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USSR Report

ENERGY

(FOUO 11/82)

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USSR REPORT

ENERGY

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FUELS

PIPELINES

FUELS

UDC 622.753:658.155

ECONOMIC FEASIBILITY OF USING NATURAL BITUMEN, HEAVY OILS, OIL SHALE, BROWN COAL

Moscow NEFTYANAYA PROMYSHLENNOST', SERIYA EKONOMIKA in Russian No 1, 1982 pp 15-18

[Article by I. I. Tuchkov and T. A. Alekperov, All-Union Scientific Research Institute of Organization, Control and Economics of Petroleum and Gas Industry]

[Text] Considering the growing demand for petroleum products and growth in their world prices, the problem of developing and utilizing alternative nontraditional sources of crude hydrocarbons is acquiring increasingly greater importance.

This is why there is so much urgency to the task of achieving national economic use of crude hydrocarbons contained in natural bitumen, heavy oils, brown coal and oil shale in the Ural and Volga river basins, the Komi ASSR, Kazakhstan, the Ukraine, Azerbaijan, Estonia, Siberia and other regions of the country.

Known accumulations of natural bitumen exist in basins of the ancient Russian and Siberian continental plateaus and, primarily, on their monoclinal slopes and in depressions (Melekesskiy, Anabarskiy, Olenekskiy, Uchuro-Mayskiy-Aldanskiy and Timano-Pechorskiy regions). Three basic types of accumulations of natural bitumen are distinguished: Blanket and lenticular-blanket; surface brea and blanket effusions (including asphalt lakes); and, finally, veins.

The first type is of the greatest interest.

The regions characterized by deposits having the most favorable geological and economic parameters are Yuzhno-Tatarskiy and Melekesskiy (Tatar ASSR, Kuybyshevskaya and Ul'yanovskaya oblasts); Tsentral'no-Embenskiy (Gur'yevskaya and Aktyubinskaya oblasts); Mangyshlakskiy (Western Kazakhstan); Priiorskiy (Western Azerbaijan, Eastern Georgia).

The following regions may be of interest to the country as its asphalt raw material base: Malo-Kinel'skiy and Zhigulevskiy (Kuybyshevskaya and Orenburgskaya oblasts); Varandey-Adz'vinskiy (Arkhangel'skaya Oblast); Izhma-Omrinskiy (Komi ASSR).

Deposits of highly viscous, heavy and residual oils are contained in practically all oil-bearing regions of the USSR. We know of more than 300 petroleum deposits located at a depth of up to 1,200 meters that would favor development by mines, open pits and wells (from the surface).

Oil shale is known to exist in the USSR in Cambrian (the Siberian continental plateau), Ordovician (the Baltic basin), Devonian (Belorussia), (Domanik) (Ural foothills, Kuznetsk Basin), carboniferous (Kazakh SSR), Jurassic (eastern Russian continental plateau, Central Asia), and Paleogenic and Neogenic deposits (Ukraine, Central Asia and the Transcaucasus).

Thirty coal basins and more than 50 isolated deposits (not contained within basins) are known to exist in the USSR. In the aspect of interest to us, brown coal basins in the European USSR, the Urals and Southern Siberia are fuel and power bases: Podmoskovsky, Dneprovskiy, Chelyabinskiy and Kansk-Achinsk, containing coal beds suited to development as large open cuts. The Yuzhno-Ural'skiy, Ubaganskiy (Turgayskiy), Maykubenskiy (Kazakhstan), Lenskiy and Tungusskiy brown coal basins are promising sites of expanded coal mining. Coal from these basins is concurrently a fabulous raw material from which to acquire synthetic liquid fuel.

Let us dwell in somewhat greater detail on one of the brown coal basins--the Kansk-Achinsk.

The coal reserves lie near the surface, in many places they emerge onto the surface, and they may be worked by the cheapest and most productive method--open cut mining.

Relatively low ash content (5-10 percent of the mineral matter) and a high concentration of volatile components are typical of Kansk-Achinsk coal. It can be used as a raw material in many sectors of chemistry and coal chemistry, and it is the best raw material for synthesizing synthetic liquid fuel and for obtaining refined solid fuel and industrial heating gas.

However, research on their development and utilization for the needs of the national economy, on the problem of developmental and refining technology, and the economic aspect of their development is still in its initial stage.

An analysis of information on the geology of shallow natural bitumen and heavy oils and an evaluation of the available resources would reveal that exploratory drilling for these materials is now being conducted only in the Tatar ASSR. In the country as a whole, the volume of exploration and prospecting aimed specifically at bitumen does not correspond to the complexity of the problem.

At present only a few regions of the country (Melekesskiy, Olenekskiy, Embenskiy, the Komi SSR, the Azerbaijan SSR) may be of interest to detailed exploration and prospecting. Others would first require regional and exploratory studies.

The main thing to consider in light of the problem under examination here is to create economically effective methods of working these deposits on an industrial basis. An investigation of the Soviet and foreign experience would show that development and improvement of the technology and methods of extracting petroleum from bituminous rock is proceeding in the following three directions:

quarry and mine extraction systems in which rock is brought to the surface for extraction of bitumen (with solvent, hot water and so on) to produce so-called synthetic petroleum;

Mine drainage systems, in which bitumen (or high-viscosity heavy petroleum) is extracted within a mine shaft, without removal of bitumen-containing rock to the surface, by way of a drainage system consisting of wells drilled into the mined rock;

in situ well method, in which bituminous oil is extracted by wells drilled from the surface, using a thermal or some other influence upon the bitumen-containing bed.

The results of laboratory research and experimental industrial operations showed that it is fundamentally possible to extract petroleum from terrigenic bitumen-containing rock using *in situ* well methods. The solution of the problem is closely associated with geological, geophysical and hydrodynamic research and with the methods of thermal power engineering and economics.

The mine method is being used today on an industrial scale only at the Yaregskoye deposit; experimental well extraction operations have been started on a limited scale at certain deposits of the Tatar ASSR.

In addition, extensive industrial application of quarry and mine extraction systems for developing bitumen and high-viscosity oil deposits is associated with a significant unfavorable effect upon the environment: the piling of sizeable quantities of surface rock and of extracted and processed bituminous rock. But the advantages of conducting mining operations by this method are obvious: extraction of a large quantity of crude hydrocarbons from the mined rock; the possibility for using existing mining equipment and for multiple use of all of the extracted rock, since following extraction of bitumen, the waste rock can be used to produce construction and road building materials.

Research shows that development of natural bitumen and high-viscosity oils may be of practical interest in a number of regions of the Ural and Volga basins, Western Kazakhstan and Azerbaijan.

The most promising and best studied deposits of natural bitumen can be found in the Tatar ASSR. About 170 deposits have been revealed here, with bituminous beds from 1 to 15 meters thick lying at depths from 0 to 400 meters.

The total outlays on obtaining heavy oil imported into this region at the time of the beginning of industrial development and the corrected outlays on production of 1 ton of "synthetic" petroleum from bituminous rock were used to determine the economic effectiveness of developing bituminous rock.

The corrected outlays on extracting natural bitumen by the *in situ* method using steam injection are the highest: They are comparatively less than the outlays on open cut and mine development of bituminous rock, and 50-65 percent of the outlays on well extraction using steam.

Comparative analysis of the parameters of different extraction methods would demonstrate the economic feasibility of introducing the open cut and mine methods of extracting bituminous oils. Thus given the conditions for extracting petroleum by the mine method at the Balakhany-Sabunchi-Romaninskoye deposit (Azerbaijan SSR), the technical-economic indicators of extraction would be commensurate with the current indicators for petroleum extraction in the "Azneft'" Association. According to corrected figures, the planned cost of extracting 1 ton of petroleum from the Yaregskoye deposit is coming close to the outlays of the "Dagneft'" Association.

The most important feature of the mine and quarry methods of developing petroleum and bitumen deposits is multiple use of the extracted carboniferous rock and the practically complete utilization of the organic mass. This is why these methods can be thought of as economically promising.

The complexity of the production process, sizeable outlays on extraction, pulverization and transportation of rock and the problems of environmental protection--the negative aspects of surface mining of oil shale--gave birth to the idea of *in situ* distillation relatively long ago. The *in situ* method is simpler in organizational respects. All production operations, with the exception of producing synthetic oil, do not differ in principle from those traditional to petroleum extraction industry--drilling the wells, breaking down the bed by hydrostatic pressure, injecting working agents, *in situ* combustion, removal of liquids by pumping and so on. The *in situ* methods are now at the stage of laboratory and field research. An analysis of the results of this research made it possible to formulate and plan measures which would make the *in situ* method of developing oil shale deposits profitable.

The need for highly productive large-scale processing of coal, mainly to obtain enriched fuel, including liquid, has become increasingly more obvious in the last 10-15 years.

There can be no doubt that gasoline, kerosene and synthetic petroleum from cheap coal obtained by the open cut method can already compete with natural petroleum and its processing products.

Today the procedures of transforming coal into liquid fuel are still far from perfect. We need to solve many fundamental and purely engineering problems to make the process simpler and cheaper. We will have to develop various production processes applicable to different kinds of coal and to different kinds of end products. The new processes will have to be thoroughly checked out with experimental and experimental industrial facilities.

It should be noted that the total corrected outlays on acquiring liquid fuels are significantly influenced by the outlays on coal, since 1 ton of liquid fuel requires the expenditure of 3-4 tons of the organic mass of coal, which in terms of Kansk - Achinsk coal is about 6 tons.

In the more remote future, "synthetic" petroleum will become competitive with conventional petroleum in terms of outlays per unit of product.

It is entirely obvious that to solve the problem of producing "synthetic" liquid fuel, we need to turn attention to the following aspects: replacing fuel oil (produced in large quantities from petroleum) by low-sulfur coke (coals, oil shales) and deeper processing of conventional oil to obtain additional quantities of lighter products; direct acquisition of liquid motor fuels from coal and tar through the pyrolysis of shale.

According to tentative estimates, a significant savings of traditional fuel, including boiler and furnace fuel, can be achieved by making extensive national economic use of crude hydrocarbons from oil shale, coal and bituminous rock.

Inasmuch as the problem of creating a stable base of crude hydrocarbons in the country is acquiring special urgency, it would now be feasible to initiate forced development of shale industry and to organize an industry to process bituminous rock, oil shale and brown coal with the purpose of putting these additional hydrocarbon resources to use in the national economy.

The decisions of the 26th CPSU Congress attach important significance to this problem. The "Basic Directions of the USSR's Economic and Social Development in 1981-1985 and in the Period to 1990" state: "Develop and introduce effective methods of multiple use and processing of solid and heavy liquid fuels, and of acquisition of synthetic fuels; ...improve the processes of extracting high-viscosity oils and bituminous petroleum."

Conclusions and recommendations:

1. Acquisition of synthetic liquid fuels from nontraditional sources of crude hydrocarbons is associated with development of specific-purpose integrated programs coordinated with scientific research and experimental design projects, with construction of pilot and experimental industrial facilities, and with the planning, erection and operation of the first enterprises producing synthetic fuel from bituminous and oil-bearing rock, oil shale and brown coals.

Scientific organizations of the USSR Academy of sciences and the scientific research, planning, design and production organizations of the ministries of geology, petroleum, chemical, petroleum refining, coal, instrument making and machine building industry and nonferrous metallurgy must take part in solution of this problem.

2. Purposeful efforts to find and explore deposits must be organized; the development of methods of industrial and field geophysics must be continued with the purpose of revealing accumulations of these minerals; a mandatory complex of scientific research must be developed and approved, and geochemical studies must be broadened; detailed maps showing the distribution of industrial, geological and predicted reserves of the indicated minerals on the territory of the USSR must be drawn up, showing the depth at which such minerals lie, the thickness of the productive horizons and the types of country rock.

3. Research should be conducted on the production processes and conditions of effective use of the quarry, mine and *in situ* (well) methods of developing deposits; integrated theoretical, laboratory and full-scale studies must be performed on various physical and chemical methods of extracting liquid hydrocarbons; effective equipment and procedures to be used with the mine, mine-drainage and well methods of extraction must be created; bitumens and heavy oils, oil shales and coals must be classified in relation to their nature and their chemical and technology properties, with a consideration for their subsequent deeper processing and multiple use in the national economy; effective liquid hydrocarbon collection and transport systems must be developed within the mining regions; attention must be turned to the concentration of organometallic compounds in liquid hydrocarbons, and the possibilities of their extraction for the purposes of engineering and economic evaluation of their subsequent use must be examined.

4. It would be important to develop the criteria of economic effectiveness of extracting and obtaining petroleum from bituminous and oil-bearing rock, oil shales and brown coals obtained by the quarry, mine and *in situ* (well) methods, depending on the mining, geographic and economic conditions; the criteria of the economic effectiveness of processing nontraditional crude hydrocarbons and of evaluating their usefulness as raw materials, depending on their natural properties, the depth to which they are processed and the ways they are used in the national economy, must be developed; an economic forecast must be made of the schedule and order of introduction of experimental industrial facilities (producing liquid hydrocarbons) at deposits of natural bitumens, heavy oils, oil shale and brown coals.

11004
CSO: 1822/206

FUELS

OIL PROSPECTING, DRILLING GUIDE FOR ENGINEERS

Moscow SPRAVOCHNIK PO NEFTEPROMYSLOVOY GEOLOGII in Russian 1981 (signed to press 25 Aug 81) pp 1-8, 526

[Annotation, table of contents and foreword from book "Handbook of Oilfield Geology", edited by N. Ye. Bykov, M. I. Maksimov and A. Ya. Fursov, Izdatel'stvo "Nedra", 4,700 copies, 526 pages]

[Text] This handbook comprehensively illuminates problems of oilfield geology encountered during preparations for exploitation and development of an oil deposit. Part One presents the methods of oilfield geological analysis. Special attention is devoted to methods ensuring maximum detail in studying the oilfield and its properties, and to the methods used to process the results, observations and measurements. Part Two examines the main objectives of oilfield geological analysis in the sequence followed in practice. Ways of integrating the research methods and the procedures for processing information using mathematical geological models and computers are discussed.

This handbook is intended for petroleum geologists and oil prospectors working for production and scientific research organizations. It may be useful to instructors, graduate students and students of petroleum engineering VUZs and schools. Fifty-four tables, 164 figures, 158 bibliographic references.

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Part Two

Basic Problems of Oilfield Geological Analysis and the Methods of Their Solution

Foreword

In recent years the country's oil industry entered a period of its development in which the necessary levels are ensured not only by the development of new oilfields but also by fuller extraction of oil from the subsoil. Solution of this complex problem would be impossible without broad use of oilfield geological methods of studying oil and gas deposits.

As a response to the needs of the industry, the traditional methods of oilfield geological analysis have been improved, and enriched with new procedures of obtaining and processing information. When we study the material composition of rock, in addition to using the usual lithological-petrographic characteristics we often obtain the characteristics of the rock's microstructure so that we may evaluate the possibilities of using different methods of physicochemical influence upon a bed and predict changes that would occur in the rock in response to the development processes.

Liquids and gases contained within a bed and pumped into it by artificial means are studied with the purpose of determining not only the physicochemical properties of these fluids but also their interaction with one another, since this interaction can cause certain negative consequences.

It would be unimaginable today to break productive deposits down into their parts and subject them to detailed correlation--especially in large oilfields, where the logs of many hundreds and sometimes even thousands of wells must be processed--without the automated computerized data processing systems that are now operating successfully in a number of the country's regions.

Geometric analysis of oil and gas deposits--that is, creation of their models--requires a detailed knowledge of the variability of characteristics (properties), which must be accounted for when selecting a particular model with which to reflect observation data. Methods of accounting for the heterogeneity of productive beds when planning oilfield development--diverse methods which adapt themselves rather well to local conditions--have now appeared and are enjoying practical application. A certain amount of development has occurred in the methods of calculating the parameters of oil and gas deposits with a consideration for the lower limits of reservoir properties, and methods of evaluating the reliability of parameters and reserves taking account of the variability of a particular characteristic, the amount of information on it and so on.

All of this has made it necessary to generalize the information on modern methods of geological oilfield analysis in a single publication, such as the handbook offered here. Part One of the handbook presents the basic methods of oilfield geological analysis. Special attention is turned to those methods which promote fuller study of a deposit and which provide more reliable information on its parameters, since these factors predetermine the quality of problem solution.

Part Two uses examples of solving concrete problems in preparing oil and gas deposits for development and in developing them in order to demonstrate how different methods of oilfield geological analysis may be integrated with hydrodynamic, economic and other methods. Emphasis is placed on the reliability of conclusions made in different stages of a formation's study. Thus the process of preparing an oilfield for development is presented from the standpoint of satisfying optimum quantitative requirements associated with the completeness of analysis and the reliability of determining all parameters needed in drawing up the flow charts and plans.

Isolation of exploitable entities within the cross section of a multiple-bed formation is viewed as an optimization problem which can be solved by using the procedures of quantitative evaluation of differences in the geological and physical properties of productive beds intended for combined exploitation, and by accounting for the influence the degree of these differences exerts on the well productivity coefficient.

In order that efficient solutions could be found to the problems associated with geological oilfield analysis in the oilfield drilling stage, it would be suitable to obtain the information for such analysis from automated systems that can process the large volumes of raw data. The procedures of such analysis are presented, using development of a multiple-bed oilfield as an example.

The problems of oilfield geological analysis associated with controlling development of an oilfield are examined both in relation to the reliability of determining the current oil or water saturation level of a bed from information provided by wells, and in relation to organizing an effective system by which to control the status of development and so on.

Thus modern geological oilfield analysis represents a system of procedures for studying and creating models of oil and gas deposits and of processes occurring within them during their development. Such analysis is performed in all stages of preparing an oilfield for development and exploitation, and it is typified by a gradual increase in the number of problems addressed and by growth in the stringency of requirements imposed on the quality of problem solution--that is, on the reliability of the obtained parameters and conclusions and of the decisions made on their basis. The methods practically employed for solving oilfield geological problems are highly diverse; therefore the appropriate sections of the handbook reflect those procedures that are best suited to typical geological conditions. Recommendations concerning other cases involving unique features of geological structure and development conditions may be found in the suggested literature.

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FUELS

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DETERMINATION OF OIL, GAS WELL CONSTRUCTION COSTS

Moscow NEFTYANAYA PROMYSHLENNOST', SERIYA EKONOMIKA in Russian No 5, 1982 pp 20-23

[Article by P. A. Berezovskiy, O. G. Generalova, S. A. Ponomarev, F. I. Sirazetdinov and N. L. Legostayev, "Bashneft'" Association and BashNIPIneft']

[Text] The system for estimating the costs of drilling is essentially a system of forming the prices on the products of drilling organizations.

While prices have been stable in industry and construction (at least for a number of years), in drilling, which is a variant of construction work, this is completely untrue (in connection with yearly changes in planned drilling rates), since there are no stable, scientifically grounded standards to serve as an operating base.

Thus the commercial drilling rate must be planned more accurately on the basis of well grounded standards. In our opinion we could solve the problem of planning commercial drilling rates if we calculate the per-meter drilling time with a consideration for natural and geological factors and if we establish labor outlay norms in relation to different categories of rock drilling difficulty that could remain stable over a number of years.

The labor-intensiveness of breaking down one meter of rock, or the drilling difficulty, lies at the basis of stable time norms used to determine commercial drilling rates necessary for drawing up the planning and estimate documents and for determining the estimated cost of completed operations.

The method proposed here is being successfully applied to time norms used to draw up estimates for structural exploratory drilling. A special study was conducted with the purpose of analyzing the theoretical and practical possibility of using this approach to determine the cost of drilling oil and gas wells in the "Bashneft'" Association.

Breaking down well profiles into stratigraphic subdivisions has become a widespread practice in oil and gas well drilling. In our opinion when we draw up estimates for well drilling, it would be more proper to deal not with stratigraphic divisions of rock (the difficulty of drilling rock of the same age may vary), but rather with the lithological homogeneity of rock beds having identical mechanical properties. This would make it possible to compare, in terms of drilling difficulty, both the rock of specific deposits and the rock of entire drilling regions irrespective of their geographical location.

Lithological-stratigraphic profiles were determined for 67 areas being drilled by the "Bashneft'" Association's Administration for Drilling Operations in order to establish distinguishing features of rock composing a particular area and responsible for the differences in rock categories. Using stratigraphic subdivisions of the profiles of all of the areas, we isolated the basic forms of rock and determined the indicators describing their hardness, drilling distance per run, and the rate of mechanical drilling. After analyzing these indicators we arrived at a classification of typical representatives of rock related to 12 categories of drilling difficulty. Specific lithological-petrographic characteristics of rock and specific indicators of drilling distance per run and mechanical drilling rate correspond to each category.

Experimental general estimate time norms were developed for drilling operations in relation to all categories of rock and intervals of well depth. These time norms were related to the drilling method, the size of the drill bit, to whether or not core samples were taken, to the form of flushing fluid employed and to the type of drilling rig. The norms were tailored to all categories of rock in relation to specific intervals of well depth (every 100 meters) with the purpose of permitting their use to draw up planning and estimate documents for well construction (for determination of commercial drilling rate and the estimated time of drilling operations).

Although the well drilling process includes a large quantity of different operations, in keeping with the standardization principle it would be best to group them as shown in Table 1.

Table 1

Group of Operations	Forms of Operations
I	Mechanical drilling, as characterized by the time required to drill 1 meter of rock and by the distance drilled in a single run of the drill bit
II	Lowering, raising and other auxiliary operations associated with well depth and drill bit running time. Adding drilling pipe.
III	Supplementary operations
IV	Securing wells with casings
V	Correcting problems arising not at the fault of the workers, and interruptions in work for reasons for which administrations for drilling operations cannot be held responsible

Mechanical drilling (operation group I) directly determines the correlation between rock drilling difficulty (the time standards for mechanical drilling of 1 meter, in hours, and the drilling distance per slot, in meters) and the well drilling equipment and procedures. This correlation is reflected in the flow charts for drill bit processing.

The time outlays on operations in group II are determined from the drilling distance per run of the drill bit in specific forms of rocks, using the unified intersector time norms presently in effect. Thus the duration of operations in groups I and II is directly associated with the lithological-petrographic characteristics of the rock being drilled.

The duration of operations in groups III and IV depends on the drilling conditions and on the design and purpose of the well, and it is determined from unified intersector time norms presently in effect.

Time outlays on operations in group V reflect the general conditions of drilling operations (climatic, social and geological, as well as the economic and industrial level of development of the region); therefore they are calculated on the basis of an analysis of the statistics for each region. After tentative general time norms were drawn up, they were tested by all of the association's administrations for drilling operations in order to reveal the sort of corrections and additions that would have to be made in the tentative norms.

In order to reveal the acceptability of the norms we developed, we compared the drilling rates shown in the planning and estimate documents with the actual well drilling rates and the rates calculated from the tentative general time norms.

The results of testing the first experimental general time norms in the "Bashneft'" Association are shown in Table 2 (1980 data).

Table 2

Indicator	Drilling Purpose		Total Volume
	Operational	Exploratory	
Tested			
Wells	417	112	529
Meters	745,944	218,553	964,497
Number of wells for which drilling rate determined from general time norms is closer to actual drilling rate than is the drilling rate determined from planning-estimate documents			
Wells	266	59	325
%	63.8	52.7	61.4
Drilling distance for wells for which drilling rate determined from general time norms is closer to actual drilling rate than is drilling rate determined from planning-estimate documents			
Meters	525,591	122,783	648,374
%	70.5	56.2	67.2

It may be concluded from just the first test that it is fundamentally possible to dispense with the existing system of compiling the planning-estimate documents and to begin calculation of commercial drilling rates and time on the basis of the general time norms we developed. However, it has been found necessary to continue the effort of improving the collection of general time norms, to make certain corrections and additions with the purpose of raising the accuracy of the norms.

In order to evaluate the quality of the general time norms more deeply, we also applied statistical methods for evaluating the significance of the correlation between the commercial rates calculated using the general and conventional norms and the actual rates. In particular we used Pearson's congruence test to verify the normality of the distribution of the mean commercial drilling rates in different drilling areas; we also used Student's tests to determine the sufficiency (representativeness) of the sample and to evaluate the significance of the correlation between the actual well drilling rates and the commercial rates determined from the general time norms and between the actual well drilling rates and the rates determined from planning and estimate documents used in the financing of the drilling operations.

Our evaluation of the significance of the correlation between commercial rates showed that in the overwhelming majority of cases there were no significant differences between actual commercial rates and the rates calculated on the basis of the general time norms. The duration of drilling operations, as determined from the general estimate time norms, reflects the existing level of the drilling equipment, procedures and organization to a greater degree, since this indicator is closer to the actual value than is the duration of drilling operations that was determined from the planning and estimate documents. All of this confirms the correctness of the principles and methods of deriving general time norms with a consideration for the use for which they are intended.

The general time norms for drilling operations are convenient to use in planning and estimate documents as a means for objectively determining the duration of drilling operations and the commercial drilling rates, for creating a stable base from which to determine the cost of oil and gas well construction and for ensuring that the cost estimates arrived at for different oil drilling regions are equitable.

The estimate time norms per meter of drilling must be reviewed as well drilling equipment and procedures improve. But their review should not require any special additional outlays, since the introduction of new equipment into drilling operations is always accompanied by a special analysis conducted to reveal the effectiveness of the new equipment and to correct the norms.

After the general time norms are introduced, estimates for drilling operations will be made on the basis of the commercial drilling rate calculated using these norms with a consideration for the geological profile of the well but without considering the previously encountered rates. This will ensure that the estimated per-meter drilling cost would remain stable over a number of years for wells drilled in constant natural and geological conditions.

A firm per-meter drilling cost estimate, one determined with an eye on socially necessary outlays that can be compensated and intended to remain constant over a number of years, would be a dependable basis for planning capital investments and for financing drilling operations. It would also mean that the collectives of drilling organizations would have a dependable basis for determining the financial end result of their work.

Under these conditions the savings in outlays enjoyed due to growth in drilling rate would be reflected as an increase in the profits of the drilling organizations, rather than as a reduction of the estimated cost of planned work, as is the practice today.

Creation of a foundation of progressive standards based on a rock classification, on general time norms for drilling operations and on objectively calculated drilling operation times would be a necessary prerequisite of increasing the drilling rates, reducing the time and cost of well construction and improving the technical-economic indicators of drilling operations.

11004
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FUELS

HANDBOOK PROVIDES INFORMATION ON WELL DRILLING EQUIPMENT

Moscow SPUTNIK BUROVIKA in Russian 1981 (signed to press 17 Nov 81) pp 1-2, 196-200

[Annotation and table of contents from book "Drill Operator's Guide" by Konstantin Vladimirovich Iogansen, Izdatel'stvo "Nedra", 35,000 copies, 200 pages]

[Text] Brief descriptions are given of series-produced turbodrills, bits, drilling, casing, pump and compressor pipes, core extractors, drilling column components, grabs, packers and blowout preventers. Well flushing and cementing are examined, and information on oilfield geophysics is presented. The handbook is laid out in the form of tables. Strength characteristics, formulas, procedures, nomograms and graphs required for calculations are provided.

This guide is intended for engineers and technicians employed in well drilling associated with all forms of minerals--oilmen, gas drillers and geologists.

Tables--173, figures--108, bibliography--26 references.

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FUELS

COLLEGE TEXT ON RADIOACTIVE RAW MATERIAL DEPOSITS

Moscow MESTOROZHDENIYA RADIOAKTIVNOGO SYR'YA in Russian 1980 (signed to press 8 Feb 80) pp 1-8, 252-254

[Annotation, foreword and table of contents from book "Radioactive Raw Material Deposits", by Vladimir Ivanovich Danchev and Tat'yana Alexsandrovna Lapinskaya, 2d edition, revised, Izdatel'stvo "Nedra", 2,400 copies, 254 pages]

[Text] Information is presented on the earth's radioactive elements and on the conditions of migration and concentration of uranium, radium and thorium. A brief examination is offered of the earth's radiogenic heat and of the principal methods of determining the absolute age of minerals and rock. The most important uranium and thorium minerals are described; a classification of their deposits is provided.

Attention is devoted mainly to describing uranium deposits--the principal sources of raw materials for atomic industry and atomic energy. Among them, exogenous deposits associated mainly with sedimentary and sedimentary-metamorphic rock are described in the greatest detail, and endogenous deposits--mainly hydrothermal deposits, which provide a significant proportion of industrial uranium--are discussed somewhat more briefly. Special sections of the book are devoted to the relationship between uranium and carbonaceous and bituminous matter and between ore-forming processes and the stages of formation of ore-bearing rock.

The book is intended as a training aid for VUZ students specializing in geology and geophysics. It may also be useful to geologists, geophysicists and other workers of geological prospecting parties having radioactive raw materials as one of their incidental objectives.

Eleven tables, 90 figures, 22 bibliographic references.

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Foreword

Our country's industry and agriculture require tremendous quantities of raw minerals. Recent technological progress and the introduction of chemistry into all areas of science and production are promoting extremely swift expansion of the range of minerals and of the complex of elements extracted from them. With very minor exceptions, almost all of Mendeleyev's table is "working" for man today. In addition to elements that are widespread in the earth's crust--iron, gold, copper, tin and lead, the history of the use of which numbers in the millenia--rare and dispersed metals and metalloids that are quite "young" in terms of their utilization--lithium, beryllium, boron, indium, germanium, selenium, cadmium, rare earth metals and many others--have gained importance in connection with the development of automation, electronics, rocket technology and other forms of modern industry.

Some of them have enjoyed broad application in the acquisition of special alloys made from ferrous and nonferrous metals, and heat-resistant glass and ceramic, and in the production of new synthetic materials, solid chemical fuels, semiconductors and so on.

Owing to the remarkable successes of physics, which have made it possible to control the nuclear fission reaction, yet another group of minerals, referred to as nuclear fuel, has acquired extremely great significance. This group contains natural radioactive elements--uranium and thorium--which, when used in atomic reactors, produce colossal quantities of energy exceeding the possibilities of all energy sources known to date. At present the main nuclear fuel is uranium, but introduction of new types of reactors into industry in the next few years will make broad use of thorium for similar purposes economical as well.

One of the greatest discoveries of mankind--development of the means for liberating energy locked within the atom--made itself known through a terrifying disaster--the explosion of atomic bombs dropped by American military pilots in 1945 on two Japanese cities. In the course of a few seconds, tens of thousands of inhabitants were annihilated, and people who had been subjected to lethal radiation more than 30 years ago are still dying today.

The Soviet Union proposed the first paths of peaceful use of atomic energy. Research of exceptional scope and depth conducted by a group of Soviet physicists led by I. V. Kurchatov resulted in the creation of the world's first atomic electric atomic power plant on 27 June 1954. Soviet scientists shared their experience at the Geneva Conference on Peaceful Uses of Atomic Energy in 1955, after which construction of atomic power plants began in the USA, England, France and other countries. Sixteen countries of the world now possess more than 100 operating atomic power plants with a total output of about 60 million kw, and there are plans for increasing their number and output further.

Atomic power engineering has gained a firm foothold in our country's life. As of 1975 the output of atomic electric power plants (AESs) in the USSR attained 4.7 million kw (20). The 10th Five-Year Plan foresaw preferential development of atomic power engineering and introduction of AESs with a total output of 13-15 million kw, which would significantly reduce consumption of gas, petroleum and coal for energy production purposes. To reduce the cost of energy and ensure fuller use of nuclear fuel, reactors are being improved continuously; systems operating on the basis of fast neutrons, which make possible the use of not only the highly radioactive isotope ^{235}U but also the naturally more widespread ^{238}U, are being introduced. A fast neutron reactor is already operating successfully in the city of Shevchenko in support of a plant desalinizing water from the Caspian Sea.

We are continuing our efforts to create low power AESs which may be broken down into modules and shipped by all forms of transportation, including airplanes, which would have great significance to industrial development of remote regions of the North deprived of their own sources of fuel.

The icebreaker "Lenin"--the world's first surface vessel with an atomic propulsion unit--was launched on 5 December 1975; a larger icebreaker, the "Arktika", was launched in 1975. On 17 August 1977 the latter was the first in the entire history of navigation to reach the geographical location of the North Pole. At the end of 1977 yet another atomic icebreaker appeared--the "Sibir'". The work of these vessels has very great national economic significance, making it possible to lengthen the navigation season in the northern seas of the Soviet Union. This will pave the way for providing new industrial centers and populated regions presently developing in the Arctic with everything they need.

Nuclear explosions are being used to build canals and reservoirs and to support stripping operations in mining industry.

The reactors of various designs used in our country not only provide energy but also permit highly important scientific research digging deeper into the secrets of the structure of matter, and development of new, economically more advantageous facilities. In its form of numerous radioactive isotopes, the peaceful atom is being extensively used in various areas of science and technology, helping us to transilluminate metals, to subject minerals and rock to highly detailed analysis, to observe the movement of water and of biocurrents in plants, to study wells and to treat severe illnesses. Scientific research in atomic science and technology has enjoyed extensive development in the Soviet Union. Soviet scientists now possess large thermonuclear facilities and a network of scientific research institutes. The United Institute for Nuclear Studies, in which scientists of many countries are laboring over the problem of the peaceful use of atomic energy, was created on the Soviet Union's initiative. Atomic energy is no longer the energy of the future, as it was not that long ago at all; it is making an enormous contribution not only to the country's defense but also to supporting the main task posed by the 25th CPSU Congress--raising the welfare of our people.

The great successes of Soviet atomic physics and power engineering owe a great deal to the labor of workers in the geological service, who have managed to provide atomic industry with the reserves of radioactive raw materials it needs.

Research on the laws governing formation of deposits of radioactive elements, started on the initiative of one of the greatest Russian scientists--Academician V. I. Vernadskiy, was continued and developed by D. I. Shcherbakov, A. P. Vinogradov, A. A. Saukov, V. V. Shcherbina and many other scientists. It should be noted that the last few decades have been marked by serious research on the geochemistry, mineralogy and geology of atomic raw material deposits in other countries as well. The data that have been accumulated have made it possible to significantly improve prospecting and pinpoint its efforts more accurately. Moreover the data have demonstrated how great an influence natural radioactive decay processes have on many geological phenomena--magnetism, regional metamorphism, tectonic processes and the thermal regime of remote territories and of the earth as a whole, and so on.

A new branch of geological knowledge has come into being--radiogeology, or nuclear geology, together with its specific research methods. Radiogeology is making it possible for us to approach prospecting for deposits of radioactive elements with better grounds. And this is one of the most important problems of modern geology in connection with the continually increasing role of atomic energy.

The geochemical features of the principal nuclear metal--uranium--are such that its ore concentrations may be formed in various conditions, beginning with the stage of the cooling of magma and ending with the latest stages in the life of sedimentary rock. Therefore industrial deposits of uranium are known to be contained in extremely diverse surrounding rock.

While in the first stage of development of atomic industry the bulk of the uranium was obtained from endogenous deposits, mainly hydrothermal, in the last 20 years ore concentrations in sedimentary and sedimentary-metamorphic rock have begun to play a distinctly more important role, and the center of gravity of uranium extraction and reserves is gradually shifting in the direction of exogenous deposits. In some types of these deposits, thorium, rare earth and other elements having industrial significance are satellites of uranium. These may be interpreted as complex deposits.

Because the range of geological conditions in which industrial accumulations of radioactive raw materials may form is relatively broad, at least some testing for such raw materials should be conducted in all geological studies, especially in relatively unexplored regions. Such incidental prospecting sometimes leads to the discovery of major industrial deposits of uranium and thorium.

In this respect great possibilities are opening up before geologists and petroleum geophysicists, who conduct regional studies in vast, often very poorly studied territories in connection with their search for oil and gas fields.

Detailed geophysical and geological analysis of core samples from numerous wells will doubtlessly be an aid to revealing new deposits of radioactive raw materials and to clarifying the behavior of radioactive elements in different types of sedimentary and sedimentary-metamorphic rock. Of course, if the quality of such research is to remain high, the prospectors must become acquainted with the fundamentals of the geochemistry, mineralogy and geology of radioactive elements.

This book is a training aid for the geology section of the course "Nuclear Geophysics and Radiometric Prospecting" for VUZ students specializing in geophysics and geology. It is also recommended for a number of sections of the course "Principles of Mineral Geochemistry and Geology." Following publication of the first edition of this book (1965) a vast new literature devoted to the geology of uranium and thorium deposits appeared. This was associated with the enormous scope of explorations and prospecting being conducted in all countries of the world, elicited by the need for providing raw material to intensively developing atomic energy production and owing to significant exhaustion of the reserves of traditional sources of energy--combustible minerals.

A symposium on formation of uranium deposits, which was attended by 220 scientists from 40 countries, was organized in Athens in 1974 for the purposes of information exchange by the International Agency for Atomic Energy. A symposium with just as broad a representation was held in Vienna in 1976 with the purpose of discussing the methods of exploring for uranium deposits. In the last 10 years the Soviet literature has been supplemented by extensive summaries on the geology of endogenous and exogenous uranium deposits in both the Soviet Union and foreign countries (works by P. Ya. Antropov, F. I. Vol'fson, V. N. Kotlyar, N. P. Laverov, V. I. Smirnov, A. I. Tugarinov and others). The need for considering these data in the training of geological engineers and geophysicists led to the creation of new textbooks. The training aid "Mestorozhdeniya radioaktivnykh i redkikh metallov" [Deposits of Radioactive and Rare Metals] edited by V. N. Kotlyar (7) was published in 1973, and in 1976 a laboratory manual intended for the same course was published under the editorship of N. P. Laverov (8). These books devote their greatest attention to formation, classification and characterization of endogenous deposits.

As in the first edition, this training aid turns its main attention to exogenous and metamorphic deposits owing to their increasingly greater industrial significance, and in connection with the fact that it is intended primarily for geologists and geophysicists prospecting for minerals in sedimentary cap rock and in metamorphic rock underlying the former to one degree or another. All of the sections of the book have been significantly revised. The description of endogenous deposits is based wholly on published literature; exogenous deposits are described in greater detail on the basis of the results of research conducted by the authors themselves, in addition to published sources, making some sections of this book original. New subsections have been introduced--"Lithogenesis and Uranium Ore Formation" and "The Role of Organic Matter in Sedimentary Rock in Concentration of Uranium." These subsections focus attention on the relationship of uranium ore formation to different stages of the lithogenesis of sedimentary rock, and on the ore-forming role of organic matter, which is such a frequently encountered component of sedimentary formations. The limited volume of the book would not permit description of many kinds of deposits. This is why either the largest deposits or those which most clearly represent a particular genetic group were selected. Despite the long time that uranium deposits have been subjected to study, a number of problems associated with their classification and genesis remain debatable, as is noted in the appropriate sections.

The authors are extremely grateful to their colleagues N. P. Strelyanov and V. A. Shumlyanskiy for their assistance in gathering some of the material on the geology of exogenous deposits, which made it possible to significantly supplement and update the descriptions of these deposits given in the first edition. The authors are also deeply grateful to Prof V. Ye. Boytsov and to instructors of the Department of Geology, Mineralogy and Geochemistry of Rare and Radioactive Element Deposits of the Moscow Geological Prospecting Institute imeni S. Ordzhonikidze, who acquainted themselves with the manuscript of the training aid and made suggestions which were taken into account in the final draft.

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PIPELINES

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OPTIMAL CONTROL OF A MARINE OIL DEPOT AND PORT FOLLOWING A STORM

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[Article by A. A. Dotsenko and L. G. Stepanets, Black Sea Administration of Main Petroleum Pipelines]

[Text] The irregularity with which tankers arrive at port to unload their oil is mainly the product of weather and the freighting conditions. In this case the most typical cause of irregularity in the arrival and processing of tankers is storms. During a storm, a large quantity of tankers can accumulate at a roadstead. When the weather returns to normal, they must be processed quickly. The experience of operating marine oil depots shows that the way the first batch of tankers to be processed is organized after a storm has fundamental significance to the control of an oil depot and port.

Because tankers must be processed quickly after a storm, the throughput of the oil depot must be increased, and a certain optimum strategy of operational control must be implemented during this period.

The possibilities for accelerating tanker processing are limited by the loading capacity of the oil depot in integration with that of the treatment facilities and the mooring space of the port. The traditional way to arrive at the tactics of operational control following a storm is to standardize the number of tankers simultaneously undergoing processing at the moorings of the oil loading port.

The existing approach to establishing the norm for simultaneous vessel processing entails setting the norm in accordance with the quantity of loading lines connecting the oil depot to the moorings. For practical purposes a branched flow and discrete control of the branches of this flow are used to simulate the transition from a continuous inflow of cargo (oil) to the oil depot to a combined discrete-continuous form of onloading of the cargo at the moorings. This model does not account for a significant form of onloading of the cargo at the moorings. This model does not account for a significant feature of the oil transloading process at an oil depot: Transloading proceeds from one reservoir at a time--that is, the transloading process is continuous-discrete. This creates objective difficulties in the onloading of oil at the moorings, where the continuous-discrete flows from several reservoirs must be distributed among the onloading lines in such a way that the time of continuous flow in the onloading lines is greater than the reservoir emptying time. The reason for these difficulties lies in the fact that the unit capacity of a reservoir at existing Soviet oil depots is less than the capacity of a tanker as a rule.

In some cases the situation is aggravated by the fact that the reservoirs at port-side oil depots located in hilly terrain are at different elevations, which severely limits the possibilities for joining the reservoirs together, owing to the danger of overflows. We should add to this that when cargo is pumped from the reservoirs at an accelerated pace, the whirlpool effect intensifies, which reduces the use coefficient of reservoir capacity and makes control over the reservoir park as a whole significantly more difficult.

It follows from this that the number of onloading lines at the moorings must correspond to the maximum loading capacity of the oil depot, which is limited by the design features of the oil depot and by the ratio between the unit capacity of a reservoir and the capacity of a tanker. The degree of this limitation is rather difficult to calculate, which is why the number of onloading lines is planned as a rule to be deliberately greater than the possibilities of the oil depot. Inasmuch as the onloading capacity at the moorings is calculated on the basis of the number of onloading lines, it would not be difficult to understand that the loading capacity of the oil loading depot imposes the greatest limitation on the possibilities for hastening the operations.

Assume that it is known from the experience of operating a marine oil depot that its maximum loading capacity is λ_m. We know from the vessel processing standards the the loading capacity $\lambda_{\Gamma i}$ of a vessel of class i ($i = 1, 2, \ldots, n$). Then the limit on the loading capacity of the oil depot may be expressed by the inequality

$$\lambda_m \geqslant \sum_i N_i \lambda_{\Gamma i}, \qquad (1)$$

where N_i is the number of vessels of class i undergoing processing simultaneously (that is, it is the vessel simultaneous processing norm for vessels of class i).

Research has shown that the number of different structural classes of vessels is usually larger than the number of moorings, and therefore vessels of different structural classes are grouped into classes i corresponding to the onloading and offloading capabilities of the vessels, and the moorings are correspondingly distributed with respect to classes i.

In a period following a storm, vessels of all n classes can usually be found at a port. The priority of vessel processing is regulated by the existing international shipping regulations. Thus to avoid the possibility of slighting the flag of a foreign vessel, the rule adhered to strictly when servicing foreign ships is to process them on a first come, first served basis. When processing domestic vessels, there are various alternatives for the priority of vessel processing, and they are entertained on the basis of economic considerations associated with the fleet's operation and cargo transport.

One known way of handling the problem of optimum operational control of tanker processing at a marine oil onloading port* entails establishment of the processing

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*Dotsenko, A. A., and Alibekov, B. I., "Optimal Planning of Tanker Processing at a Marine Oil Onloading Port," RNTS. TRANSPORT I KHRANENIYE NEFTI I NEFTEPRODUKTOV, No 2, Moscow, VNIIOENG, 1981.

sequence in relation to a certain operational time interval $\Delta\tau$, on the basis of the considerations indicated above. In a period following a storm the situation is such that the economic grounds for changing the order of vessel processing are significantly diminished owing to the long time the tankers had stood idle (up to 5-9 days). Consequently the criterion used in the solution described above cannot be used to make a sufficiently grounded decision as to the priority of processing a certain group of tankers immediately after weather returns to normal. Assume that $\bar{N}_i$ vessels of each class have accumulated at the port during a storm. Next assume that the port possesses N_{mi} moorings for each class of vessels. By solving the problem indicated above (that of optimizing the long-range plan), we can isolate from $\bar{N}_i$ a certain quantity of vessels $\bar{\bar{N}}_i$ with an equal right to inclusion in the first batch of vessels to be processed. This creates different alternatives for defining N_i such that inequality (1) and inequalities

$$N_i \leqslant \bar{\bar{N}}_i; \quad (2) \qquad N_i \leqslant N_{mi} \quad (3)$$

are observed.

The effectiveness with which an oil depot and an oil port operate following a storm may be evaluated either directly from the size of λ_m reached or indirectly from the level of satisfaction of the norms for N_i, as is traditionally done. In the latter case, however, we would have an additional limitation which would not always permit us to select the most advantageous alternative of N_i in relation to the criterion of achieving λ_m.

And in fact, the actual onloading capacity $\sum_i N_i \lambda_{ri}$ depends strongly on the correctness with which N_i is defined, since in view of the discreteness of $\sum_i N_i \lambda_{ri}$, it cannot be equated exactly to λ_{cr}. But when control is organized properly, the shortfall in utilizing the oil depot's onloading capacity following the storm may be minimized. Therefore the tactics of operational control of a complex consisting of an oil depot and an oil port following a storm should be established not by the traditional method indicated above, but rather on the basis of the criterion of minimum shortfall in the use of the oil depot's onloading capacity during the processing of the first batch of tankers.

$$\Theta = \min\left(\lambda_m - \sum_i N_i \lambda_{ri}\right). \qquad (4)$$

Thus problem (1)-(4) is formulated as a problem of optimum formation of the first batch of tankers to be processed in the period following a storm. This problem is in the class of mathematical whole-number programming problems. It must be solved by the appropriate methods at the level of an automated tanker processing control system in combination with the problem of optimum operational control of tanker processing at a marine oil onloading port.

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