Integrated Exploration Technologies of Passive Rift Basins

Science & Technology Management Department

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CHINA NATIONAL PETROLEUM CORPORATION

Make Passive Rift Basins Exploration No Longer Passive!

Contents

China National Petroleum Corporation (CNPC) is a state-authorized investment agency and a state holding company. On July 1998, with the implementation of the Institutional reform of the State Council, CNPC was reorgnized to become an integrated oil company of cross-regions, cross-industries and cross-countries, it adopts modern enterprise system to realize the integrations of upstream and downstream operations, internal and external trade, production and marketing. CNPC's business covers six main sectors: oil and gas operations, petroleum engineering service, petroleum engineering construction, petroleum equipment manufacturing, financial services and new energy development. In 2012 CNPC produced 110 million tons of crude oil and 79.82 billion cubic meters of natural gas, while crude processing volume reached 191 million tons. The total revenue of RMB 2,690 billion with a profit of RMB139.1 billion had been achieved the same year.

CNPC was ranked 4th among the world's largest 50 oil companies and 6th in Fortune Global 500 in 2012.

CNPC strictly follows by the combined strategies of increasing resource capacity, expanding market shares and consolidating the international role, and persists in regarding technical innovation as a key framework to advance technological progress. To develop its core businesses, focuses will be placed on the solutions of key bottleneck technologies and key proprietary technologies. Thanks to continuously improving of the technical innovation system, optimizing the configuration of technological resources and strengthening the construction of strong talent teams, CNPC's technological creativity has been considerably upgraded. Consequently, a large number of technologies have been developed independently, with its own intellectual property.

Integrated Exploration Technologies of Passive Rift Basins is one of representatives for major innovations of CNPC.

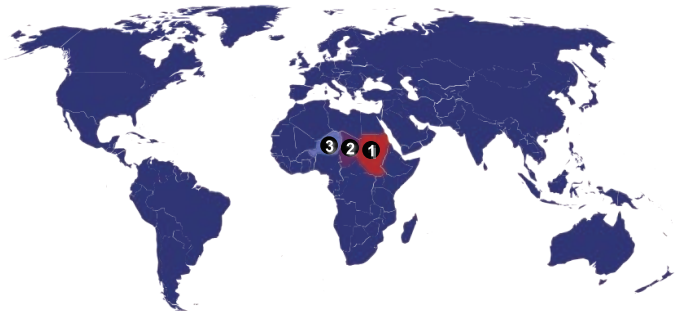
CLEAN ENERGY SUPPLY FOR BETTER ENVIRONMENT

1 INTRODUCTION

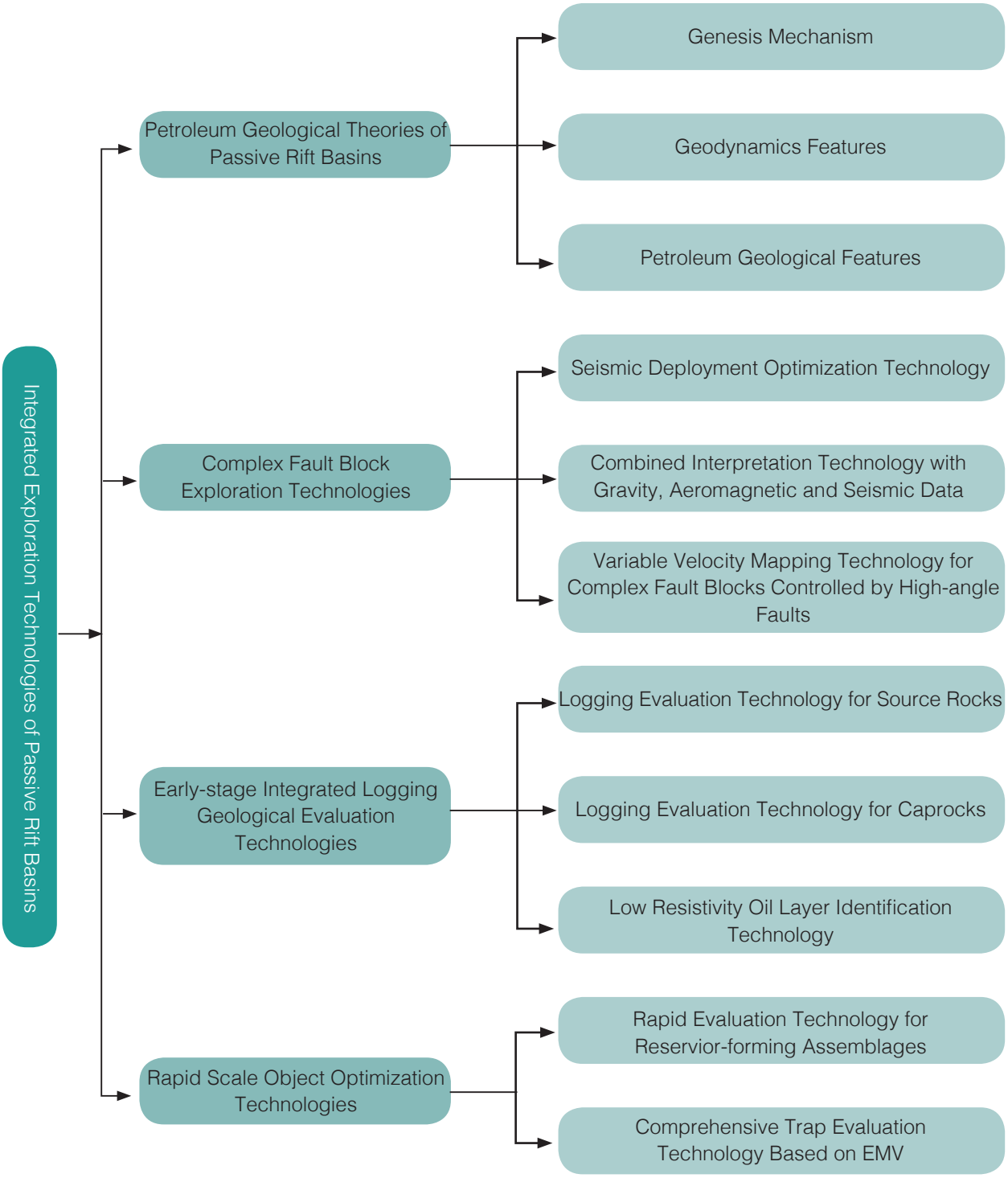
Rift basins are one of the most favorable petroliferous basins in the world and can be divided into active rift basins and passive rift basins in terms of geologic origin. The concept “passive rift basin” was proposed by scholars as early as in 1978, and its basic meaning is the rift basin caused by non-mantle uplifting. Since 1996, the scientific research team of CNPC led by Prof. Tong Xiaoguang academician of Chinese Academy of Engineering, has focused on passive rift basins taking Central and West African rift systems as objects and has deeply studied the genesis mechanism, classification, geologic models and hydrocarbon accumulation models of passive rift basins, thereby forming oil and gas geology theories of passive rift basins and integrating a set of comprehensive exploration technologies for passive rift basins according to international oil and gas exploration features.

Committed to the development of passive rift basin exploration basins, CNPC has a number of excellent professional and technical personnel, has built up first-class laboratories and can provide various relevant technical services.

Theoretical recognition and technical innovation promote exploration discoveries. Block 1/2/4 project in Muglad basin in Sudan has obtain tremendous benefits and a large oilfield of 15 million tons per year has been built up. World-class Palogue large oilfield was rapidly discovered through Block 3/7 project in Melut basin in Sudan in two years. A scale breakthrough has been made in both Chad and Niger, where two oilfields of 100 million ton reserves each, ten oilfields of 10 million tons reserves each and a series of medium to small oil and gas fields have been discovered.



① Sudan/ Southern Sudan ② Chad ③ Niger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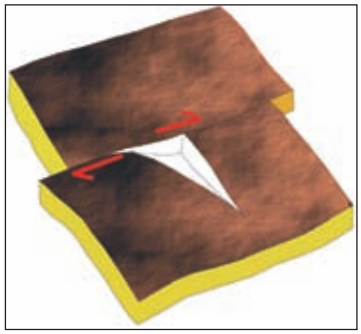
2 PETROLEUM GEOLOGICAL THEORIES OF PASSIVE RIFT BASINS

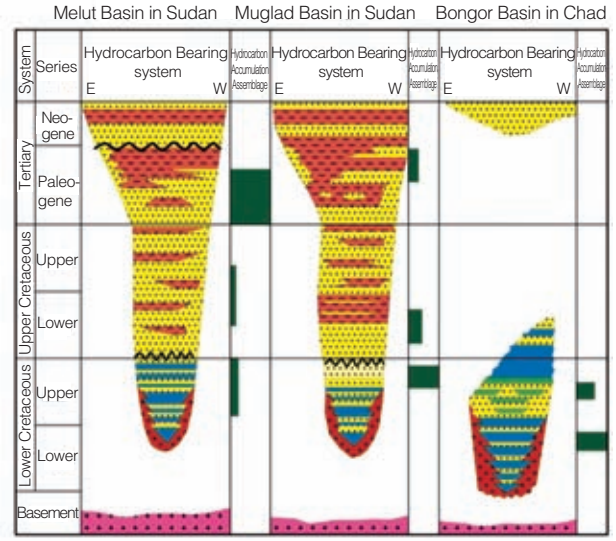
By systematically analyzing and comparing the difference between the basin groups in Central and West African rift systems and the active rifts in Eastern China, CNPC has proposed the viewpoint that the forming of Central and West African passive rift basins is due to the induction by activities of Central African shear belts and has established the geologic models and hydrocarbon accumulation models of passive rift basins.

Due to different genesis mechanisms, passive rift basins are different with active rift basins to a large extent in geodynamics features and petroleum geology features.

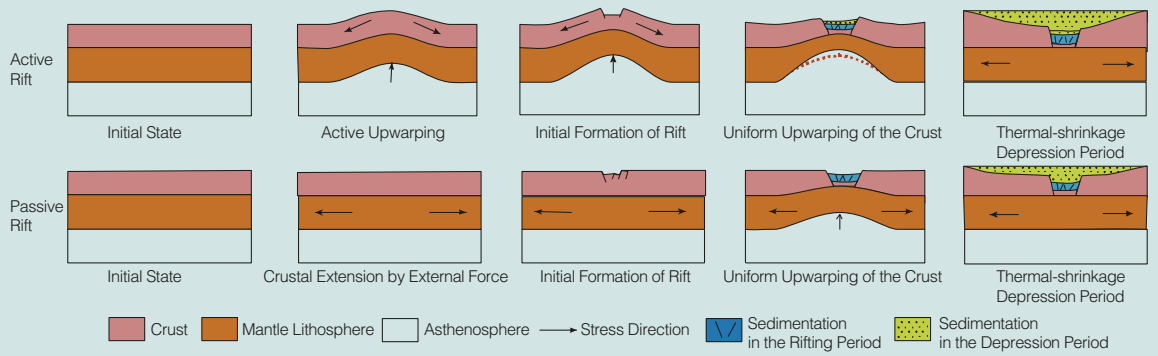
The petroleum geological features of passive rift basins: single source rocks, late hydrocarbon generation and long hydrocarbon generation time; reservoirs are thin sandstones in the rifting period and blocky sandstones in the depression period; regional caprocks and main reservior-forming assemblages depend upon the development of late superposed rift valleys; structural traps mainly include reverse fault blocks; fault depressions mainly include half-grabens; the structural transfer zones between slope zones and sags are the richest in oil and gas.



Formation Model of Central and West African Passive Basins



Central and West African Passive Basins



Kinetic Mechanism Difference between Passive Rift Basins and Active Ones

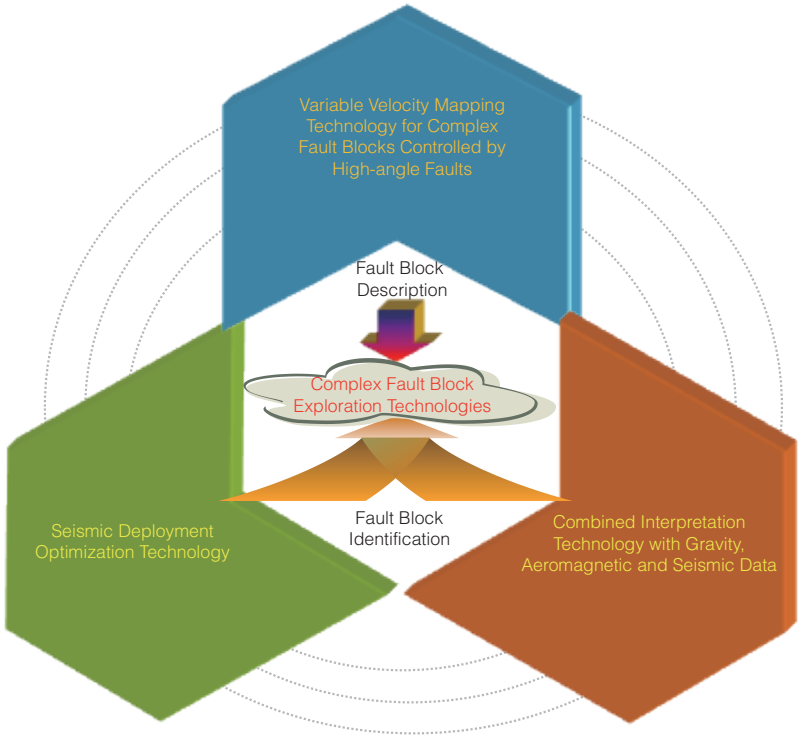
3 UNIQUE TECHNOLOGIES

3.1 Complex Fault Block Exploration Technologies

Complex fault block exploration technologies of passive rift basins have been integrated according to the features of passive rift basins such as multi-stage activities of faults, main traps including fault blocks, fault blocks related to one or multiple faults in general and large dip angles of main control faults. The technical functions of the technologies include fault identification and fine structural mapping.

The complex fault blocks are effectively identified starting with seismic deployment and acquisition by comprehensively utilizing multiple geophysical data and means, and according to the geologic features of basins. Accurately described various geologic elements of targets are to provide accurate and reliable drilling targets for exploration of rift basins.

Complex fault block exploration technologies include seismic deployment optimization technology, combined interpretation technology with gravity, aeromagnetic and seismic data and variable velocity mapping technology for complex fault blocks controlled by high-angle faults.



Seismic Deployment Optimization Technology

Early exploration of passive rift basins is faced with may risks due to their complex structures. Seismic deployment optimization work is done according to exploration rhythm, geologic tasks in different exploration stages, exploration tasks and technical requirements, so that the seismic deployment and construction design can meet the requirements of geologic tasks. This will improve the quality of seismic data with the lowest investment, determine complex geologic structures and exploration objects rapidly, realize exploration discoveries and reduce exploration risks.

· Analysis of Geological Conditions

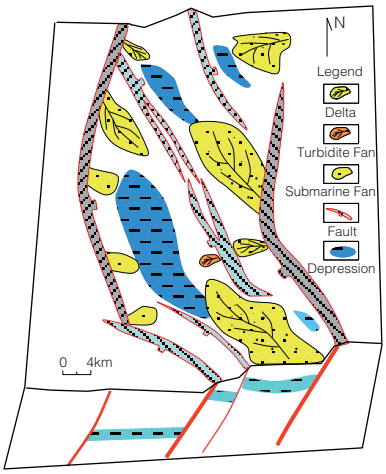
Before the seismic deployment, the geological background data are deeply analyzed, including basin structures, the distribution of structural belts and main control faults, etc. and the buried depth of exploration target formations and the longitudinal and transverse variation of reservoirs for convenience of targeted seismic deployment are determined.

· Analysis of Existing Seismic Data

Deeply analyze the quality of the existing seismic data, the existing problems and the survey net density; determine reasonable deployment and optimize the process flow according to the geologic objective and task.

· Deployment of 2D Seismic Lines

Deploy 2D seismic lines economically and effectively in terms of three levels such as regional structure investigation, belt evaluation and target determination. Carry out seismic deployment reasonably and optimize the number and strike direction of inlines and crosslines according to geologic features.



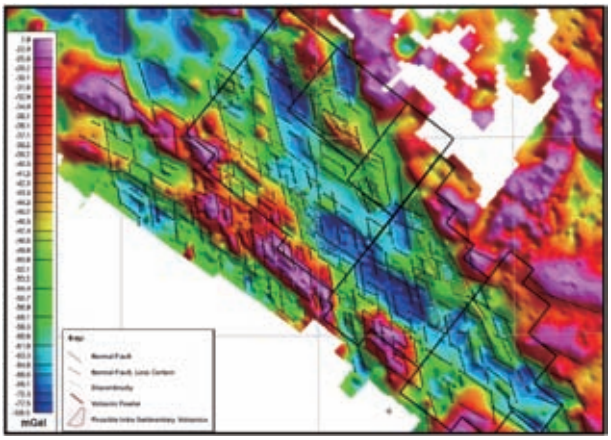
Basalt Mountain

· Deployment of 3D Seismic Lines

Deploy 3D seismic lines reasonably and in time, according to the requirements of exploration and development evaluation as well as economic evaluation and medium and long-term development.

Combined Interpretation Technology with Gravity, Aeromagnetic and Seismic Data

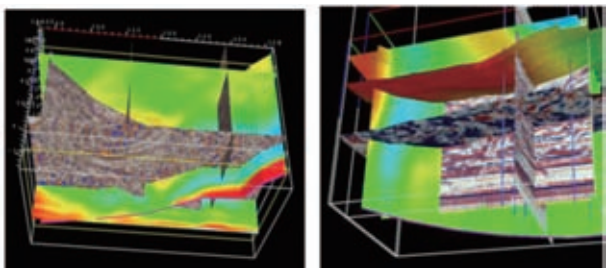
The combined interpretation technology with gravity, aeromagnetic and seismic data fully uses various geophysical data including gravity data, aeromagnetic data, seismic data, etc. to rapidly obtain the geologic information on sedimentary basin structures, sedimentary strata distribution, division of structural units, anomaly body distribution, etc., and provides guidance to rapid "sag determination and belt selection" and exploration deployment optimization in early exploration of basins according to the features of international oil and gas exploration such as centering on economic benefits and taking high-efficiency scale discoveries as the objective.



Bouguer Gravity Anomaly Distribution Map after Processing

Main technical means: processing of gravity data and aeromagnetic data, extraction of research target anomalies; seismic data processing; qualitative interpretation of gravity anomalies and magnetic anomalies; regional seismic data interpretation; combined inversion with gravity data, aeromagnetic data and seismic data; combined interpretation of gravity data, aeromagnetic data and seismic data.

The combined interpretation technology with gravity, aeromagnetic and seismic data can realize combination of planes of gravity data and aeromagnetic data with seismic profiles, combination of deep strata research with shallow strata research and combination of high precision with low precision. Multiplicity is greatly reduced using gravity data and aeromagnetic data in cooperation with special lithosomes from seismic interpretation. Regional geologic information and macroscopic structural background can be obtained rapidly



Effect Chart of Combined Interpretation of Gravity, Aeromagnetic and Seismic Data

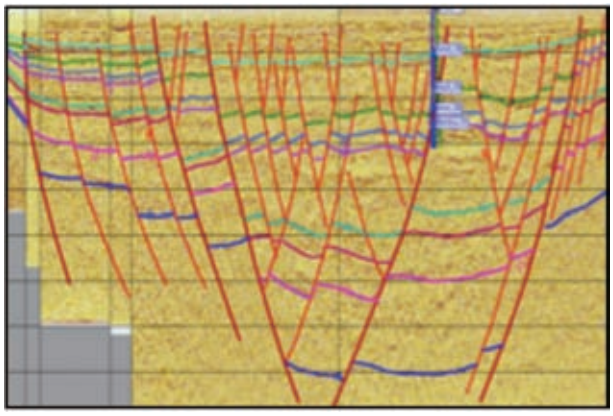
through combined forward inversion of gravity data and aeromagnetic data taking seismic data as constraints.

The technology is applicable to the exploration of regions where gravitational exploration, magnetic exploration and seismic exploration are completed and especially the complex regions including the regions with low quality of seismic data and complex surface conditions, volcanic rock development regions, etc.

Seasonal River

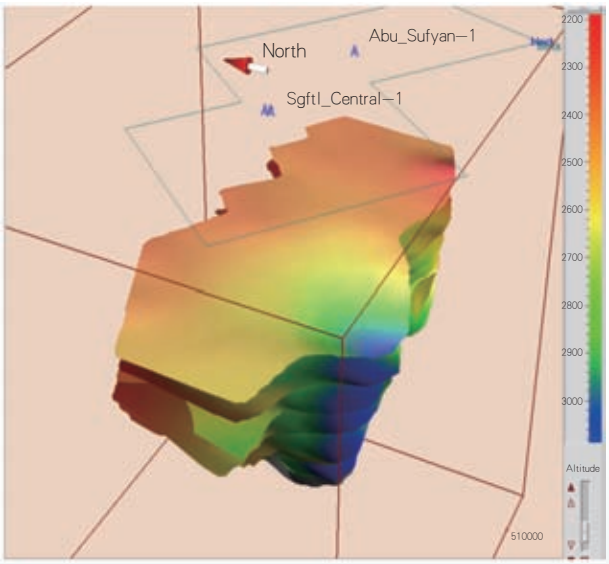
Variable Velocity Mapping Technology for Complex Fault Blocks Controlled by High-angle Faults

The main control faults in passive rift basins have a large dip angle and traps mainly include complex fault blocks. A fault block is controlled by multiple high-angle faults with a large dip angle in general, thus resulting in a large change of the seismic interval velocity in the same formation in the uplifted wall and bottom wall of a fault. In addition, the lateral facies variation of the lithology of passive rift basins leads to strong aeolotropism of underground media and a large change of seismic wave propagation velocity longitudinally and transversely. Therefore, it is difficult to accurately obtain the structure map of target formations through time-depth conversion using conventional mapping methods. The variable velocity mapping technology for complex fault blocks controlled by high-angle faults can ensure the trueness of the structure map of complex fault blocks, thus accurately achieving the purpose of describing traps.



Technical process: analysis and reorganization of seismic velocity spectrum data, seismic interval velocity calculation, velocity field establishment, velocity field calibration and correction and time-depth conversion.

Technical features: each calculation grid has a time-depth relation. In case of time-depth conversion using the ray migration method, the variable velocity mapping result is equivalent to depth migration, and can adapt to lateral velocity variation and overcome the adverse impacts caused by velocity variation in complex fault blocks in high-angle faults.



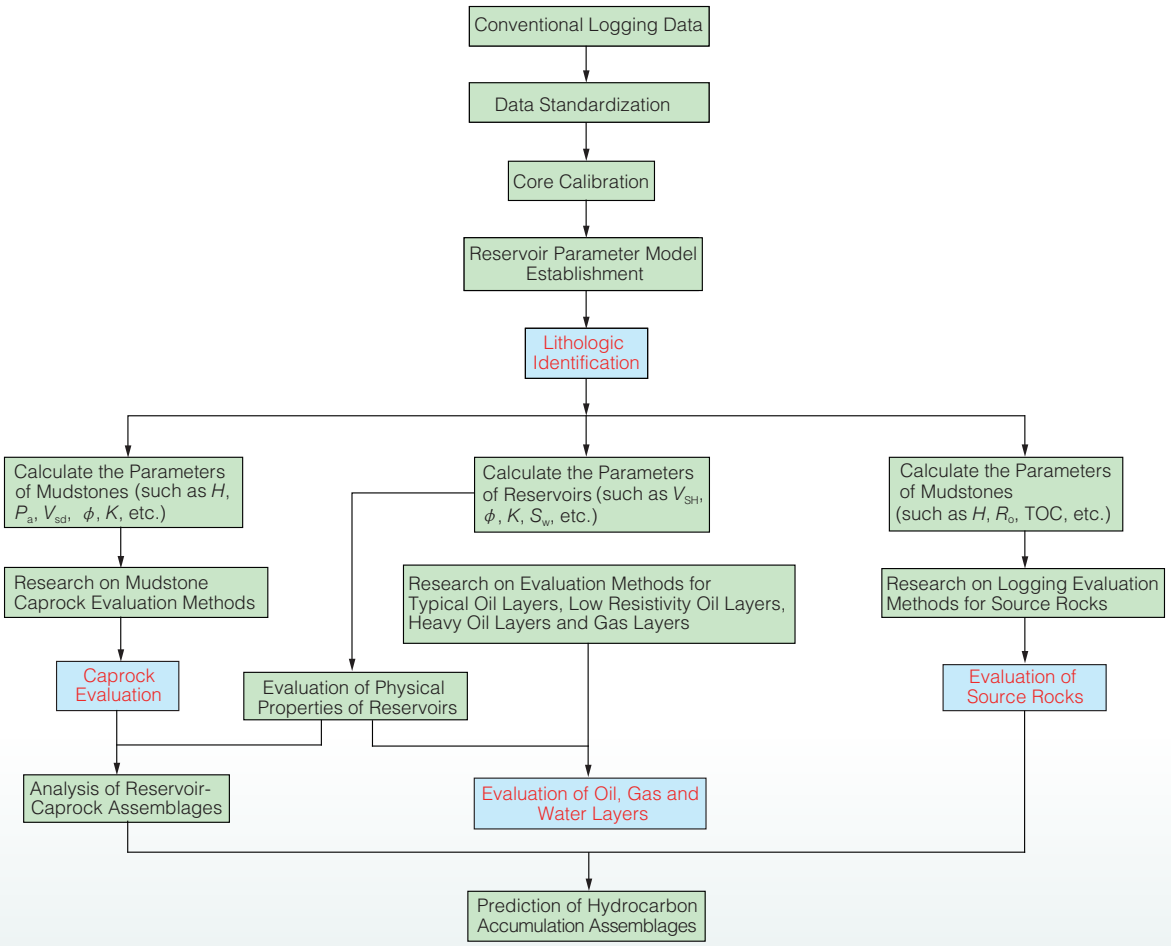
The technology is applicable to each stage of oil and gas exploration and development and especially to geologic conditions with lateral velocity variation but not remarkable lateral velocity variation.

3.2 Early-stage Integrated Logging Geological Evaluation Technologies

In view of the challenges including a short period of international oil and gas exploration contracts and deficient exploration analysis and test data in new regions, the integrated early-stage logging geological evaluation technologies fully use limited drilling data to evaluate source rocks, reservoirs and caprocks, thus rapidly determining main hydrocarbon accumulation assemblages and timely providing decision bases with high efficiency. The integrated low resistivity oil layer identification technology can effectively solve the difficult problems of low resistivity oil layer identification caused by the above factors according to the features of passive rift basins such as small reservoir thickness, large specific surface of grains, complex pore structure and easy forming of low resistivity oil layers.

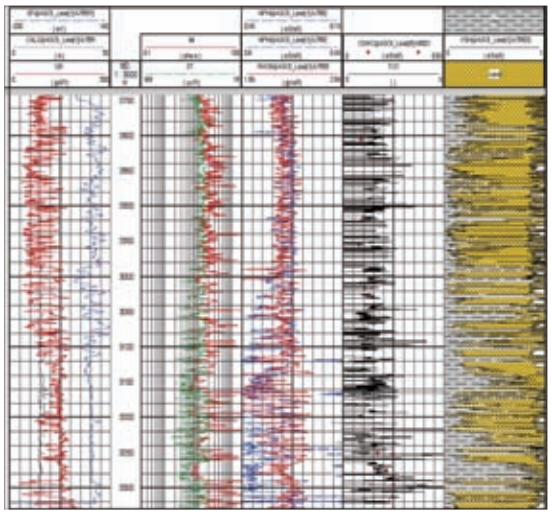
The integrated early-stage logging geological evaluation technologies include logging evaluation technology for source rocks, logging evaluation technology for caprocks and low resistivity oil layer identification technology.

CNPC has plenty of early-stage integrated logging geological evaluation experience and technical means as well as all sorts of logging geological evaluation software and can provide domestic and foreign oil companies with early-stage integrated logging geological evaluation services.



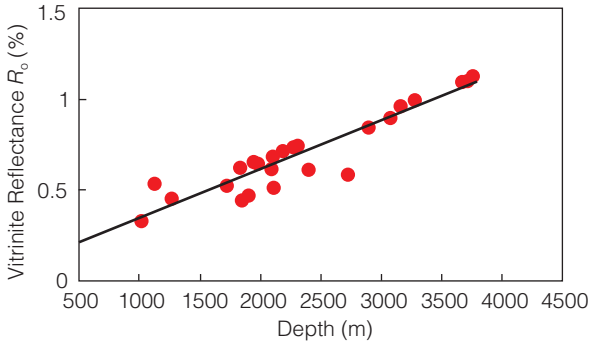
Logging Evaluation Technology for Source Rocks

There are very few samples of cores or cuttings for evaluation of source rocks in the early exploration period of basins, so it is difficult to reasonably evaluate the exploration potential of basins. The logging evaluation technology for source rocks can overcome the difficulty in few samples and can be used to calculate the TOC of mudstones in all strata of a whole interval and the corresponding vitrinite reflectance accurately and rapidly and to evaluate source rocks using conventional logging data on the basis of calibration of a small quantity of measured samples.

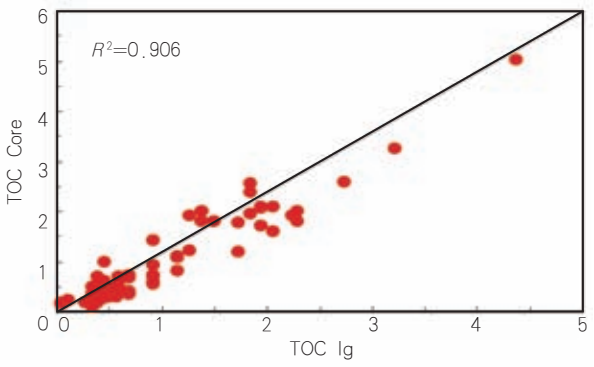


Logging Evaluation of Source Rocks

Technical advantages: calculate the TOC of mudstones using limited analysis data and calibration logging data according to the features of conventional logging data such as accuracy and continuity, thereby overcoming the difficulty in identification and evaluation of source rocks due to insufficient cores. In addition, this saves cost and can also provide geologic bases for estimation of resources and oil and gas exploration decisions and measures in time.



Relation of Vitrinite Reflectance (R_o) from Laboratory Analysis vs. Buried Depth

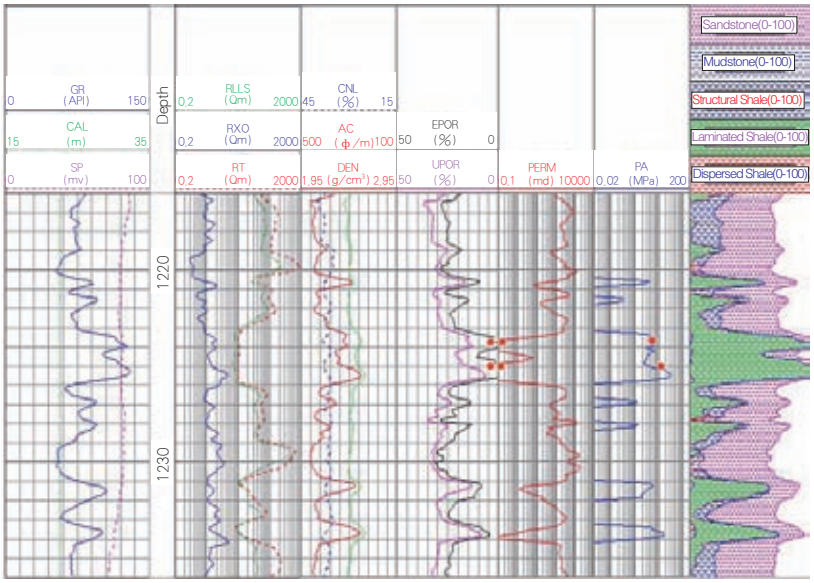


Relation of TOC (TOC Core) from Laboratory Analysis vs. Logging Calculation Value (TOC lg)

Logging Evaluation Technology for Caprocks

The logging evaluation technology for mudstone caprocks has been integrated according to the features of passive rift basins such as main caprocks including mudstones etc. The technology is used to calculate the evaluation parameters of argillaceous caprocks such as total porosity (ϕ_t), effective porosity (ϕ_e), permeability (K), sand content (V), thickness (H), breakthrough pressure p_a, under-compaction anomaly, etc., which establishes microscopic, macroscopic and comprehensive evaluation standards, and comprehensively evaluates caprocks using logging information on the basis of the research on the influencing factors for microscopic sealing mechanism and macroscopic distribution.

Technology features: microscopic evaluation parameters are combined with macroscopic ones in the comprehensive evaluation process; according to the significance of parameters, they are given a weighted value; a quantitative evaluation standard suitable for evaluation of argillaceous caprocks in passive rift basins has been established and can be used to evaluate caprocks quantitatively and semi-quantitatively; caprocks in a single well are evaluated longitudinally using logging data; through comparison of offset wells, caprocks are studied with a large scope, so that the evaluation of caprocks has been developed from microscopic single-point analysis into macroscopic analysis of continuous profiles. This makes up for the shortcoming of limited experiment analysis samples and has very high practicability and economic efficiency.

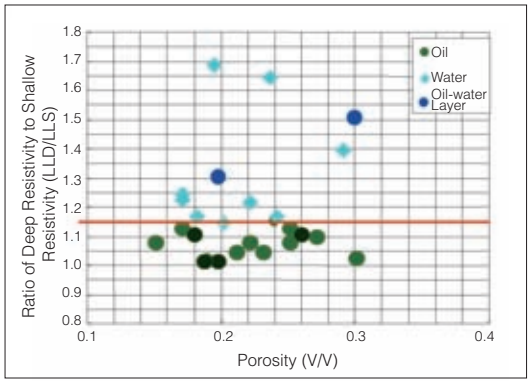


Logging Evaluation of Caprocks

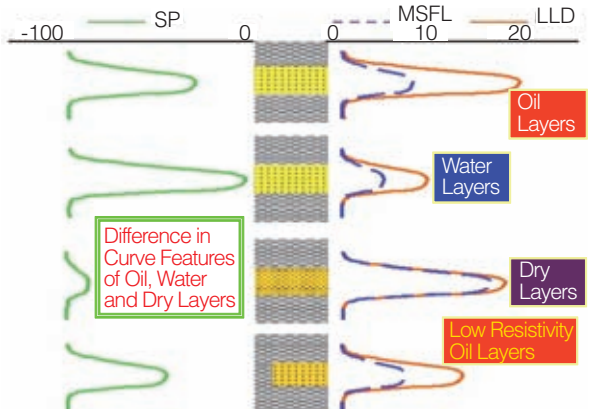
Note: the red points are the laboratory analysis results.

Low Resistivity Oil Layer Identification Technology

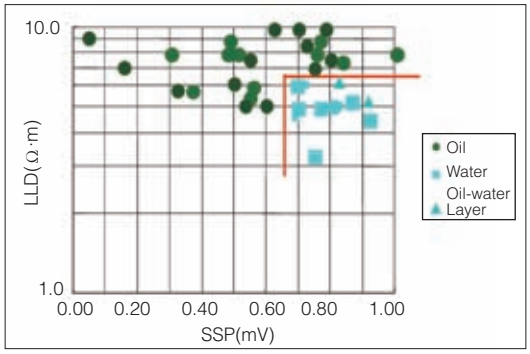
Low resistivity oil layers are easily formed because of small reservoir thickness, large specific surface of grains and complex grain structure in passive rift basins in the rifting period. In addition, low resistivity oil layers are also developed in part intervals due to invasion of brinish drilling fluid in the drilling process. The low resistivity oil layer identification technology can be used to identify the low resistivity oil layers caused by the above two factors accurately and effectively.



Cross Plot of Shallow Resistivity Ratio vs. Porosity



Low Resistivity Oil Layer Identification



Cross Plot of SSP vs. LLD

Evaluation methods for low resistivity oil layers with complex pore structure: RDSP identification method, improved PICKETT chart method, resistivity method for low resistivity thin layers, Indonesian equation with variable m index, etc.

Evaluation methods for invasion of drilling fluid into low resistivity reservoirs: intersection method of deep detection resistivity (RT) vs. static SP (SSP), FMT (MDT) data identification method, etc.

Technical advantages: realize continuous calculation and judgment and overcome the shortcoming of non-continuity of forward inversion simulation calculation; combine longitudinal resolution of high microresistivity and transverse resolution of high deep resistivity, eliminate the impact of wall rocks and evaluate low resistivity thin oil layers.

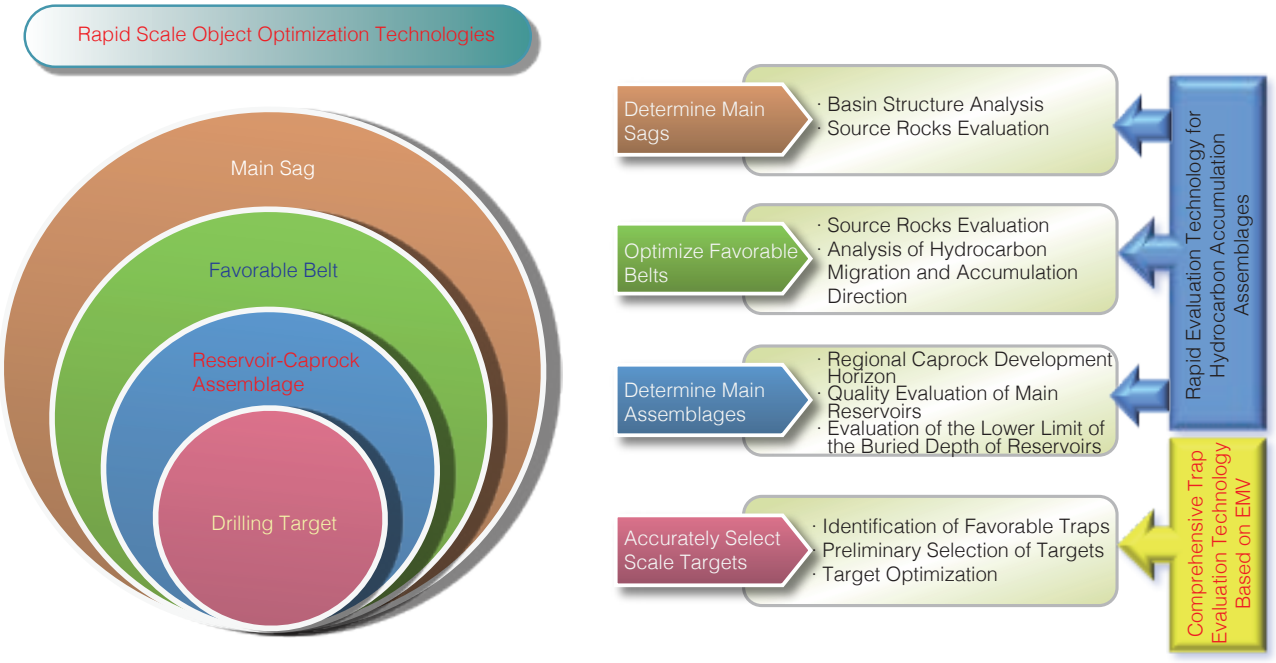
3.3 Rapid Scale Object Optimization Technologies

Rapid scale object optimization technologies have been integrated according to the features of international oil and gas exploration such as large investment and high economic threshold. This will reduce the scope of exploration target areas and accurately select scale objects according to regional geologic conditions.

Basin structures anulysis source rocks evaluation are carried out to rapidly determine main sags using limited seismic data, drilling data and laboratory analysis data through the analysis of basin structures. Select main target formations longitudinally and favorable exploration belts transversely are accurately and rapidly selected through the analysis of hydrocarbon accumulation conditions. Introducing the EMV value of the targets to be drilled for quantitative trap evaluation, the scale targets are ensured to be drilled firstly.

Rapid scale object optimization technologies include rapid evaluation technology for hydrocarbon accumulation assemblages and comprehensive trap evaluation technology based on EMV value.

CNPC has plenty of experience in and matured technologies for rapid optimization of scale targets as well as experienced well-known experts and can provide rapid and accurate scale target optimization services for exploration of different types of basins at home and abroad.



Rapid Evaluation Technology for Hydrocarbon Accumulation Assemblages

The rapid evaluation technology for hydrocarbon accumulation assemblages is used to evaluate and optimize the main hydrocarbon accumulation assemblages in basins rapidly and accurately with high efficiency and to provide bases for decisions by the decision-making layer using limited geologic data, drilling data and geophysical data.

· Determine Main Sags

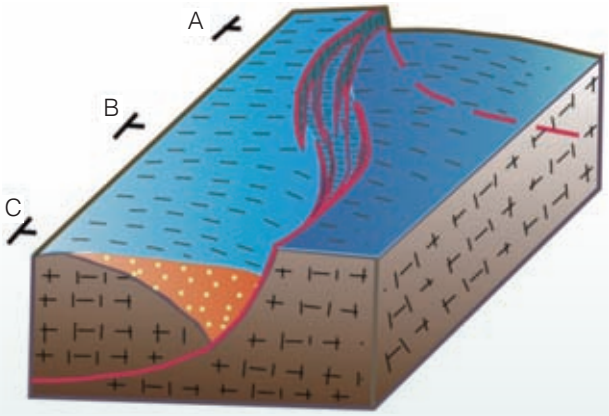
Analyze basin structures, evaluate source rocks and rapidly determine main hydrocarbon generation sags using limited data.

· Optimize Favorable Belts

Divide basin structure units, ascertain the relationship among units, make a rapid analysis of oil and gas migration and accumulation direction and trend, and optimize favorable belts on plane.

· Determine Main Assemblages

Determine the development horizons of reservoirs and caprocks in basins and rapidly make certain the lower limit of the depth of main exploration series of strata; rapidly determine the main reservoir-caprock assemblages in basins according to the longitudinal assemblage relationship among effective source rocks, effective reservoirs and main caprocks; determine main hydrocarbon accumulation assemblages according to their lithology distribution and the types of main traps.



Technical advantages: determine the main hydrocarbon accumulation assemblages in basins rapidly, accurately and highly effectively; fully utilize limited data including geologic data, drilling data, geophysical data, laboratory analysis data, etc.; the technology is easy to understand and operate in actual applications; the technology has strong professional comprehensibility and involves the disciplines such as geology, geochemistry, well logging, geophysics, etc.

Comprehensive Trap Evaluation Technology Based on EMV

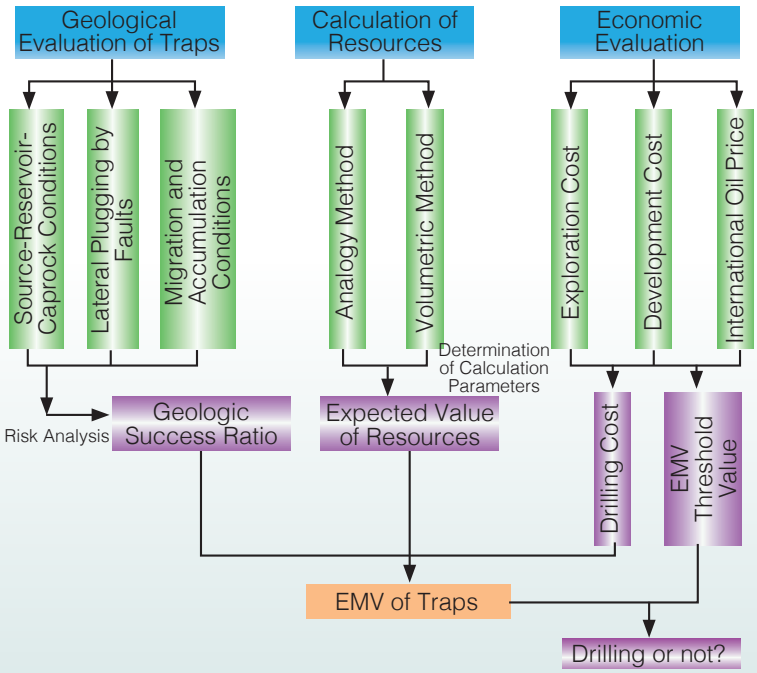
Comprehensively evaluate and optimize traps by combining geologic evaluation with economic evaluation; optimize scale targets based on the calculated EMV (Expected Monetary Value) of traps.

· Target Identification

After determining main target formations, carry out fine structure interpretation and mapping of target formations according to their seismic data; comprehensively identify traps according to the structure maps and seismic profiles of main target formations. The main favorable traps in passive rift basins include fault block traps and faulted anticline traps.

· Preliminary Selection of Targets

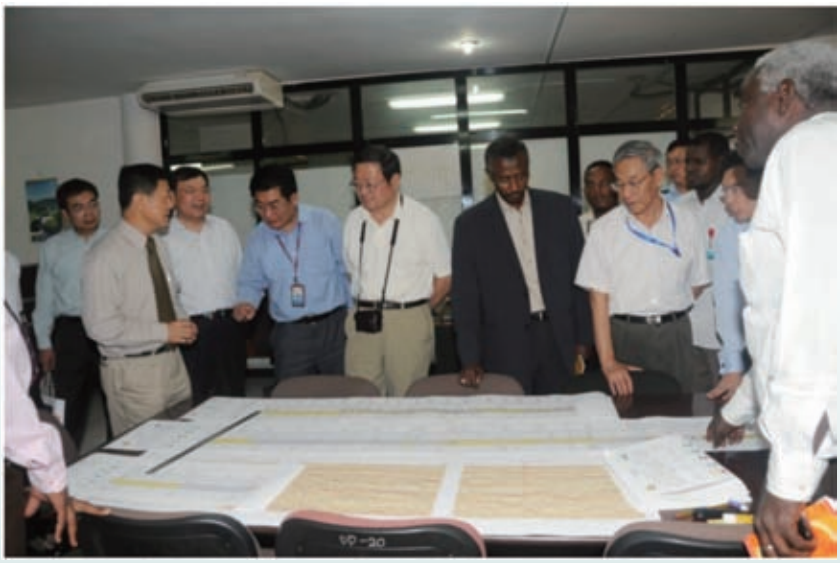
Mainly analyze the reliability and determination degree of data according to the traps found from seismic data mapping and screen out the traps that have been determined to a high degree.



· Target Optimization

The main evaluation targets are the traps that have been determined to a high degree in the previous stage. The EMV of each trap is calculated on the basis of geologic risk analysis, resources calculation and economic evaluation of traps. The trap with the largest EMV is the target with low geologic risks and a large resource scale.

Technical advantages: combine geologic evaluation, resources calculation and economic evaluation; center on scale targets; the procedure is simple and easy to operate; decisions are simple and visual; the technology overcomes the subjectivity and randomness in trap evaluation.



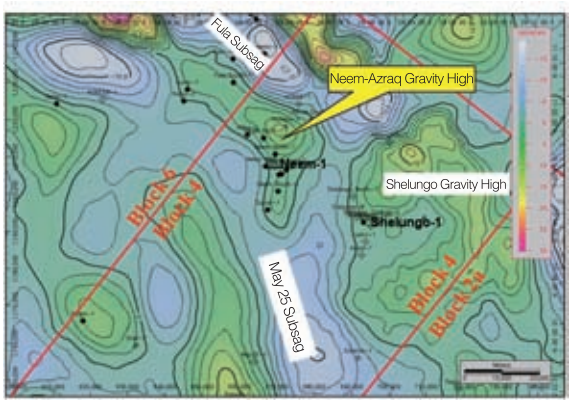
4 TYPICAL CASES

4.1 Combined Interpretation Technology with Gravity, Aeromagnetic and Seismic Data —— Block 4 in Muglad Basin of Sudan

The surface conditions and underground conditions of Block 4 in Muglad basin of Sudan are very complex. After entering the block for exploration, CNPC has carried out a comprehensive study of Block 4. The distribution of structural belts was analyzed using gravity, aeromagnetic and 2D seismic data and rapidly determined Neem-Azraq ancient uplift of the adjacent sag was determined rapidly as the key region. A breakthrough in exploration has been made and Neem oilfield with the largest scale at present has been dissevered in Block 4.

· Applications of Gravity Data in the Early Exploration Stage of Basins

Predict Neem-Azraq gravity anomaly high of the adjacent sag as the exploration key point of Block 4 by studying the relationship of gravity anomalies vs. oil generation sags and structural belts vs. current oil and gas discoveries.



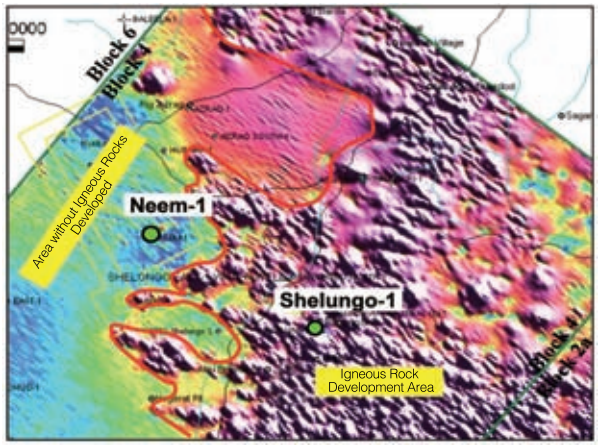
Residual Gravity Anomaly Map of Neem-Azraq Region Block 1 in Muglad, Sudan

· Applications of Gravity Data in Seismic Deployment

After adding seismic data into the seismic interpretation system and carrying out interactive interpretation with the original 2D seismic profiles, seismic deployment is performed to make the survey grid reasonable, thereby improving the quality of seismic data and reducing interpretation multiplicity.

· Guidance to Exploration Direction using Aeromagnetic Data

Through the comprehensive analysis of aeromagnetic data, the near-surface volcanic rock development areas was avoided in exploration and the exploration key points was shifted to Neem-Azraq uplift region with weak late tectonic activities. 6 exploration wells and 3 appraisal wells were successfully drilled in Neem-Azraq region in 2003-2004, including 6 wells with high production commercial oil flows obtained. At present, the production scale of 2 million tons per year has been built up.



Magnetic Anomaly Distribution Map

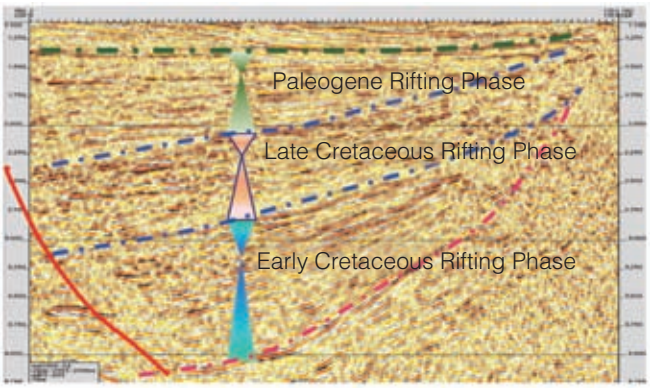
4.2 Rapid Evaluation Technology for Hydrocarbon Accumulation Assemblages——Melut Basin in Sou-thern Sudan

Melut basin in Southern Sudan is a typical Central African passive rift basin.

With the rapid evaluation technology for hydrocarbon accumulation assemblages, the north sags is made certain rapidly, and Paleogene reverse fault blocks was selected as the main hydrocarbon accumulation assemblages and the EW-trending adjustment belts on the east side of the north sags as the favorable belts. Palogue extra-large oilfield of 100 million tons reserves has been successfully discovered. Till the end of 2011, the oil and gas reserves of the project discovered in Paleogene accounted for over 90% of the total reserves.

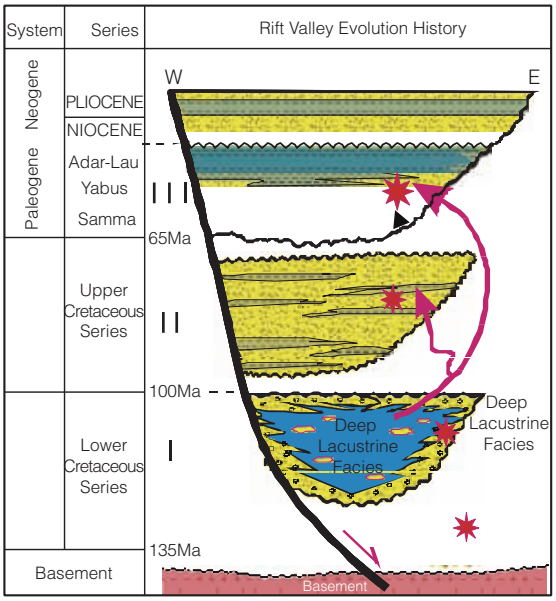
· Analysis of Basin Structures and Evaluation of Source Rocks——Rapid Determination of Main Sags

Make certain the north sags with the largest scale through the analysis of basin structures; verify that effective source rocks are developed in the north sags using the logging evaluation technology for source rocks and the sag analogy method.



· Vertical Selection of Formations——Rapid and Accurate Selection of Main Reservior Assemblages

Vertically, through logging evaluation of caprocks, the only one set of regional caprock in Paleogene is made certain which is developed in sags. The reservoir evaluation shows that high quality reservoirs with high porosity and high permeability are developed below Paleogene regional caprock. The reverse fault block assemblages in Paleogene are main assemblages and match with the reservoir forming period well.

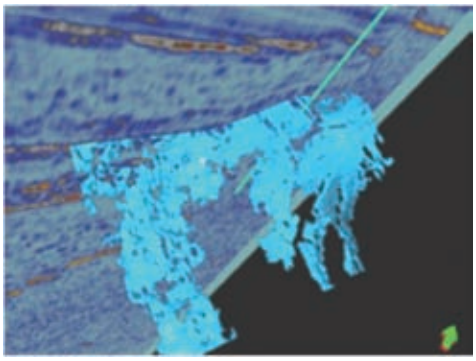


· Lateral Selection of Belts——Accurate Selection of Favorable Exploration Belts

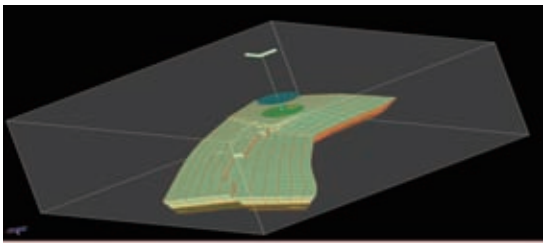
Laterally, the EW-trending adjustment belts (Palogue structural belts) on the east side of the north sags was selected as the favorable belts through the analysis of structural belts as well as oil and gas migration and accumulation direction and trend. A time-transgressive oil and gas accumulation model has been established.

4.3 Comprehensive Trap Evaluation Technology Based on EMV——Melut Basin in Sudan

After optimizing main sags and main reservior assemblages, fine seismic data interpretation and structural mapping in favorable belts was carried out. The comprehensive trap evaluation technology based on EMV has been used to optimize targets for the purpose of discovering scale reserves through drilling of the first well.



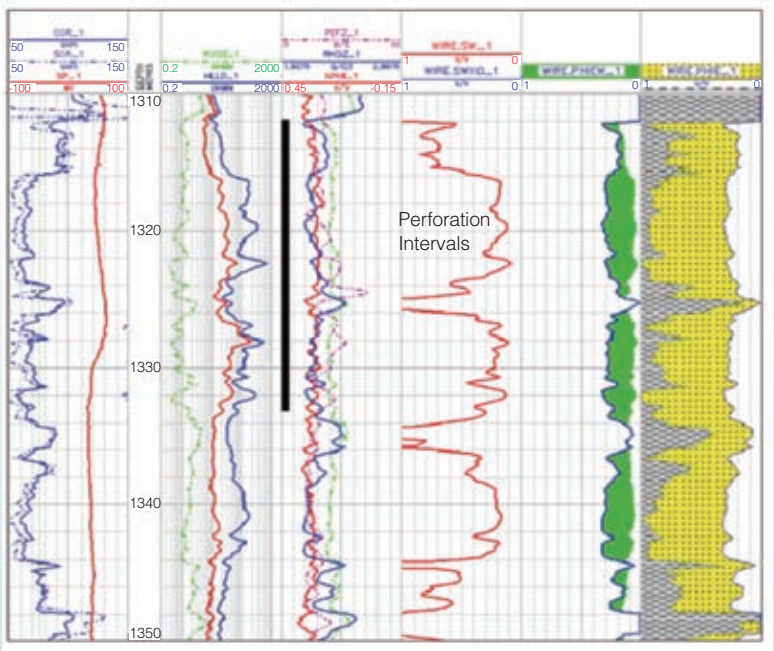
Preliminary selection of targets: 104 non-drilled traps have been found in main reservior assemblages through target formation structure mapping, including 60 traps that have been ascertained to a relatively high degree. The selected traps that have been ascertained to a relatively high degree are used as the evaluation objects in the optimization stage.



Target optimization: by calculating the resources and making a geologic evaluation of the 60 traps that have been ascertained to a relatively high degree, the risk-adjusted recoverable resources of each trap was calculated and then the EMV of each trap was calculated to provide parameters to the comprehensive evaluation of traps.

Comprehensive evaluation: firstly predict the exploration and development cost for different drilling depths were predicted firstly and the EMV threshold values of traps were converted. Then traps are graded according to their EMV and threshold value: highly economic, relatively highly economic, commonly economic and non-economic traps.

Implementation result: there are 12 highly economic traps and 10 relatively highly economic traps in Paleogene in Melut basin; 15 traps have been optimized and all of them have succeeded. The EMV of Palogue-1 trap is the highest. After implementation, totally 9 oil layers of 71m thick have been found in Paleogene, and the daily test oil production of a single layer is 810 m^3, thus disclosing the exploration potential of Paleogene in the north sags.



Logging Interpretation Result Chart of Paleogene in Well Palogue-1 in Melut Basin

5 R&D EQUIPMENT

Depending upon key laboratories with high quality equipment and advanced technologies involving petroleum geochemistry, oil and gas reservoir, geophysical and well logging as well as a VR-platform, CNPC ensures that the demands of experimental analyses of exploration of passive rift basins are satisfied and provides technical services for various relevant experimental analyses.

Key Laboratory of Well Logging

The laboratory has over 20 sets of large to medium instruments and equipments including comprehensive two-dimensional gas chromatography—time-of-flight mass spectrometers, isotope mass spectrographs, chromatography-mass spectrographs, chromatography-mass-mass spectrographs, multi-function microscopes, thermal simulation equipment for hydrocarbon generation and expulsion, thermal simulation equipment for hydrogenation, etc. and has reached the international first-class level.

Key Laboratory of Oil and Gas Reservoir

The laboratory has 40 sets of software and hardware equipments for experimental analyses including reservoir diagenesis simulation systems, online laser isotope mass spectrometers, electronic probes, SEMs, X-ray diffractometers, ground penetrating radars, gamma ray spectrometers, portable mineral element analyzers, cathode luminescence instruments, microscopes, hot and cold stages, sedimentary reservoir spectroscopic imaging software, sequence stratigraphy simulation software, etc.

Physical Simulation System for Hydrocarbon Generation and Expulsion

Large Physical Diagenesis Simulation System

Key Laboratory of Geophysics

The laboratory has two sets of newly built major equipments such as “rock physics test and experiment system” and “new seismic technology R&D software platform” and totally 27 sets and 3 major categories of softwares including seismic data processing software, integrated seismic interpretation and reservoir prediction software and software development tools whose newness coefficient is 87%. In addition, the laboratory also has 4 sets of 1120CPU microcomputer groups and dozens of sets of workstations/ microcomputer workstations which are used in the study and application of complex object mapping and complex reservoir prediction technologies.

Microcomputer Group System of CNPC for Petroleum Exploration & Development

Key Laboratory of Petroleum Geochemistry

The laboratory has combined HTHP rock electricity and capillary pressure measuring systems and HTHP NMR measuring systems for displacing state and has reached the international advanced level. In addition, the laboratory also has the matching experiment equipments including HTHP displacing rock electricity measuring systems, porosity measuring instruments, permeability measuring instruments, core preparation equipment, etc., which can be used to measure the experiment parameters involving HTHP full-diameter rock electricity, NMR, etc. and are of much significance to enhancing complex reservoir logging processing, interpretation and evaluation capacities.

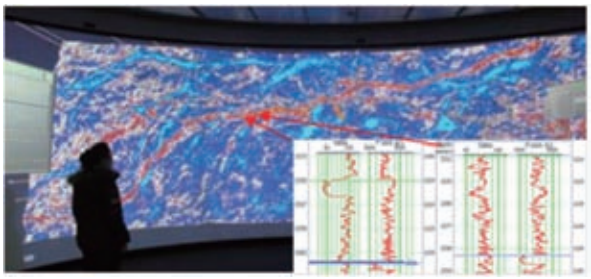
Combined HTHP Rock Electricity and Capillary Pressure Measuring System (RCS-763Z)

HTHP NMR Measuring Systems for Displacing State

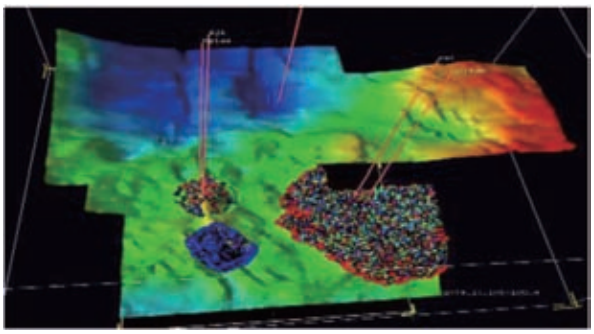
VR-platform

The main hardware equipment consists of one set of high performance computer of American SGI Company, three 1200-lumen projectors of Belgium BARCO Company, large dimension curtain walls, 3D positioning tracking systems, etc. The main application software system is VR5 software system of Schlumberger.

VR Application Platform Working Environment



Identification of Carved Channel Sand Bodies with the VR Application Platform



Description of Volcanic Gas Reservoirs with the VR Application Platform

6 ACHIEVEMENTS AND REWARDS

CNPC has formed a high level expert team engaged in R&D of integrated exploration technologies for passive rift basins for a long period of time. The project “High-efficiency Exploration Technology and Practice in Block 1/2/4 project in Muglad Basin in Sudan” was awarded with Grade I National Science and Technology Advance Prize in 2003; the project “Integrated Technology and Practice for Rapid Discovery of Large Oilfields in Melut Basin in Sudan” was awarded with Grade II National Science and Technology Advance Prize in 2005.

7 EXPERT TEAM

Tong Xiaoguang petroleum geology and exploration expert, Academician of the Chinese Engineering Academy, doctoral supervisor. He is engaged in the study of oil and gas geology and exploration for a long period and has participated in oil exploration of Daqing, Liaohe, Tarim Basin, etc. and carryed out petroleum geology studies in Bohai Bay Basin, Eastern China as well as the whole country. He has established the petroleum geology theory basis for passive rift basins. Over 20 professional papers and 8 works published.

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Xue Liangqing petroleum geology and exploration expert, professor level senior engineer, doctoral supervisor. He is the member of Chinese Petroleum Society, Geological Society of China, Chinese Society of Mineralogy, Petrology and Geochemistry and AAPG. He is the leader of national major projects and engaged in domestic and foreign sedimentary geology and petroleum exploration for a long period. He has been successively awarded with 1 grade I ministerial level prize, 1 grade II ministerial level prize, 8 grade I bureau level prizes, 6 grade II bureau level prizes and 1 CNODC special contribution prize. Over 30 papers and 4 works published.

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Dou Lirong petroleum geology and exploration expert, professor level senior engineer. He is engaged in integrated petroleum geology research and overseas risk exploration project management work for a long period and has established the hydrocarbon accumulation model for passive rift basins in Sudan, the hydrocarbon accumulation model for “dominant accumulation in sources” in strongly inverted rift basins and the exploration methods and technologies for “basin selection, belt determination and rapid discovery” in overseas high-risk exploration blocks. 3 works and 64 papers published.

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Su Yongdi petroleum geology and exploration expert, professor level senior engineer. He is engaged in seismic data interpretation and integrated petroleum geology research for a long period. He is the deputy leader of national major special projects and the leader of major special projects of PetroChina. He has worked out a set of practical integrated exploration technologies for reducing exploration cost of overseas complex regions and rapidly discovering oilfields through comprehensive research and reasonable exploration deployment using gravity data, aeromagnetic data, etc. into a seismic interpretation system in combination with seismic data. Over 10 papers published.

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Xu Zhiqiang petroleum geology and exploration expert, professor level senior engineer. He works in the front-line of overseas passive rift oil and gas exploration and production for a long period. He has got a series of exploration technology achievements by insisting on linking theory with practice and active exploration and innovation. He was awarded with 1 award of national science and technology advance prize, 1 award of grade II national science and technology advance prize and 2 award, grade I science and technology innovation prizes of CNPC.

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Pan Xiaohua petroleum geology and exploration expert, professor level senior engineer. He is engaged in integrated overseas oil and gas geology research, exploration project technology support and new project evaluation work for a long period and has successively taken charge of integrated geology research on exploration projects in Sudan, Central Asian and five large oil and gas cooperation regions in the world as well as multiple national and CNPC's scientific research projects. 4 works and 26 papers published.

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Xiao Kunye petroleum geology and exploration expert. He is engaged mainly in geology research on and technical support to exploration of oil and gas in Africa and has taken charge of multiple scientific research projects of CNPC and national major special subjects. He has proposed the new viewpoints including hydrocarbon accumulation model for strongly inverted rift basins etc. and the early evaluation method for rift basins with a low exploration degree. Over 20 papers and 3 works co-published.
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Li Zhi petroleum geology and exploration expert. He is engaged mainly in geology research on and technical support to exploration of oil and gas in Central and West African rift systems and has participated in multiple scientific research projects of CNPC and national major special subjects. Over 20 papers published and 2 works co-published.
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