ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ

Satbayev University

ХАБАРЛАРЫ

ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ
НАУК РЕСПУБЛИКИ
КАЗАХСТАН
Satbayev University

N E W S

OF THE ACADEMY OF SCIENCES
OF THE REPUBLIC OF
KAZAKHSTAN
Satbayev University

SERIES

OF GEOLOGY AND TECHNICAL SCIENCES

3 (453)

MAY – JUNE 2022

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, NAS RK

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«ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Меншіктеуші: «Қазақстан Республикасының Ұлттық ғылым академиясы» РҚБ (Алматы қ.).

Қазақстан Республикасының Ақпарат және қоғамдық даму министрлігінің Ақпарат комитетінде 29.07.2020 ж. берілген **№ KZ39VPY00025420** мерзімдік басылым тіркеуіне қойылу туралы куәлік.

Тақырыптық бағыты: *геология, мұнай және газды өңдеудің химиялық технологиялары, мұнай химиясы, металдарды алу және олардың қосындыларының технологиясы.*

Мерзімділігі: жылына 6 рет.

Тиражы: 300 дана.

Редакцияның мекен-жайы: 050010, Алматы қ., Шевченко көш., 28, 219 бөл., тел.: 272-13-19
http://www.geolog-technical.kz/index.php/en/

Типографияның мекен-жайы: «Аруна» ЖК, Алматы қ., Мұратбаев көш., 75.

«Известия НАН РК. Серия геологии и технических наук».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Собственник: Республиканское общественное объединение «Национальная академия наук Республики Казахстан» (г. Алматы).

Свидетельство о постановке на учет периодического печатного издания в Комитете информации Министерства информации и общественного развития Республики Казахстан **№ KZ39VPY00025420,** выданное 29.07.2020 г.

Тематическая направленность: *геология, химические технологии переработки нефти и газа, нефтехимия, технологии извлечения металлов и их соеденений.*

Периодичность: 6 раз в год.

Тираж: 300 экземпляров.

Адрес редакции: 050010, г. Алматы, ул. Шевченко, 28, оф. 219, тел.: 272-13-19

http://www.geolog-technical.kz/index.php/en/

Адрес типографии: ИП «Аруна», г. Алматы, ул. Муратбаева, 75.

News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technology sciences.
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Owner: RPA «National Academy of Sciences of the Republic of Kazakhstan» (Almaty).
The certificate of registration of a periodical printed publication in the Committee of information of the Ministry of Information and Social Development of the Republic of Kazakhstan **No. KZ39VPY00025420,** issued 29.07.2020.
Thematic scope: *geology, chemical technologies for oil and gas processing, petrochemistry, technologies for extracting metals and their connections.*
Periodicity: 6 times a year.
Circulation: 300 copies.
Editorial address: 28, Shevchenko str., of. 219, Almaty, 050010, tel. 272-13-19
http://www.geolog-technical.kz/index.php/en/

Address of printing house: ST «Aruna», 75, Muratbayev str, Almaty.

NEWS of the National Academy of Sciences of the Republic of Kazakhstan
SERIES OF GEOLOGY AND TECHNICAL SCIENCES
ISSN 2224-5278
Volume 3, Number 453 (2022), 198-211
https://doi.org/10.32014/2022.2518-170X.190

UDC 553.98(574)
IRSTI 38.53

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BUILDING THE ONLINE GEOLOGICAL AND GEOPHYSICAL DATABASE MANAGEMENT SYSTEM FOR HYDROCARBON FIELDS IN KAZAKHSTAN

Abstract. A geological and geophysical database of hydrocarbon fields in the Kazakhstan part of the Caspian depression wasbuilt, enabling the efficient geological forecasts and assessment/re-assessment of field reserves. The database has the capacity to reuse and replenish the stored information, allowing the oil and gas companies, engaged in modelling, to effectively address issues of complex interpretation of geological and geophysical data for prospecting, exploration and evaluation, complex geological structure of oil and gas fields. The WEB-based Oil&Gas Resources Database Management System (OGR. Version 1.0) was developed, the pilot loading of initial information on 60 oil and gas fields into the database was carried out, and a basis for using this information in specialized geoinformation systems for building hydrocarbon reservoir models on complex geological and geophysical data was developed. This will enable subsoil users to apply information resources accumulated over many years more quickly and efficiently to prepare digital databases of geological and geophysical data needed to study and monitor the state of the subsoil geological structure, assess hydrocarbon reserves and conditions of their location in the subsoil.

Key words: geological and geophysical information, database management system, interface, hydrocarbons, fields, Caspian Depression.

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ҚАЗАҚСТАННЫҢ КӨМІРСУТЕК КЕН ОРЫНДАРЫНЫҢ ГЕОЛОГИЯЛЫҚ-ГЕОФИЗИКАЛЫҚ ДЕРЕКТЕР БАЗАСЫН БАСҚАРУДЫҢ ОНЛАЙН ЖҮЙЕСІН ҚҰРУ

Аннотация. Каспий маңы ойпатының Қазақстан аумағы бөлігіндегі көмірсутектер кен орындарының геологиялық-геофизикалық деректерінің базасы Қазақстанда кен орындарының қорларын геологиялық болжау және бағалау/қайта бағалау мәселелерін тиімді шешуге мүмкіндік беретін сақталатын ақпаратты көп мәрте пайдалану және толықтыру мүмкіндігімен құрылды. Бұл модельдеумен айналысатын газ-мұнай саласының компанияларына газ-мұнай кен орындарының геологиялық құрылысы бойынша күрделі геологиялық-геофизикалық деректерді іздеу, барлау және бағалау үшін кешенді түсіндіру мәселелерін тиімді шешуге мүмкіндік береді. «Oil&Gas Resources» деректер базасын басқарудың WEB-жүйесі әзірленді (ДҚБЖ OGR,1.0 нұсқасы), деректер базасына мұнай мен газдың 60 кен орны бойынша бастапқы ақпаратты тәжірибелік жүктеу және оларды геофизикалық өрістерді модельдеу, кешенді геологиялық-геофизикалық деректер бойынша көмірсутектер шоғырының модельдерін құру үшін арнайы геоақпараттық жүйелермен (Petrel, Geoframe, Landmar-дан Geosciences, Paradigm Geolog және т.б.) пайдалануға дайындау жүргізілді.

Түйін сөздер: геологиялық-геофизикалық ақпарат, деректер базасын басқару жүйесі, интерфейс, көмірсутектер, кен орындары, Каспий маңы ойпаты.

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СОЗДАНИЕ ОНЛАЙН-СИСТЕМЫ УПРАВЛЕНИЯ БАЗОЙ ГЕОЛОГО-ГЕОФИЗИЧЕСКИХ ДАННЫХ МЕСТОРОЖДЕНИЙ УГЛЕВОДОРОДОВ КАЗАХСТАНА

Аннотация. Создана база геолого-геофизических данных месторождений углеводородов казахстанской части Прикаспийской впадины с возможностью многократного использования и пополнения хранимой

информации, которая позволяет эффективно решать вопросы геологического прогнозирования и оценки/переоценки запасов месторождений в Казахстане, а компаниям газо-нефтяной отрасли, занимающиеся моделированием, эффективно решать вопросы комплексной интерпретации геолого-геофизических данных для поисков, разведки и оценки, сложных по геологическому строению газонефтяных месторождений. Разработана WEB-Система Управления Базой Данных "Oil&Gas Resources" (СУБД OGR. Версия 1.0), проведена опытная загрузка исходной информации по 60 месторождениям нефти и газа в базу данных и подготовка их к использованию специализированными геоинформационными системами (Petrel, Geoframe, Geosciences от Landmar, ParadigmGeolog и др.) для моделирования геофизических полей, построения моделей залежи углеводородов по комплексным геолого-геофизическим данным.

Ключевые слова: геолого-геофизическая информация, система управления базой данных, интерфейс, углеводороды, месторождения, Прикаспийская впадина.

Introduction. The problem of a unified database (DB) storage and data management system (DBMS) for use of geological and geophysical information in Kazakhstan has not yet been solved. So far, the main achievement in this area has been the conversion of analogue information to digital and the building of an electronic archive. As part of solving the overall problem of organizing the online database management system (DBMS) with the Web-interface on hydrocarbon (HC) fields of Kazakhstan, an essential place is taken by a set of works on collection, input, storage of spatially distributed information, its processing and delivery of digital data of geological content to users. [1,2]. Today it is relevant to build a unified system of storage and access to geological and geophysical data, for multiple use and replenishment of online stored information and modelling of geological section using specialized geoinformation systems (Petrel, Geoframe, Geosciences Landmar, Paradigm Geolog and oth.)

An essential requirement to DBMS must be various operations with the original data: input, storage, manipulation, query processing, search, selection, sorting, updating, maintaining the integrity and protection of information, the ability to integrate the processed data into geographic information systems (GIS) widely used in the industry, designed for processing, interpretation and construction of geological section model [3,4].

Prospecting works result in the information about the subsoil geological structure, mineral reserves and conditions of its location in the subsoil. Reports are prepared containing the obtained maps, sections, charts and appropriate

explanatory notes, with the following storage of the reports in the state and territorial geological funds. In other words, the work which consumes enormous efforts and resources results in the field data [5].

In order for the collected data to be of practical use, it must be readily available for specific subsurface applications. At present, it takes a long time to bring a set of heterogeneous data from different sources into a form suitable for their subsequent integrated use in modelling or analysis systems. Data unification and standardisation is one way of addressing this problem.

Telecommunications technology is another area for accelerating progress in the accumulation and use of geological information. Thanks to the development of modern means of communication and the use of Internet/ Internet technologies, specialists separated by large distances (common situation in geology) are able to solve current tasks corporately using common geological information resources.

The effective real-time remote access to field and accumulated geological information also requires further development and implementation of telecommunication systems in the DBMS for use by Kazakhstan oil and gas companies in solving day-to-day tasks.

The research materials and methods. Specialists at the Satpayev Kazakh Research Technical University have developed an online geological and geophysical database management system for the Caspian region. The system allows production and scientific institutions in need to promptly obtain primary geological and geophysical information to conduct high quality summary, processing and interpretation of geological data.

The authors faced the task of building a digital database of geological and geophysical information which had to conform to the following requirements:

-the possibility of combining different ways of storing and managing spatial information (GIS and DBMS);

- availability of integration and dynamic adjustment tools for changing database structures;

- availability of interfaces to existing systems for storing and processing geological and geophysical information;

- support of remote access by telecommunication means.

The software development for the computer databank was carried out in stages.

Stage I - System analysis.

Stage II - Design and development of the software.

Stage III - Evaluation (testing) of the software.

Stage IV - Use of the software to form an online geological and geophysical databank management system.

The following requirements were taken into account in the building of the online DBMS:

- the software operates under standard operating systems (of the WINDOWS type);
- the software tools:
• support standard network protocols;
• have a system of system protection and recovery after failures;
• provide for:
-secure long-term storage, prompt access to archive data and protection of data from unauthorized access;
-simultaneous access to data by users;
-immediate access to the information throughout the period of its storage;
-data retrieval and forwarding according to prescribed forms;
-providing materials in the form of tables, texts, maps, drawings, etc. based on the information contained in the database.

System of collection, processing and cataloguing of collected materials on hydrocarbon (HC) deposits in Kazakhstan.

The main issue in the transition to modern information processing technology is the accumulation of some initial amount of textual, graphical, cartographic and attributive data in electronic form. The technology of building and maintaining diverse data, whereby objects are described by pairs of linked coordinates, has long been successfully developed. This method of data representation is economical in use of computer resources, allowing considerable amounts of information to be processed on existing hardware. The digitisation procedures are well established and produce consistent results, but there is a significant investment of manpower and time in the building and maintenance of the data [6].

The proposed solution is based on the initial accumulation and systematisation of diverse information in hard (paper) or electronic media from different sources. This is followed by a step-by-step replacement of analogue information by digitised scanners and appropriate software. The advantage of this approach is that as new analogue data is updated and made available, the information is systematically replaced by digitised data. The actual database of incoming data can be maintained in mixed analogue-digital form.

The database structure consists of the following subsystems (Figure 1), which implement the above functions:

- subsystems for input and registration of materials;
- subsystems of information retrieval and visualization;
- information storage subsystems;
- the database operation management subsystems;
- information security subsystems.

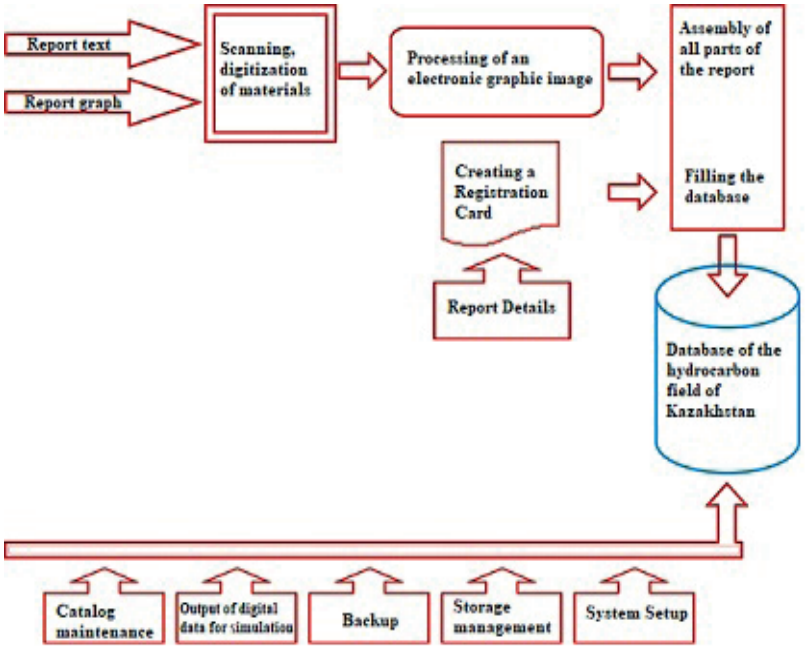

Figure 1 - The DB structure

Such technology makes it possible to collect, process and catalogue incoming information on hydrocarbon deposits in a timely manner, ensuring wide access and efficient use of digital data by subsoil users.

The technology of geological information resources processing and cataloguing is based on the following principles:

• Standardisation and unification of input and stored data;

• Quality control of information resources at the stages of collecting, preparing data for input, storage and output of information;

• The need to store, manage and organize access to a wide range of primary and processed factual, textual and spatial information of all types and sections of information resources;

• The transfer of information resources to users in the required formats;

• Compatibility and possibility of interaction with the Unified Computer System of the State Subsurface Information Bank of the Republic of Kazakhstan.

The incoming field information was digitised and put into a shared folder. The raw data collected was presented in a volume of 2.5 Tbytes. The information was then sorted according to field ownership and placed in a specific folder. Within the field directory, the data were scattered to the relevant adopted sub-directories (Figure 2).

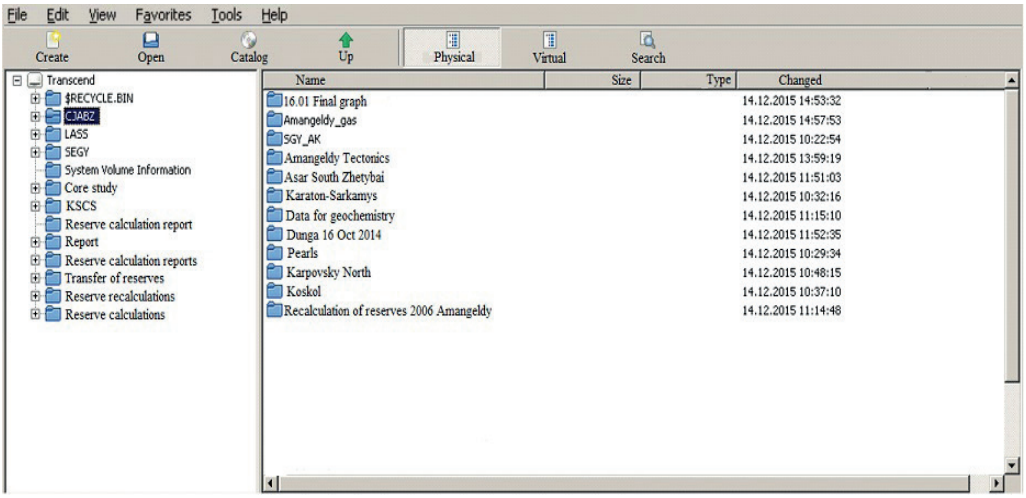

Figure 2 - Formation of fields' directories

In the process of collecting and analyzing the incoming information about the hydrocarbon fields, it was decided to catalogue the geological and geophysical data by sub-directories titled as follows:

«Drilling»
«Geology»,
«Geophysics»,
«GIS»,
«Maps»,
«Laboratory research»,
«Seismic exploration»,
«Reports»,
«Development».
«Stocktaking».
«Presentations»,
«Other».

The collected data have been distributed to relevant directories. In the absence of relevant data, the subdirectories remain empty (Figure 3).

Software development for the Geological and Geophysical Data Base Management System

As a result of the analysis of the software requirements, the following functions of the DBMS system were identified:

• receiving and input of geological and geophysical materials and data for permanent storage;

- keeping records of stored documents;
- organization of data management and administration;
- operational provision and unloading of data on request;
- carrying out statistical processing of information.

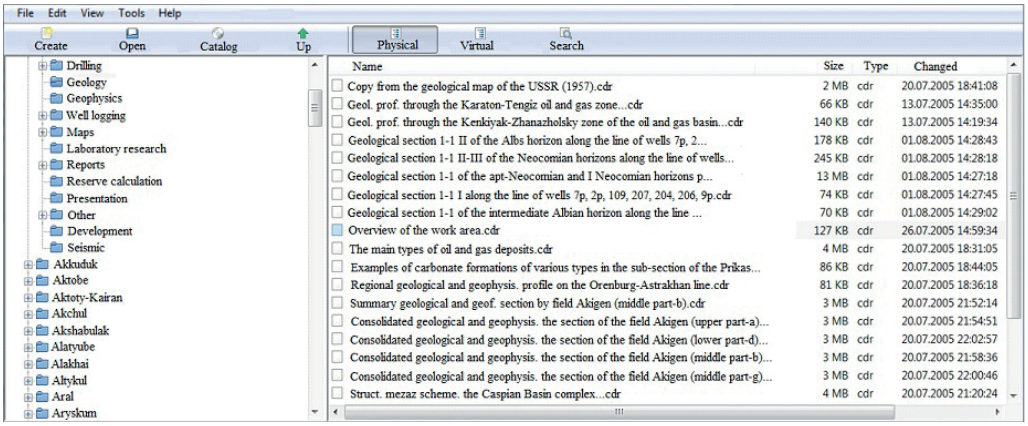

Figure 3-Formation of fields' subdirectories

Software development. The Go programming language (Golang) was chosen to build and develop a web application to interface with the RDBMS, with basic functionality such as configuration file handling, HTTP (HyperText Transfer Protocol) and a module loading system. Go programming language (often also called Golang) - a compiled, multi-threaded programming language developed by Google. Developed as a system programming language for building high-performance programs running on modern distributed systems and multicore processors. When developing it, special attention was paid to providing high-performance compilation. Go programs compile to object code (although an interpreter is also available) and do not require a virtual machine to run. The web application developed combines the information retrieval and processing advantages of databases with the visibility of maps, charts and graphs. It combines the powerful means for searching and presenting data. The startup screen and the menu of tools and dialogues are designed according to the principles of programme design [7].

Structure of a database management system for the storage and delivery of geological and geophysical data.

The web application was connected to a MySQL database server. The MySQL is a popular open source database management system that is commonly used in web applications because of its speed, flexibility and reliability. The MySQL uses SQL (Structured Query Language) to access and process data in the database. Storing data in the database server provides centralized management,

compliance with standards, data security and integrity, reduces redundancy and eliminates data inconsistency. A web application was built using a two-tier architecture where clients communicate directly with the server. Based on use of applications, the core modules - Operator, Administrator and Client - were built on HTTP, Server-a, which supports the modularity of the database. The modules were incorporated into the server at the moment of compilation and loaded dynamically via configuration file directives. These modules can be managed from the system kernel, which in turn allows data to be taken and stored in the SQL database module (Figur e4).

The modules implement features such as:

- Support for programming languages.
- Adding functions.
- Bug fixes or modification of basic functions.
- Security enhancement.

The following subsystems have been formed in the Operator's module:

- Input and registration subsystems;
- Cataloguing and retrieval subsystems.

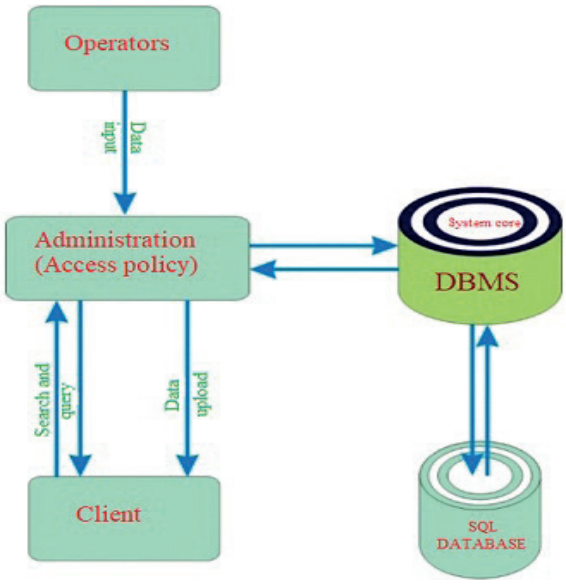

Figure 4- Operational principle of the Database Management System

First, the operator must be authenticated in order to access the system. To do this he will receive a login and password from the Administrator. If the operator does not log on from the local server but remotely via the Internet it must be entered into the Network Settings. Operator authentication data is stored in the system's account manager repository. From the operator's module

such operations as primary input with entering information and attributive data characterizing the field, which have been sorted and prepared for entering into the Database.

Next, filling in the field card with the following items (Table 1):

- Name (Title) of the field
- Comment (description)
- Deposit type
- Collector
- Tectonics
- Stratigraphy
- Parameters of the reservoir
- Hydrodynamic conditions
- Hydrocarbon characteristics
- Coordinates

Table 1- Example of completing a Morskoye field card

Name (Title) of the field	**oil field - Morskoye**	**UID: 36**
Comment	It is located in the Embensky district of Atyrau region, 90 km southwest of the Kulsary railway station	
Deposittype	stratified tectonically shielded	
Collector	Terrigenous rocks, pore reservoirs	
Tectonics	It is confined to the three-winged salt dome structure	
Stratigraphy	Oil-bearing Lower Albsky and Aptian deposits K1 of the north-eastern and south-eastern wings.	
Deposit parameters	The depth of the productive reservoir is 1178-1236 m., respectively, for the Lower Albsky and Aptsky horizons; the height of the deposits is 18.6 and 38.8 m. The oil-water tank is installed at -1219.4 and 1297.5. The oil-saturated thickness is 3.17-6.58 m	
Hydrodynamic conditions	The initial reservoir pressure is 12.8 and 14.6 Mpa, t 42-45°C. The mode of deposits is water-pressure. Formation waters of the chlorocalcium type, density 120 kg/m3 and mineralization 135-139 g/l.	
Hydrocarbon characteristics	Heavy oils, density 934-954 kg/m^3, high-sulfur 2.58%, paraffin 3.89%, contain 24.4 and 25.6% asphaltenes	

The operator can also remotely ‘add or edit’ as well as delete field data. The capabilities of the system do not allow geographical coordinates to be entered directly in dynamic form. For this purpose, an additional dialog box «Enter coordinates» in JSON format is introduced.

The client module of the application is implemented as two constructs: internal (accessible to the programmer) and external (intended for the user).

The design, intended for the user includes the control of subsystem of search

and visualization, for fast and accurate selection at request of the necessary information for the client. Fields search is conducted, firstly, by vectorial, interactive map of Kazakhstan and, secondly, by the built Database of the fields' catalogue. The database search is divided into search by metatags, i.e., we may search for a deposit by such properties as type of deposits, tectonics, deposit parameters and etc. (Table2).

Table 2 - Metateg search engine

Name	**Comment**
Types of deposits	Collector
Tectonics	Stratigraphy
Deposit parameters	Hydrodynamic conditions
Hydrocarbon characteristics	

For the Visualisation subsystem, backing images were built in the form of spatially referenced vector bases of the map of Kazakhstan with a breakdown by layers [8].

Client-side selection of layers has been added.

These images in the program were built and compiled as:

-Relief based on SRTM DEM, 30m resolution;

-Data on settlements of Kazakhstan;

-Data on major water bodies, roads and railways, along the border of Kazakhstan;

-Fields on the map;

-When zooming in, names appear on the points of the fields;

-In the mode of Information on deposits, moving the cursor leads to appearance of the name of the deposit;

-Clicking on the inscription, the field card is displayed (picture 5).

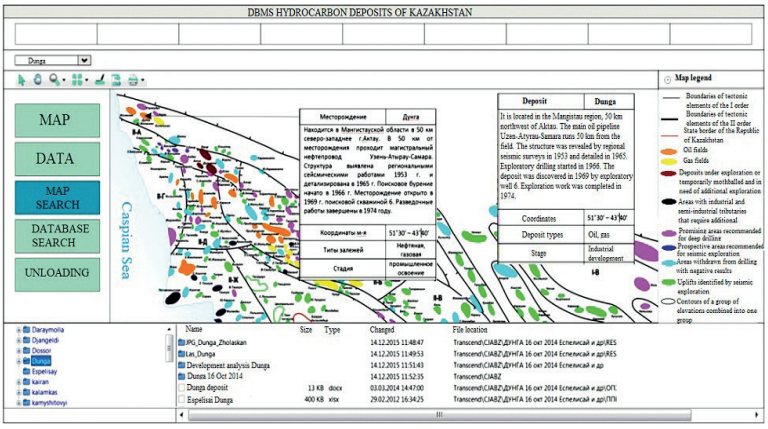

Figure 5- Display of a field on the map

The internal design involves managing the subsystem to authenticate the user and grant the client access to physical information. The System Administrator has this function.

To enable further customisation, a configuration support file containing configuration data has been added (support for comments is available).

Configuration file contains the settings:

1. Path to www files
2. Port number for web browser
3. Path and file name of the main bitmap backing (terrain)

The research outcomes. The Geophysics Department of the KazNITU have installed a database under the control of the developed Oil&Gas Resources (OGR) application on the file server. The database contains sets of geological and geophysical data, forming spatial (having the coordinates of objects) and analogue diverse information, which is organised to build digital models for 60 fields of the Kazakhstan part of the Caspian Depression [9-12]. On a server of a storage of files of electronic images of documents, the server software of management of storage of files is established. Data storage in the database provides centralized online management, compliance with standards, data security and integrity.

The database is built and accessed (via queries) by means of a DBMS, the functions of which are provided by Oil&Gas Resources (OGR). This application supports the optimum operating mode, whereby workstations of network clients send queries to the database located on the computer serving them - a file server, receive there needed files, perform a set of operations of search, selection and output of data. In the other mode, the workstations act as clients while the database server entirely serves the queries and sends results of selections to the clients, implementing the client-server technology.

Physically, the entire database is located in a secure, separate drive on the file server, in the DBOGR directory, in the Data subdirectory. A password system is used to protect data. Access is only granted to authorised users, who are appointed by the network Administrator. Technically, the server has capacity for potential expansion of solvable tasks. Reliable, faultless power supply is provided.

Discussion. Workplaces are equipped in accordance with all hygienic and ergonomic norms and rules, is assigned to a specific user, who is responsible for safety of the equipment connected to the KazNITU local network with further access to the Internet. The licensed software is installed on the workplace, which allows specialists to perform their functions. The software was purchased from certified vendors, with the aim of further technical support, ensuring delivery of updates and revisions.

The minimum set of software products installed in a file server includes:

The Windows Server 2017 operating system;

The office software package;

The geo-information softwares for viewing GIS data;

The antivirus software package.

Installation, configuration and maintenance of the software is carried out by qualified specialists of the University.

The operating system is protected by the software and, if necessary, hardware means against unauthorised access to information resources. The antivirus software should ensure that the system is continuously monitored for computer virus penetration. The antivirus software must be updated and updated on a weekly basis. Operating system tools regulate user access rights to information resources of the enterprise, and continuous security audits are organised.

All important information is archived and backed up on a scheduled, weekly, monthly and annual basis. Archived data are catalogued, periodically checked and copied to other media for long-term preservation.

Conclusions. A general model of an automated system for collecting, processing, storing, searching and querying of geological and geophysical data of hydrocarbons in Kazakhstan has been built. The WEB-based database management system «Oil&Gas Resources» (OGR. Version 1.0) on hydrocarbon fields of the Kazakhstan part of the Caspian Depression was developed; the pilot loading of initial information in the database and preparation was conducted for its use by specialized geoinformation systems (Petrel, Geoframe, Geosciences by Landmar, Paradigm Geolog and others) in order to model geophysical fields, build hydrocarbon reservoir models using complex geological and geophysical data.

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www:nauka-nanrk.kz
http://www.geolog-technical.kz/index.php/en/
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Редакторы: *М.С. Ахметова, А. Ботанқызы, Р.Жәлиқызы, Д.С. Аленов*
Верстка на компьютере *Г.Д.Жадыранова*

Подписано в печать 15.06.2022.
Формат 70x90$^{1}/_{16}$. Бумага офсетная. Печать – ризограф.
17,5 п.л. Тираж 300. Заказ 3.

Национальная академия наук РК
050010, Алматы, ул. Шевченко, 28, т. 272-13-19