected 50°C at 7 km and 100°C at 10 km, 2.5°C were added every 100 m after the first 3 km, reaching 180°C at 10 km. Hundreds of cubic metres of wash is warmed up to 45°C by the flow arriving from the mantle. With depth, the chemical reaction of water (chloride-calcium at the surface and carbonate-sodium at the bottom) and gas changes, the content of hydrocarbons falls and that of hydrogen and helium increases.

Prior to the Kola experiment, scientists, relying on the surveyed-deposit data, sought to grasp ore-formation processes. Now, they have seen for themselves brines that contain bromine, iodine and heavy metals, an indication that a high copper and nickel content and, at 4.5-9.5 km, large fragmented-rock zones have been found. The fragments are cemented by quartz, calcite and copper, iron, lead, zinc, nickel, cobalt and other sulphides, evidently also arriving from the mantle. This is seen from the sulphur isotope composition, which approximates that of meteorites, believed to be the Earth-forming material.

The Kola experiment shows that, in different crystalline-based structures, volcanic processes were added to the accumulation of sediments and everything became mixed and shifted. Hence, the laminated crystalline crust-based composition.

Two carbon dioxide sources have been revealed, disproving the opinion that deep horizons are lifeless. One of them is associated with the mantle and the other is biogenic and predominates in the rock where the remains have been discovered of 17 ossified-micro-organism types, dating back to the first billions of years of Earth's existence. They witnessed the early biogenic Earth-evolution process. In the crystalline basis, Precambrian formations which appeared 3.5-1.6 billion years ago have been discovered.

All this is evidence of the Earth's crust being mostly biosphere remnants, as outstanding Russian scientist Vladimir Vernadski (1863-1945) believed. Only the origin of basalt and other non-magma rocks is not associated with the biosphere — the Earth's envelope, in which the activity of living organisms, including man, combined to produce a geochemical factor, he said. This means the Earth had a biosphere way back in the Precambrian era, four billion years ago, when the oxygen atmosphere and life appeared. Remarkably, the basalt seas are proof that the Moon has no biosphere; nor has Venus.

To Be Continued

The Soviet Union with its 12 superdeep wells is the only country which can routinely bore down to 7000 m and more. The Kola well is king among them. Progress to the 15,000 m mark slowed in the hard geological zone — the far-off region where the behavior of both abyssal and artificial substances is unpredictable. This hard zone was predicted, but not expected to have extreme pressures and temperatures. The rig has to be updated because very complicated and unprecedented phenomena have sprung up. The 12 km probe is not enough for scientists now, but they are hopeful the updated version will be more efficient.