REPORT ON TECHNICAL EXHIBITION AND EXCURSION

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The seminar was organized in

- 2 plenary sessions,
- 3 section meetings:
  Section A: Regional Deep Geophysical Research
  Section B: Techniques and Technology of Superdeep Borehole Drilling
  Section C: Methods and Technical Facilities of Geologo-geophysical Research in Boreholes and Surroundings
- Poster presentation
- Round-table discussion
- Technical exhibition
- Excursion to Krivoy Rog well site

TECHNICAL EXHIBITION

The Russian equipment exhibited deserves special attention.

1. Gear reduction tool 7-3/4" (195 mm), pictures 1, 2
   Reduction ratio: 3.69 one stage, 3.65 m, 660 kg
   13.62 two stages, 4.20 m, 720 kg

The reduction tool can be employed with various turbines of Russian design (tables 1 and 2), thus resulting in a rotational speed from 30 to 300 min-1 for the bit. Moineau motors of a type such as Dynadrill 1000 can also be used with the gear reduction tool.

The model exhibited is evidently a new version, because it can be employed in either the one- or two-stage version without special modifications or length additions. The second stage can be obtained by replacing one stage by a cross-over spindle.

2. Apparatus for determining rotational speed of turbines, picture 3

A mechanical-hydraulic tool driven be the rotor of the turbine operates with an extreme reduction ratio and drilling fluid pulse system for indicating the actual speed of a turbine.

3. Aluminum drill pipe (RDP) with steel connections, picture 4

The drill pipe on display had a wall thickness of 1" (25.4 mm) and a conical thread connection to the steel tool joint. (A special report on the discussion on aluminum drill pipe follows.)

4. Moineau motors

The following sections of Moineau motors were shown:

- 9/10 MM version with hollow rotor, chrome-plated, picture 5
- 5/6 MM version with rotor constructed of metal sheets with a thickness of about 3 mm, chrome-plated, picture 6

5. Model of 7-3/4" turbine with about 20 stages, reduction gear, and roller core bit, picture 7

6. 217-mm roller core bits, new and used, pictures 8, 9

Four roller cones with five cutting rows and a gauge row were exhibited. The TC inserts were chisel-shaped. The number of inserts per row was as follows:

- for gauge protection: 26 inserts;
- OD-row: 20 inserts;
- second row: 18 inserts;
- third row: 14 inserts;
- fourth row: 9 inserts;
- fifth row: 3 inserts.

The diameter of the inserts was reduced toward the center of the cone to about one-half the size of the OD inserts.

7. Scale models of drill pipe inspection unit for tool joints and drill pipe, picture 10

8. Scale model of hole opener which employs two or more turbines in a bundle, picture 11

The bundle body was designed in the form of drill collar for large-hole drilling with the use of dead-weights for high mass concentration.

In addition to the drilling equipment mentioned above, the exhibition featured models of shelters, living quarters, storage bins (silos) for cement and drilling fluid materials, personal computers for drilling supervision, as well as heat- and pressure-resistant components of electronic devices for the investigation of superdeep boreholes. The latter have the following specifications:

$T_{max} = 250\ ^{o}C$
$p_{max} = 200$ MPa

9. Discussion with Russian experts on aluminum drill pipe (ADP)

The paper of K. Sträter and E. Quadflieg, Mannesmannröhren-Werke Düsseldorf on "Material Selection and Concept for the Drill Strill to be Used for the Continental Deep Drilling Project KTB" was the cause of a controversial open discussion with Russian experts. Dr. Fain, responsible for ADP development in the Soviet Union, and other tubular goods for the Kola borehole, summarized the Russian standpoints favoring ADP during the section meeting as follows:

- The reduction in strength of ADP at elevated temperature is well known. We strictly disagree with the conclusions drawn by Dr. Quadflieg with respect to its application to superdeep drilling. Kola is the proof that ADP provides a reliable drill string which can be employed at a temperature up to 220 oC.

- The weight reduction with ADP, as compared with steel drill pipe, is about 50 percent, in spite of the use of steel tool joints.

- ADP can better protect the casing against wear than does steel drill pipe.

- Corrosion can be controlled with the drilling fluid used.

The Russian experts invited the German participants interested in more information on the subject of ADP to attend a separate meeting. The Russian group was headed by Dr. B. N. Khakhaev, Nedra.

ADP is employed in combination with downhole motors (DHM). In addition, the drill string is rotary-rotated at 4 to 6 min-1 in Kola SG 3, and the torque is limited to 2400 to 2700 N.m.

It can also be used for rotary drilling. Explanations were given by Dr. Fain, chief metallurgist for Kola SG 3 and promotor of ADP:

Because of reduction in strength of ADP with temperature, the drill string is normally a combination of three different grades of ADP. The strength is plotted against the temperature for the three available grades in figure 1. The data given by the Russian experts are presented in the table included in figure 1.

For specific applications, the optimal capacity of the ADP drill string can be obtained by selecting the appropriate wall thickness.

A configuration of various geometries used with aluminum drill pipe is shown in figure 2. The connection between ADP and steel tool joints is specially designed for thread profile, and a shrink fit system is employed for improving make-up.

Corrosion

Inhibitors are available for controlling corrosion. Documented instructions indicate which of the ADP is to be used in a given borehole situation when load and temperature profiles are known.

Design

The design cannot be directly compared with that of steel drill pipe. As mentioned above, some designs employed in superdeep borehole drilling are shown in figure 2. For wear protection in the middle of the ADP, an upset can be provided with or without hard material.

For reverse circulation, the OD may be reduced, while the ID of the pipe has the same dimension as the tool joints.

For Kola SG 3, the steel pipe was preferably designed to be flush at the OD (with the tool joint?) and had a pronounced internal upset of the pipe at both ends to the steel connector. At least 27 m above the bit, the core receiver (inner barrel) was designed for allowing hydraulic lifting of the cores into the core barrel.

For cement jobs and in risky operations involving a hazard of getting stuck, ADP without steel connectors may be used for allowing easy milling.

Spiral ribs in combination with upsets in the middle of the pipe were provided for reducing vibration and improving bit performance.

For general turbine core drilling, ADP is employed, but its use is not limited to drilling with downhole motors.

The side force on the casing and borehole is greatly reduced with the use of ADP. Since Young's modulus, E, is about three times the value for steel,

$$(E_{el,ADP} = 3\ E_{el,steel}),$$

not only side forces are decreased; fatigue failure also does not occur.

Some peculiarities associated with the use of ADP deserve mention and are summarized as follows:

- In rotary drilling, the number of revolutions executed by the rotary table before the bit starts turning is three times higher than for steel pipe.

- The string can be designed by utilizing the properties of the three grades introduced by the USSR, and a wide choice of wall thickness is available for adjusting to the depth and temperature.

- In Kola, practically no failure was experienced with ADP.

- Easy milling helps in cases of stuck pipe.

At the end of the presentation, Dr. Khakhaev and Dr. Fain indicated their willingness to design a drill string for use at KTB, if boundary conditions are specified on our part.

After the presentation, the following questions were raised and answered by the Russian experts:

Q: What is your experience with the use of ADP with respect to corrosion and connections between aluminum pipe and steel connectors?

A: We had problems at the beginning, but were able to solve them. Excessive torque did not occur, and we kept the drilling fluid in the pH-range from 7 to 9.5, since we know that the corrosion rate increases at a pH-value above 9.5. As already mentioned, special corrosion inhibitors for ADP are available. Corrosion was always very slight in the borehole, but more pronounced in air. Steel corrosion problems between ADP and tool joints did not occur

Q: Did you experience axial vibration during rotary drilling or turbine coring with your four-roller-cone core bit design?

A: Axial vibration did not cause major problems. I wish to point out further advantages of ADP with respect to casing wear. We experienced less casing wear because of:

- lower string weight;
- higher elasticity of the drill string;
- casing somewhat protected against wear by powdered aluminum covering the inside of the casing.

Q: How often did you change your wear casing in Kola?

A: After ten kilometres of pipe movement, we turned the casing through 90 degrees. We replaced the casing after four turns.

Q: What is your experience with drill pipe fatigue?

A: We rely on good pipe inspection (flaw detection) by means of ultrasonic (US) testing. 250 m is under inside inspection (?)

Q: Do you have a process for inspecting drill pipe during round trips?

A: Yes, but only for the pipe, not for the tool joint.

Q: What is the joint stability between ADP and steel joints?

A: The aluminum thread may be damaged by the steel thread because of excessive load, torque, and axial load.

Q: Do you apply grease between steel and aluminum during make-up?

A: No; the joints are made up by heat shrinking and controlled torque.

Professor Rischmüller expressed his thanks for this discussion and stated that there are no contradictory opinions. He promised to send KTB specifications for enabling the Russian side to perform calculations and provide recommendations for an ADP string design.

It was agreed to address the specifications for this cooperation to:

Cand. Tech. Sc. Vladimir S. Basowitch,
Deputy Head of Geological Prospecting Expedition
Kolskaya GRESD

10. Krivoy Rog - excursion, 29 August 1988

10:30 to 12:30 h House of Technique in Krivoy Rog

1. General survey of area and town

2. Geological situation in the area of Krivoy Rog superdeep borehole - 8, by M. S. Kuslov

12:30 to 17:00 h Drill site, laboratories, and downhole tools

The rig is a standard derrick with a capacity of 300 t (10 lines):

depth capacity with ADP (downhole motor and wireline): 7000 m;
depth capacity with steel pipe and rotary drilling: 6000 m;
electrically powered drawworks: two 600 kW units, with DC motors;
pumps: four 600 kW duplex and 1 mixing pump of same size.

For the depth range from 7000 to 12 000 m, a new derrick structure of type Uralmesh 15 000 will be employed.

Program and status

The total depth planned is 12 km. During phase 1, with the derrick on the drill site, a depth of 3550 m was reached with a borehole inclination of 35 degrees. The deviation was allowed for reasons of investigation. The vertical borehole with a diameter of 480 mm to a depth of 3550 m was drilled by a method using turbo-bundle (two turbines).

- Casing: 420 mm to depth of 3550 m

General lay-out and equipment

Square kelly and swivel: 250 bar, 250 t

Hydraulically operated slips and air tongs for spinning

Reverse circulation installation for pump-out of downhole coring system in 12 min from a depth of 1600 m at a pumping rate of 30 l/s

One drill string ADP, one drill string steel drill pipe

During the visit, the rig crew demonstrated the pump-out of the downhole coring tool, replacement of the core barrel, and pumping-in of the same equipment. The traveling speed of the equipment was about 0.6 m/s. The actual depth was about 1600 m; coring was performed only for correlation and demonstration.

The pump-out time for the 132 mm downhole tool was 12 min. The arrival of the equipment at the surface is indicated by a sensor in combination with a light signal. After reaching the fishing spear, a central collar is lifted by the upward movement. A hydraulic damping system with a locking device for the tools similar to the fishing spear for wireline tools is employed.

The downhole tool (picture 12, figures 3 and 4) which was pumped out consisted of:

- a core bit, 132 x 69 mm; average tool life: S = 8 to 40 m (picture 13); (AUF DER VORLAGE STEHT ,,bis **14** m" BITTE PRÜFEN!)

- core barrel with one three-blade spiral stabilizer above the core bit; core barrel length: 6 m;

- reamer section, 132 x 217 mm: with four blades, picture 13

  The blades are about 8 cm in width, and the inserts are diamond-impregnated (Slavotitsch). They are hydraulically extended by normal drilling fluid circulation after the tool has reached bottom position, and retracted by reverse circulation applied for pump-out operation.

- speed reducer: 7-3/4" (195 mm)

The data are compiled in tables 1 and 2. The speed reducer is sealed and hydraulically balanced, and features roller bearings. The planetary gears have a reduction ratio of 3.69; a second stage with the same ratio can be added in series, thus providing a total reduction ratio of 13.62. The speed reducer is connected by a square pin at the top and a square box at the lower end.

The circulating fluid passes through the speed reducer by way of a separate annulus between the gear housing and outer barrel. In the case of the pump-out version, the cross-over section to the core barrel has a reduced diameter of 132 mm. The bevelled shoulder from the 132 mm section to the 195 mm section is the lower shoulder which matches the corresponding shoulder at the mantle tube of the drill string.

- Turbine

One of the several turbine designs with bearing sections is specified in table 1.

- Upper section of the downhole tool (picture 15, 15a) with:

  o torque splines which are hydraulically extended during drilling by fluid circulation;

  o a radial connection to the mantle tube by means of two rubber cups subjected to the circulation pressure;

  o central fluid passage for by-passing the annulus;

  o fishing neck for wireline retrievers

For application of the hole-opener system (pictures 16, 17) with two turbines combined to form a bundle, steel drill pipe is preferred.

The steel drill pipe used on this location had threaded connections to the tool joint and, in addition, a circumferential welded seam between the tool joint and pipe. The operations manager for Krivoy Rog, P. Stanko, explained that three versions of steel drill pipe are in use with respect to the connection between the tool joint and pipe:

1. threaded connection with shrink fit;

2. threaded shrink-fit connection with additional welding;

3. friction welding between the tool joint and pipe.

For interbedded harder streaks, the reamer does not cut effectively, and the system for coring and hole opening is withdrawn from operation. The lower part of the internal drilling system is now replaced by a wireline-retrievable three-cone roller bit (picture 18). This bit section is fully exchangeable with the core barrel plus reamer section. After the hard streaks have been penetrated, operation of the system with the coring equipment and four-blade hole opener (132 to 217 mm) is resumed.

In the case of continuous sections of rock which is too hard for the reamer section, the pump-out system must be replaced by the turbine coring tool with retrievable inner barrel and hydraulic lifting of the core into the inner barrel during the coring operation. This hydraulic lift is achieved by reversing a portion of the drilling fluid stream through the inner barrel in a manner similar to that for a reverse circulation tool.

The formation at a depth of 1600 m had a drillability index of 8 on the scale from 0 to 12, where 12 corresponds to quartzite.

For the maximal flow rate applied - in this case, 50 l/s (3m³/min) - the solids control equipment consists of

three shale shakers (picture 20);

desander, desilter, degasser (picture 21);

settling tanks with level indicators (picture 22).

The return line is open, the pressure line from the drilling fluid pumps is insulated for a wintertime temperature of about -10 oC. The pumps are located in a separate building with ample space (picture 23).

The front of the V-door is served by a beam crane with an electric hoist (picture 24).

At the end of the catwalk, a powerful wireline hoist (picture 25) was being installed in front of the crane for retrieving the coring and hard rock drilling bit assembly by means of wirelining instead of a pump-out operation, which is associated with the risk of fracturing formations. Evidently, the wireline was not previously available in the quality required for heavy-duty operations in superdeep boreholes. The equipment to be lifted has a weight of 1.5 t.

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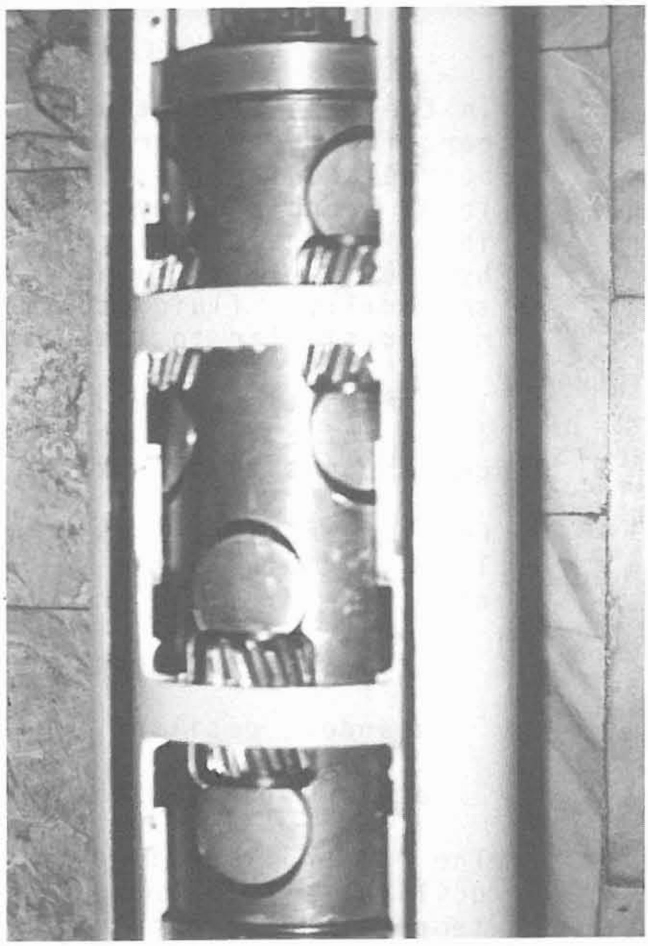

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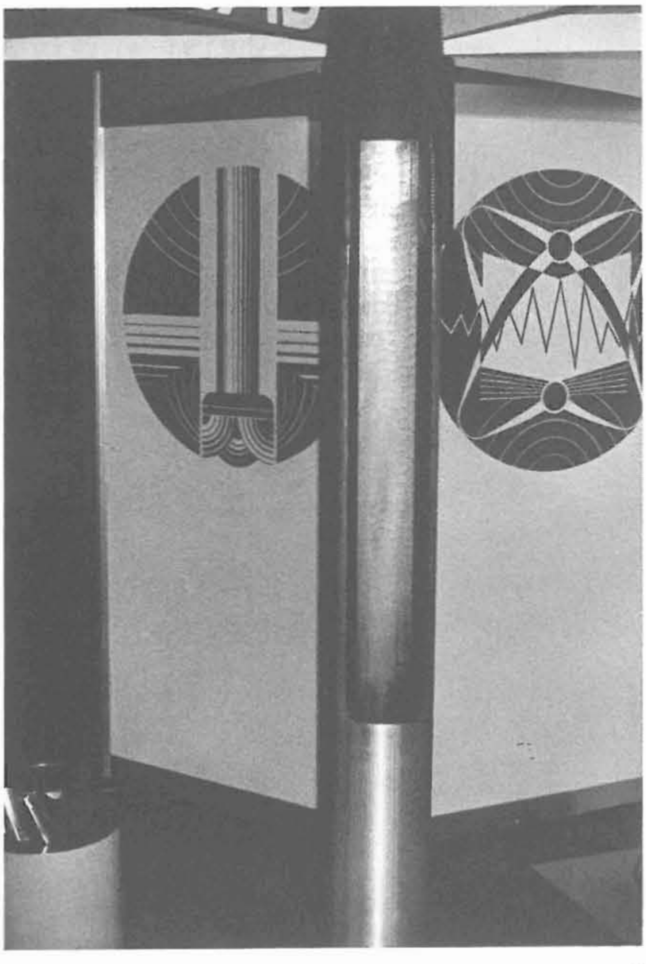

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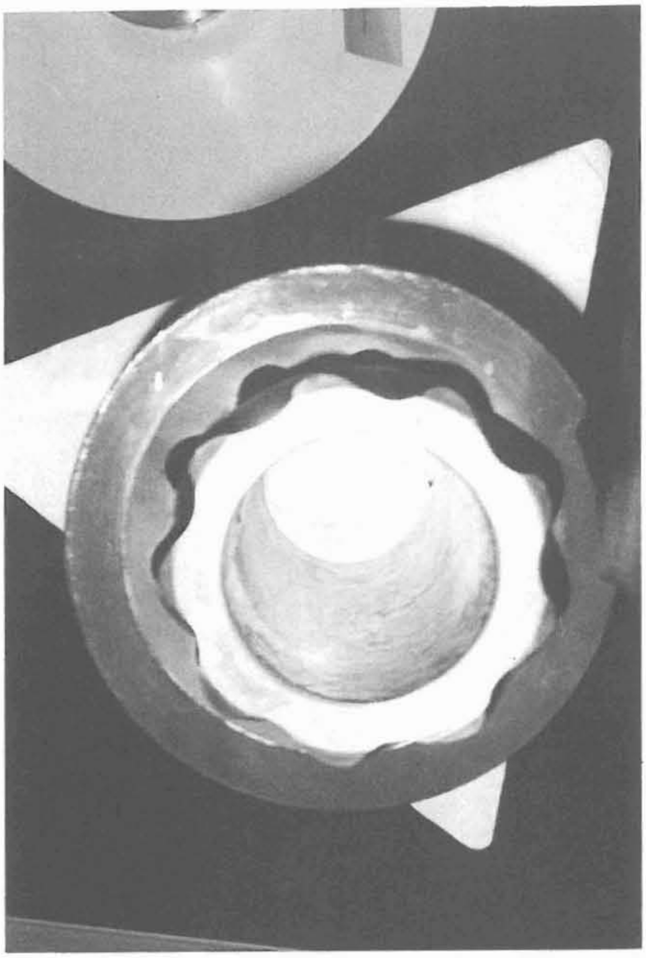

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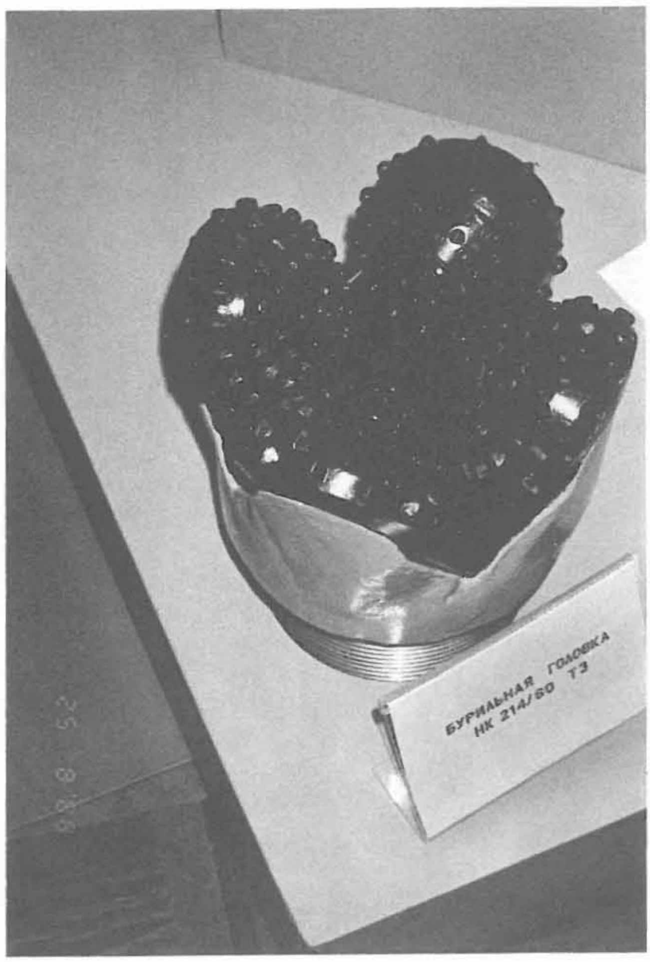

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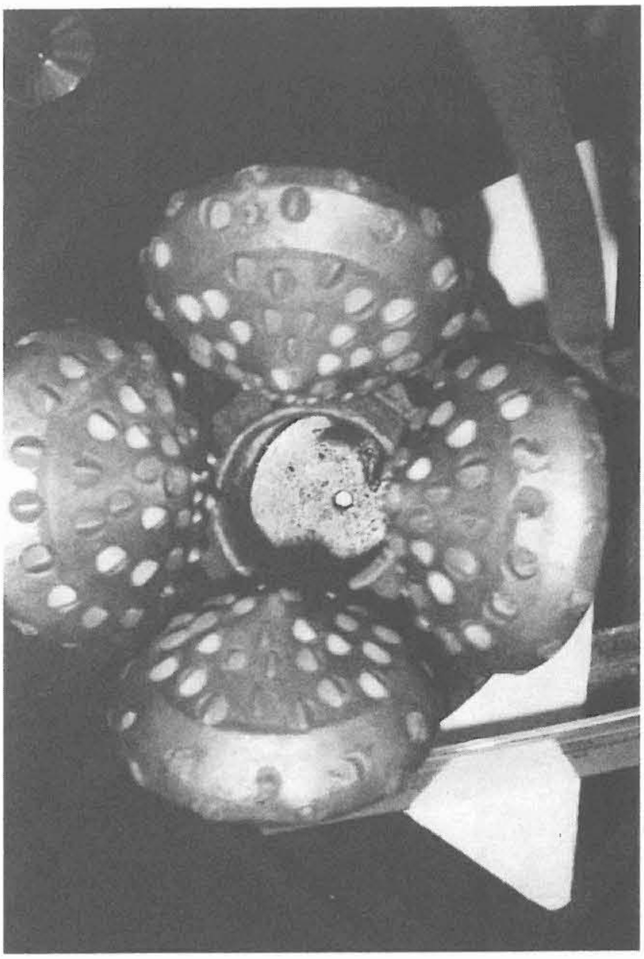

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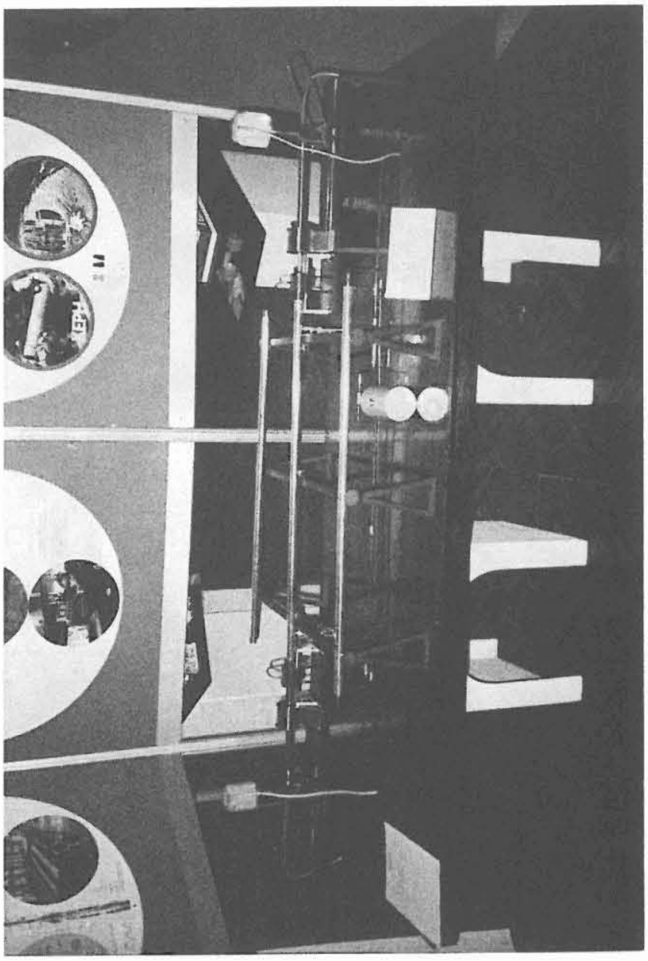

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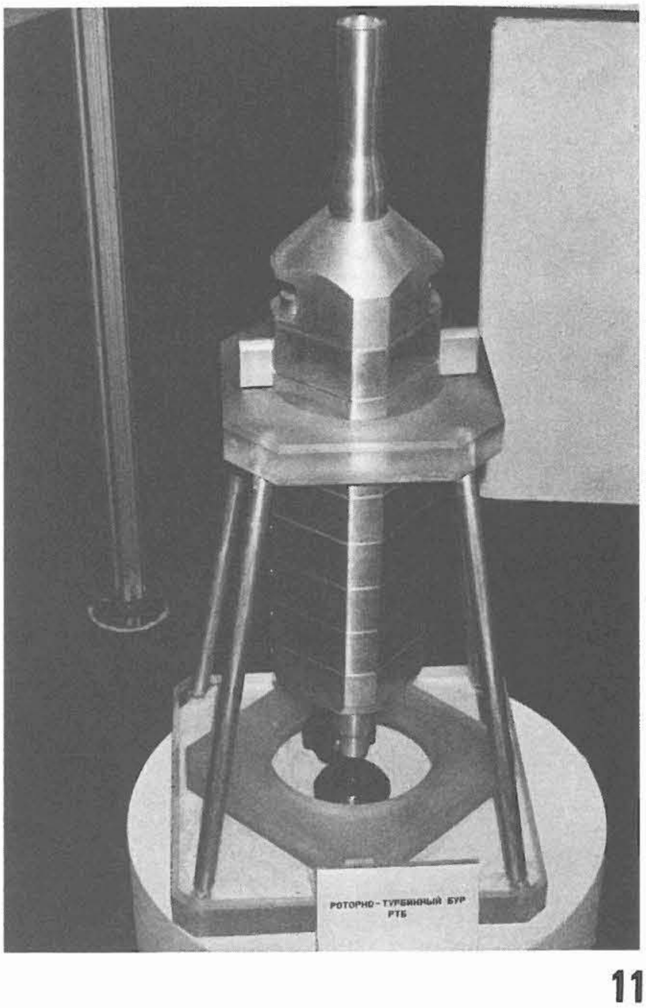

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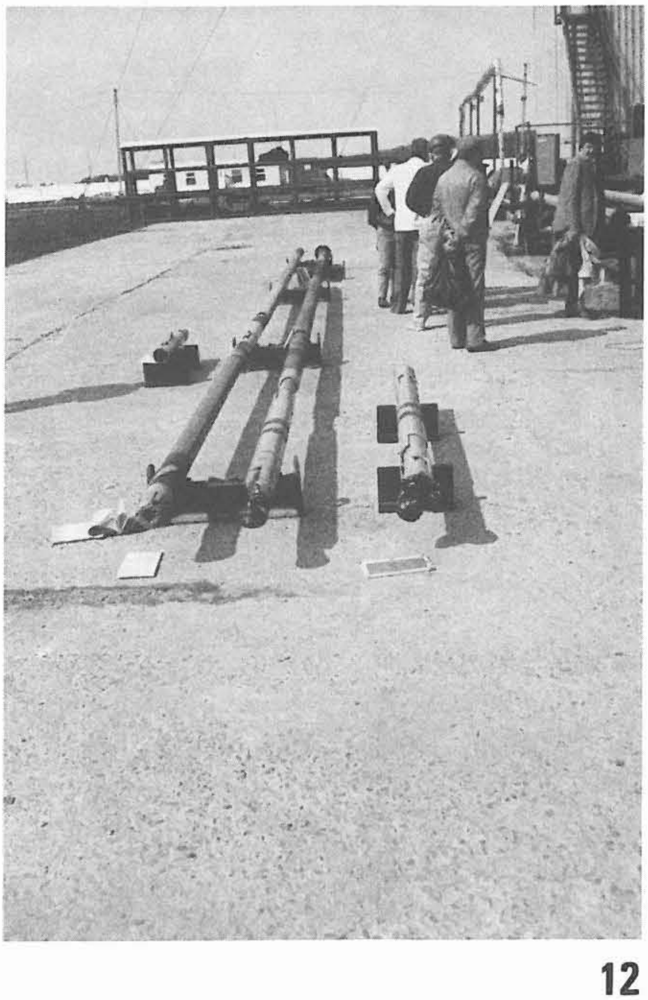

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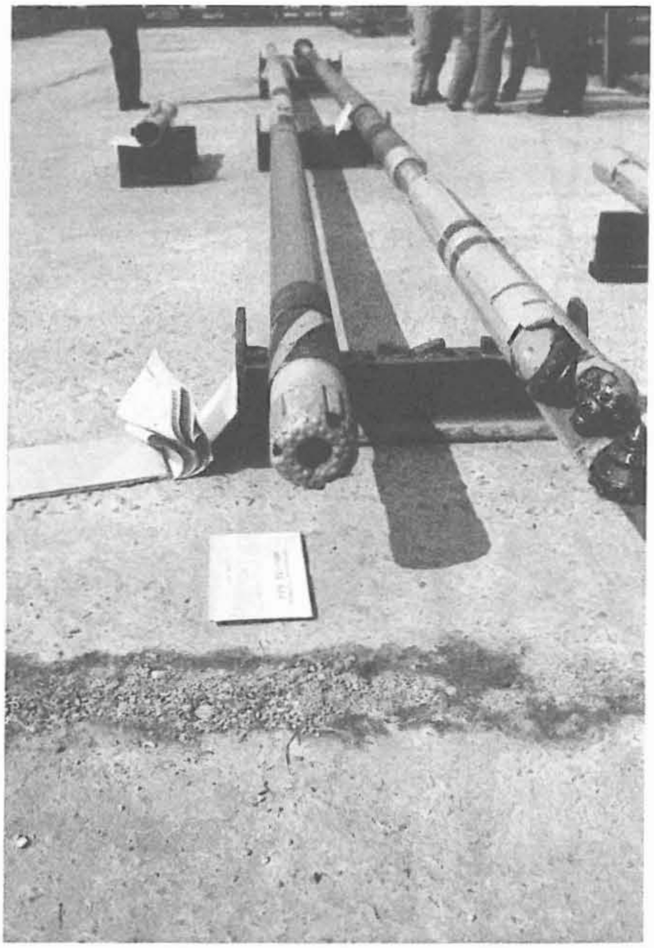

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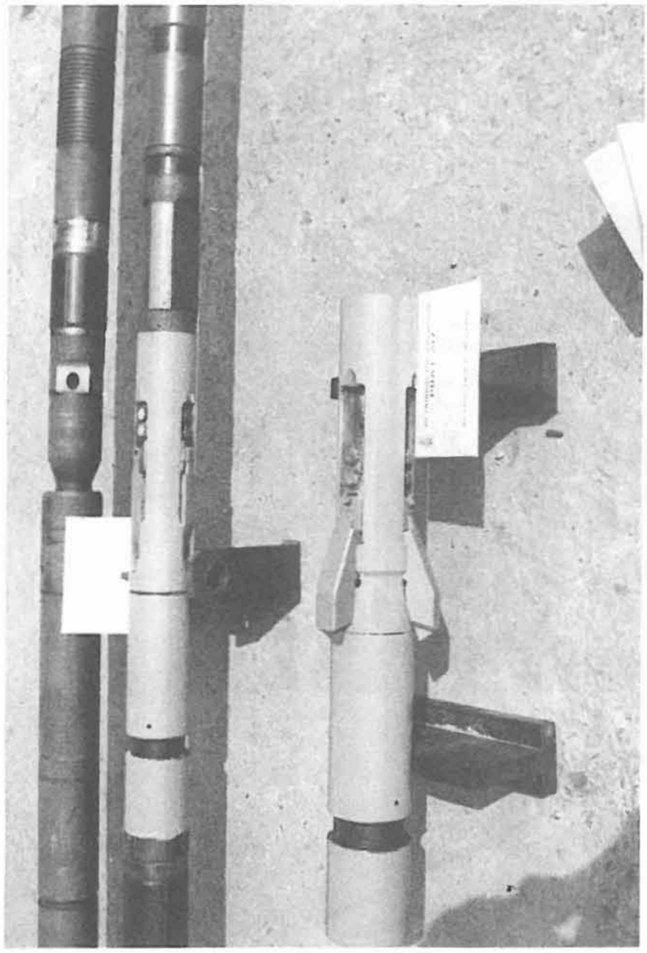

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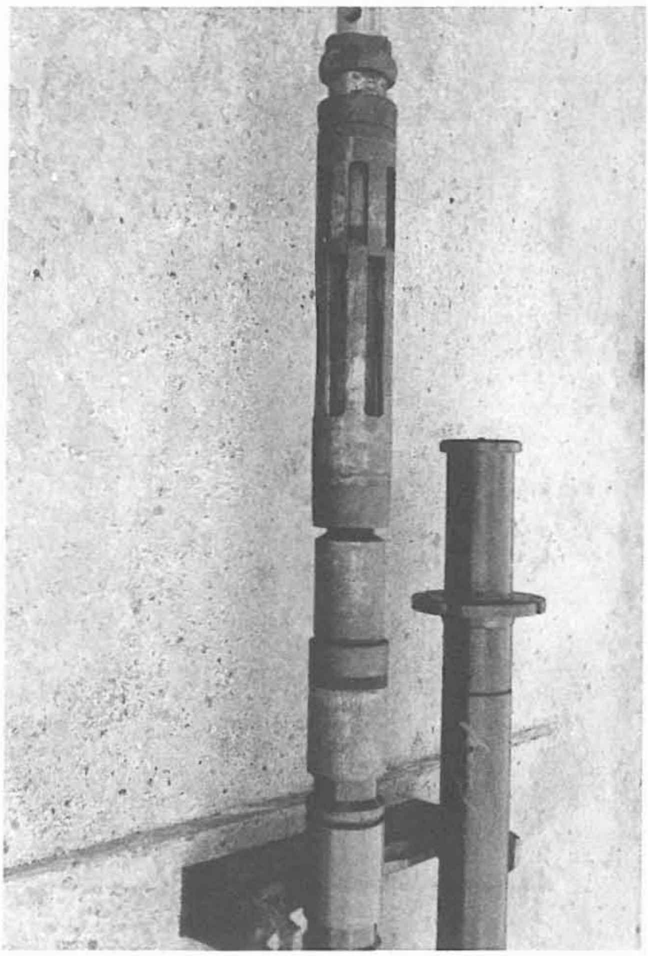

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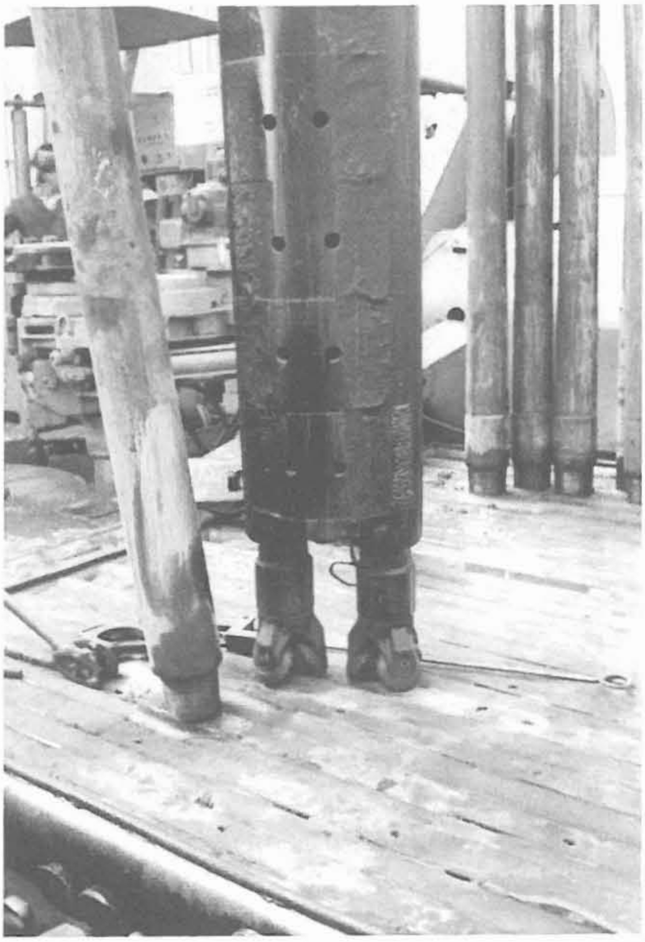

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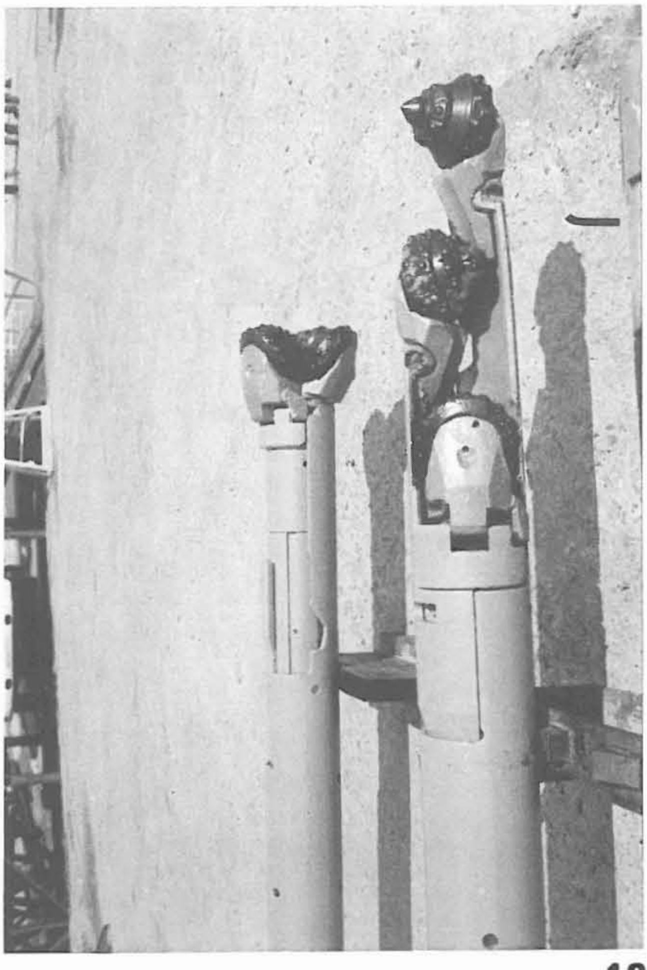

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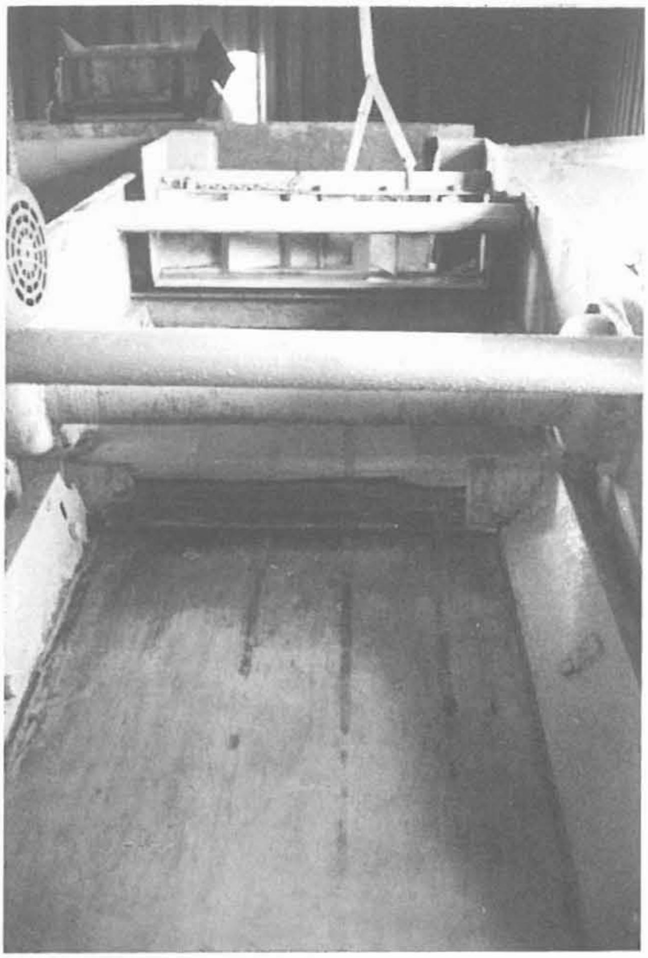

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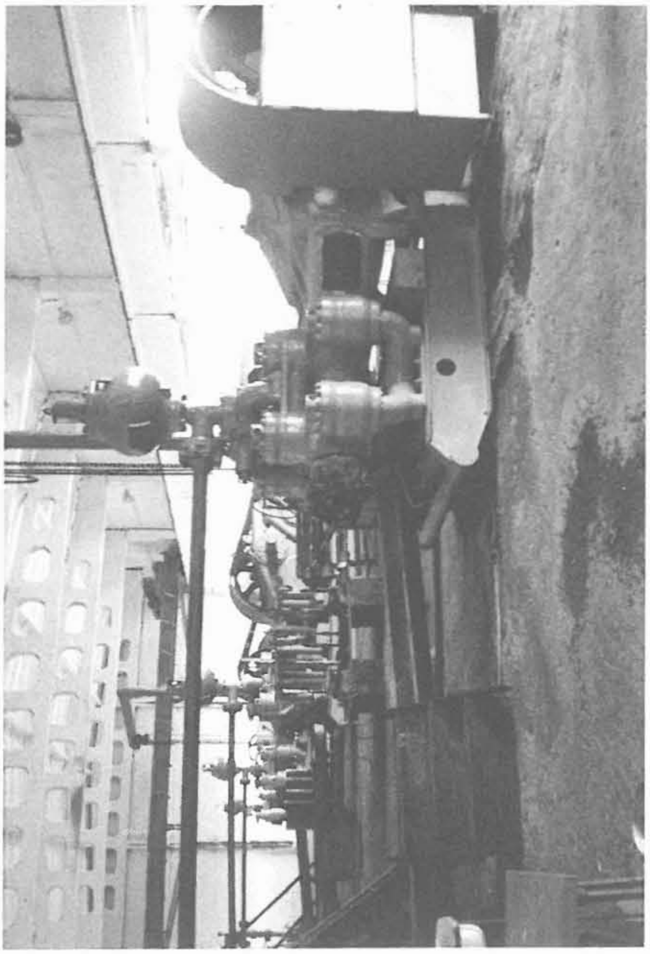

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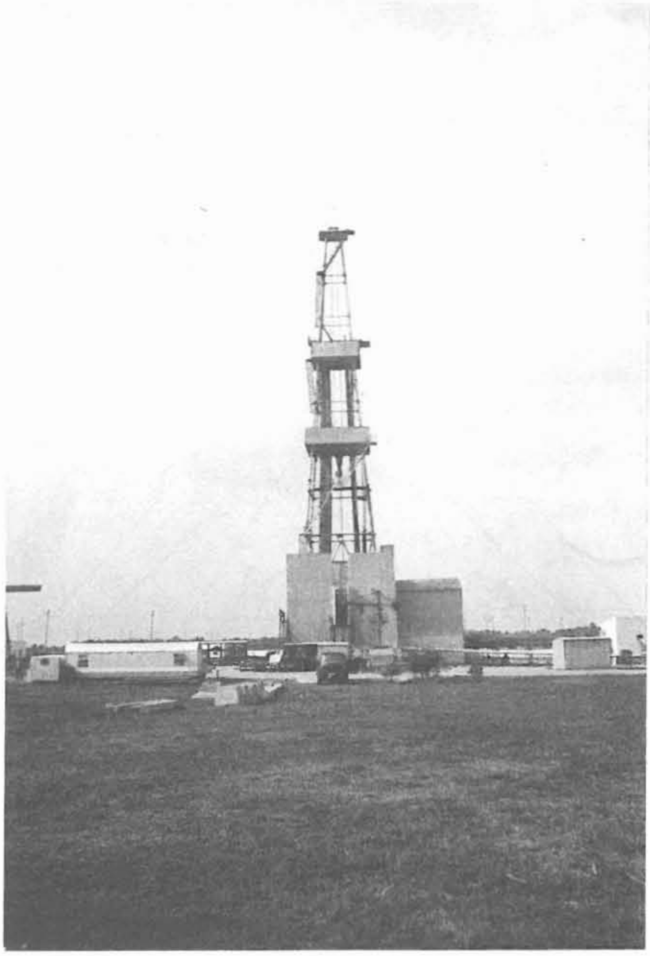

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Kurlov N.S

INFORMATION

to the participants of the International Seminar at the Krivoy Rog Superdeep Borehole-8

Esteemed guests!

To realize geological tasks a program of complex research is worked out by the Ministry of Geology and Academy of Science organizations. This program envisages examination both the borehole and the area of its location (in the surroundings of Krivbass). Such an approach is necessary to interpret the results obtained from the borehole in drilling and also to specify the project technico-geological conditions.

Let me briefly report some features of the region geological structure as it's difficult to understand results obtained without such preliminary acquaintance.

The borehole is located in the northern part of the Krivbass Saksagan region, which is a part of Krivoy Rog-and-Kremenchug structure. We believed the structure was made up by Krivoy Rog series, occurring upon the Archean plagiogranitoids of the PreDnieper and Kirovograd blocks.

The series is d vided into five formations (upwards): Novokrivoy Rog - essentially metabasites, Skelevatskaya formation - arkose metasandstones, metaconglomerates, fillites; Saksaganskaya productive formation - ferrous quartzites, gespillites, various schists; Gdantsevskaya - biotite-graphite schists, marbles with the layers of poor ferrous quartzites; Gleevatskaya - polymictic metaconglomerates, metasandstones, apoaleurolite and apopelitic schists.

Degree of the regional metamorphism of the Krivoy Rog series increases from the south to the north from greenschist till epidote-amphibolite facies. We believed the rocks had been dislocated with formation of sinclinal structure. The eastern flank of this structure has been preserved completely while the western one (in the south) remained in fragments and on the north it is cut by deep fault.

A number of problems doesn't fall uniformly in this stratigraphic-tectonic scheme. These are as follows:

1. In the northern part of Krivbass amphibole-magnetite quartzites occur together with metabasites and various schists associating with schists and marbles of Gdantzevskaya formation. These rocks form enlongated layers, which are known in literature as West-Annovsk and Far West bands. Some geologists (Belevtzev Ya.N. et al.) reckon these layers to be of the Saksagan formation and that they are elevated from depth in the form of scaled-skinned structure along faults. A group of other geologists (Reshetnyak V.V. et al.) refer these bands to younger than Saksagan independent ferrous-siliceuous formations. The latter concept served as a basis in development of Krivoy Rog superdeep borehole project.

2. The West-Inguletz synclinorium occurs to the west and north-west of the Krivoy Rog - Kremenchug structure. It is situated also on the Archean plagiogranitoids of Krivoy Rog - Kirovograd block. The synclinorium is made up by rocks of Ingulo-Inguletz series. This series has the same age as Krivoy Rog's one, but differs from the latter by the smaller thickness and higher degree of regional metamorphism.

The Ingulo-Inguletz series includes the following formations: Zelenoretchenskaya formation which consists of sillimanite quartzite, hornblende amphibolites, gneisses which are similar to Novokrivoy Rog series. The Artemovskaya formation is made up by pyroxene and amphibole - magnetite quartzites, biotite and amphibole gneiss, it is analogous to the Sagsagan formation; Rodionov formation consists of quartz sandstones, ophicalcites, calcifiers, biotite and graphite-biotite gneisses, it also contains sparse thin interlayers of magnetite quartzite; and at last - Spasovskaya formation is represented by diopcide and hyperstene gneisses and schists.

The degree of metamorphism of Ingulo-Inguletz series increases from south to north from epidote-amphibolite to amphibolite facies. Metamorphics of the Early-Proterozoic and Archean plagiogranitoids have been intensively subjected to the processes of granitization and reomorphism. These processes result in the formation of anathectic and reomorphic plagiomicroclinic granites, akerites and polymigmatites of Kirovograd-Zhitomir complex. A granitization in the rocks of Krivoy Rog series are considerably poor and has a local character.

It is very important to stress the following: the bodies of the silicate-magnetite quartzites of the Artemov formation are located in the northern part of the West-Inguletz structure and form here a group of magnetic geophysical anomalies. The group of these anomalies called on the Ukranian shield "The Region of Right Bank magnetic anomalies" - as it is located on the right bank of the Dnieper River.

In this region there is a junction of Inguletz and Krivoy Rog - Krementchug structures. Many scientists consider the so-called deep western fault to be a boundary between these structures. But in this case it is not clear why the rocks of Ingulo-Inguletz series grade into the rocks of Krivoy Rog series at one and the same level of metamorphism. Moreover, during the investigations of this area in 1987-88 within the traditional Krivoy Rog - Kremenchug structure, rocks very characteristic to Western Inguletz structure were reported. These are biotite-graphite gneisses, calciphiers, ophicalcites, meta-sandstones with quartz-diopside matrix, etc.

It is strange and unreal to find in the area of the so-called deep western fault a stratigraphic contact through ancient metamorphic eroded crust between Lower Proterozoic metamorphics and Archean plagiogranitoids.

The above mentioned problems remained under discussion for a long time. And as a result of the superdeep borehole drilling in Krivoy Rog and regional geologo-geophysical survey more or less certain answers to these problems have been obtained. Now let me discuss the main results of drilling and survey of the borehole area.

Statistic data

The borehole was spudded on September 7, 1984. Down to the depth of 950 m a drilling was done without coring. The interval 0-950 m was drilled with continuous coring by "Sputnik-I" borehole. The depth of the borehole is 3351 m, from the depth of 950 m the core was recovered. Core recovery amounted 94%, the total core recovery-1550 m, linear core recovery was 64%.

The borehole diameter is 215,9 mm, the core diameter depending on the technology used was 52 mm, 60 mm and 80 mm; zenith angle at the bottom-hole is 34°, azimuth is 270°, downhole temperature is $57^{\circ}C$, temperature gradient is $1,5^{\circ}/100$ m. The complex study of the Earth's crust at drilling of the Krivoy Rog super-deep borehole included the following kinds of work and methods:

1. Drilling
2. Core and cutting sampling and their documentation
3. Determination of rock physical properties
4. Core sampling for chemical, mineralogical and spectral analyses
5. Downhole geophysical studies including downhole complex: technical, electric, magnetic, acoustic, radioactive, thermal, density, seismic analyses, mud logging, etc.
6. Sampling of drilling mud, formation fluids and their analyses.
7. Carrying out regional and local field geological and geophysical studies on the site simultaneously with drilling. Regional studies are carried out by the Krivoy Rog geological expedition in the region of 52 th. km^2. They include magnetic, gravity and seismic surveys, shallow borehole drilling in order to determine physical and geophysical rock properties, deep borebole drilling in the most interesting geological and structural intersections. The information obtained is used for the reconstruction of the geological history of the region from the geodynamical point of view, metallogenic evaluation of different structural complexes, deep structure of the Krivbass surroundings.

Local detailed geological studies are done by geological survey of the Krivoy Rog superdeep borehole in the region of 400 km^2. A geological survey is done here, study of the previously drilled boreholes with sampling for chemical and analitical investigation with a purpose of correlation of geological section in super-deep borehole and specification of its structural position.

8. Sampling monomineral fractions of accessary ore and rock-forming minerals for their precisive studies, which include determination of radiogenic age, isotope composition of oxygen, sulphur, lead, hydrogen, inner mineral structure and other properties.

9. Complex information systematisation and processing for geological and geophysical borehole section construction and different models of the borehole site.

The borehole research on "Super-deep drilling and complex research of the Earth's interior" is done by the USSR Ministry of Geology, the USSR and Ukraine Academy of Sciences and is coordinated by Interbranch scientific council on "Super-deep drilling and complex research of the Earth's interior".

The core along the axis is cut into two parts: one of them is being stored, the other one - is the object of research.

The research is held according to the plan in the following scheme:

1. Stratigraphy and structural and formational analysis.
2. Petrography and mineralogy
3. Radio and geological chronology, geochemistry of stable and radioactive isotopes
4. General geochemistry
5. Geophysics and petrophysics
6. Hydrogeology
7. Ore formation
8. Laboratory analyses
9. Drilling and coring technology.

Most of the organizations have chosen the necessary core specimens to be analysed. Some of the results have already been obtained by the expedition. A set of downhole logging has been performed.

To determine strike and dip of metamorphics a method of electrical correlation in "Borehole-surface" version has been performed additionally.

Dear collegues!

According to the project at the first stage of drilling the borehole should penetrate rocks of the Krivoy Rog series down to 7 km depth. The series consists of the following formations: Gleevat, Gdantsevskaya and Upper Saksagan.

But in the interval of 63-2351 m the borehole intersected the sequence of metamorphics which, with an ancient zone of weathering, occursupon plagiogranitoid close by their composition to the Archean rocks.

In the penetrated section the composition of the primary rocks is close to the Krivoy Rog series composition but differs from it by higher degree of metamorphism and thickness. The thickness tends out to be 8-10 time less than that of the Krivoy Rog series.

From the other hand by degree of metamorphism and lithological composition the section proved to be very similar to that of the Ingulo-Inguletz series of the northern part of the West-Inguletz structure.

The section was very close to the sections of those intricate Far Western and West-Annovskaya bands which do not have exact stratigraphic position in stratigraphy and structure of the Krivbass.

A special attention was given to study these bands and the area of the Right Bank anomalies.

Works to correlate the section penetrated have been performed. They include the set of the following indications: lithologo-formational, structural, geophysical, geochemical, isotopic, radiologic, etc.

Complex investigations revealed the following:

1. The isotopic age of zircons from plagiogranitoids proves to be of 2960 mln years - the Archean time.

2. Comparison of plagiogranitoids with those from the area of borehole site by petrophysical, geochemical properties pointed to the fact that they belonged to the plagiogranitoids of the Kirovograd block.

3. Staurolite-andalusite quartzites and quartz-sandstones occuring at the bottom of metamorphics happened to be ancient redeposited metamorphized zone of weathering of Archean plagiogranitoids. Relic minerals pirofillite and diaspore were found in the quartzites.

4. Quartz-staurolite-mica schists, quartzites down the section represent the ancient crust of weathering preserved in situ.

5. The results of lithological, geochemical petrochemical, isotopic, geophysical and other investigations of metamorphics penetrated by the borehole confirmed they are close to the rocks composing Far-West, West-Annovskaya bands and Right Bank magnetic anomalies, i.e. to the formations of Ingulo-Inguletz series rather than Krivoy Rog series of the eastern flank of Krivoy Rog structure.

This conclusion is confirmed by difference between the formation temperature of the Krivoy Rog and Ingulo-Inguletz series. The temperatures were established by X-ray spectral measurements of granites, isotopic investigations of oxygen and quartz, thermobaric measurements of fluid inclusions in carbonates and quartz.

The isotope composition of oxygen in magnetite from the ferrous quartzites shows different conditions of sedimentation and evolution of metamorphism in both series.

Ferrous quartzites in this borehole, as far as their geochemistry is concerned, radically differ from those of the Krivoy Rog series and are close to Ingulo-Inguletz series.

The rocks of the Far Western and West-Annovskaya bands were subjected by granitization more intensively than those of the Krivoy Rog structures. On the first two bands different gneisses, calcifiers, metamorphic pyroxenites, bodies of anathectic plagioglase microclinic granites and ackerites, similar to those of the West-Inguletz sinclunorium.

Thus, lithological and structural position, which was revealed by the Krivoy Rog superdeep borehole, proved to be different from that one, characteristic to the eastern flank of the Krivoy Rog structure.

6. Naturally the question arises - where and how are these structures made up by Ingulo-Inguletz and Krivoy Rog series conjugated? and how deep does the productive Saksagan series under the plagiogranitoids occur?

As a result of geodynamic research of the Krivoy Rog super-deep borehole site by Kalyaev and Reshetnyak, the principles of paleographic reconstruction of Early Precambrian are worked out. According to these ideas Krivbass is a fragment of intercratone paleorift, that is assymetric monocline remained due to uncomplete subduction in the zone of Vadati-Zavaritsky-Banioff. On this way metamorphic rocks, intersected by the borehole, correlate with sections of the Far West, West-Annovskaya bands and the Right Bank Magnetic anomalies. They make up complex sinclinal fold, which together with Archean granites overthrusted upon the Krivoy Rog series. The latter uniformly subsides to the west under the nappe zone in the junction of Pridneprovsky and Kirovogradsky blocks. These blocks, made up by Archean plagiogranites, have their own Proterozoic "nature" and conjugate to the nappe zone. The nappe is well distinguished by seismic measurements and is fixed by tristed and decompacted rocks, by development of metasamatic microline, albite, anathectic bodies of ackerites and Early Proterozoic granites, by intensive reomorphism of Archean plagiogranites, localization of characteristic geochemical anomalies and by other processes. That 's why the Krivoy Rog series are to be penetrated at 4500-5000m depth. To the north of the borehole on the extention of the Krivoy Rog -Kremenchug structure in the crystalline basement down to the depth of 1000-1500m a geologo-structural position similar to that expected in the superdeep borehole is revealed. Rocks of the Krivoy Rog series section, including Saksagan one uniformly dip to the west and along fault overcovered by the plates of reomorphised Archean plagiogranites. The Ingulo-Inguletz series occur on the granite. The idea of the Krivbass deep structure is difficult to be understood as new results on deep structure open new prospects in searching for ferrous and other metals in the underthrusted block.

Dear guests! Thanks for your attention! You may have a look at the specimens of rocks and ores sampled from the Krivoy Rog borehole and in adjacent area. My collegues-geologists will help you to be aquainted with the collection.