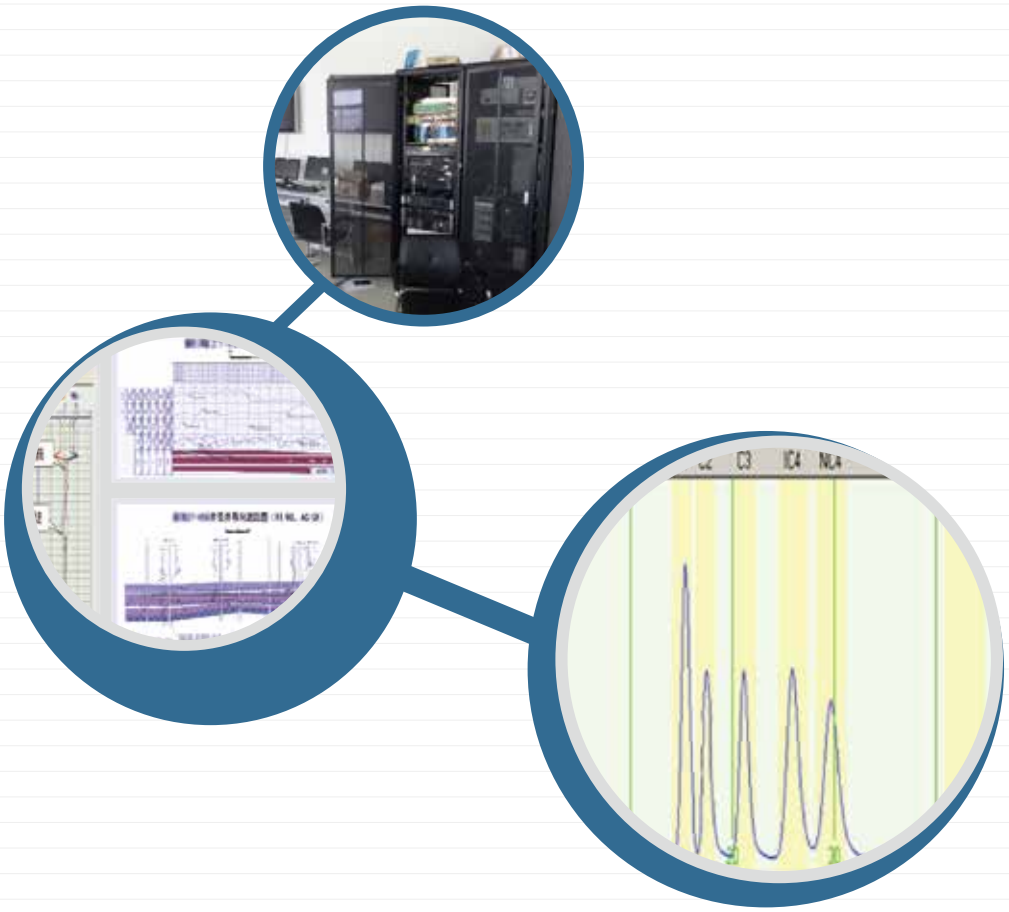
GW-MLE Mud Logging Equipment

Science & Technology Management Department, CNPC

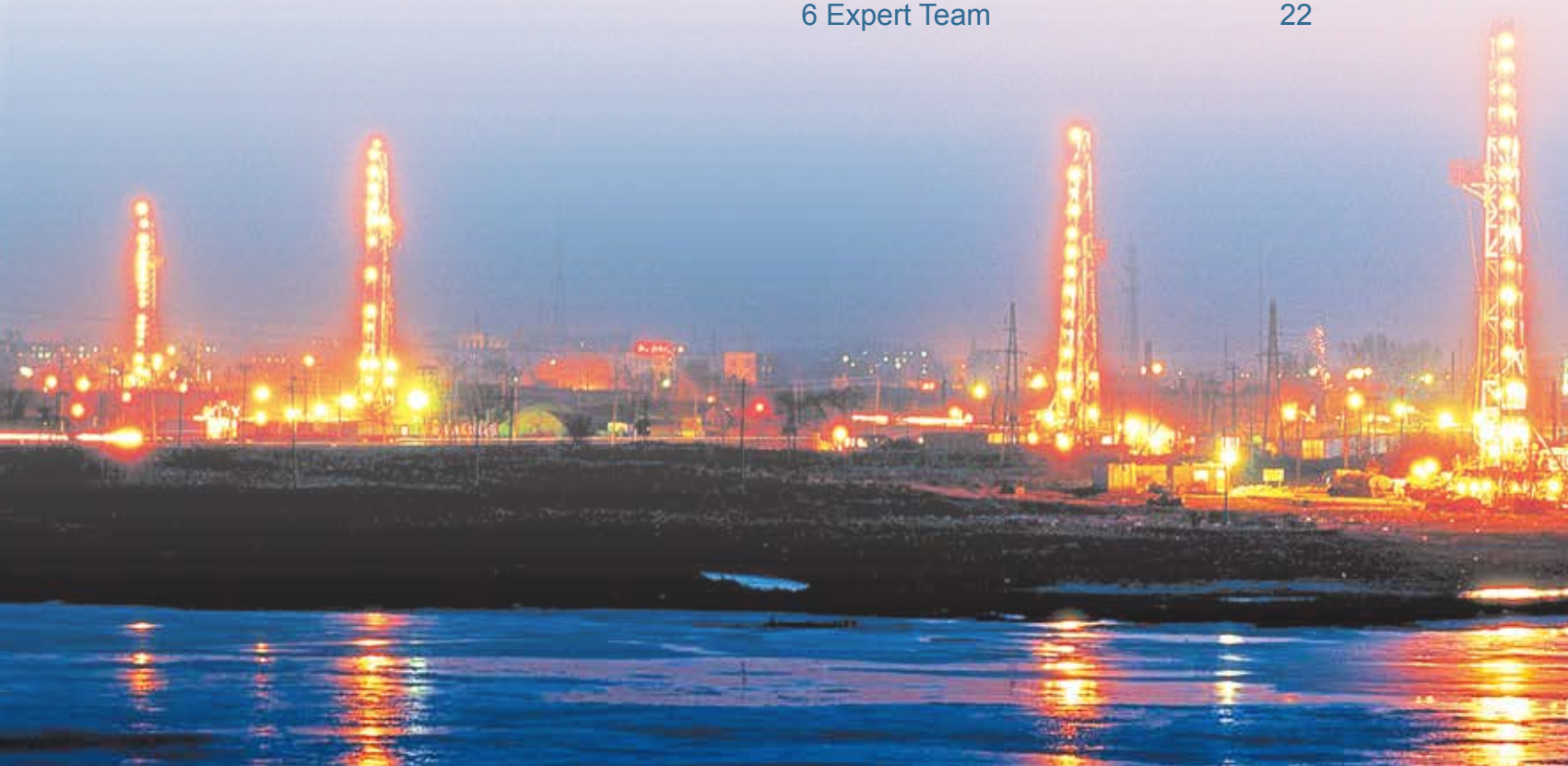
2015



CHINA NATIONAL PETROLEUM CORPORATION

GW-MLE Mud Logging Equipment:
"Penetrating Eyesight" of Petroleum Drilling!

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 2014 CNPC produced 113.67 million tons of crude oil and 95.46 billion cubic meters of natural gas, while crude processing volume reached 150.2 million tons. The total revenue of RMB 2,730 billion with a profit of RMB173.4 billion had been achieved the same year.

CNPC was ranked 3th among the world's largest 50 oil companies and 4th in Fortune Global 500 in 2014.

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.

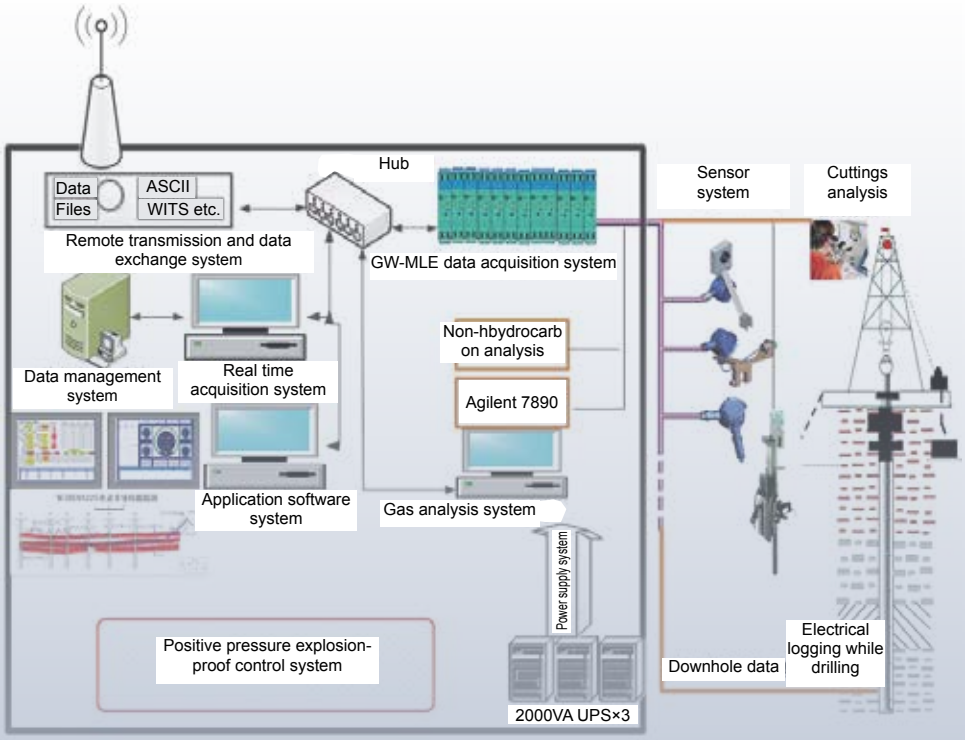
The GW-MLE mud logging equipment is one of representatives for major innovations of CNPC.

OFFERING ENERGY SOURCES, CREATING HARMONY

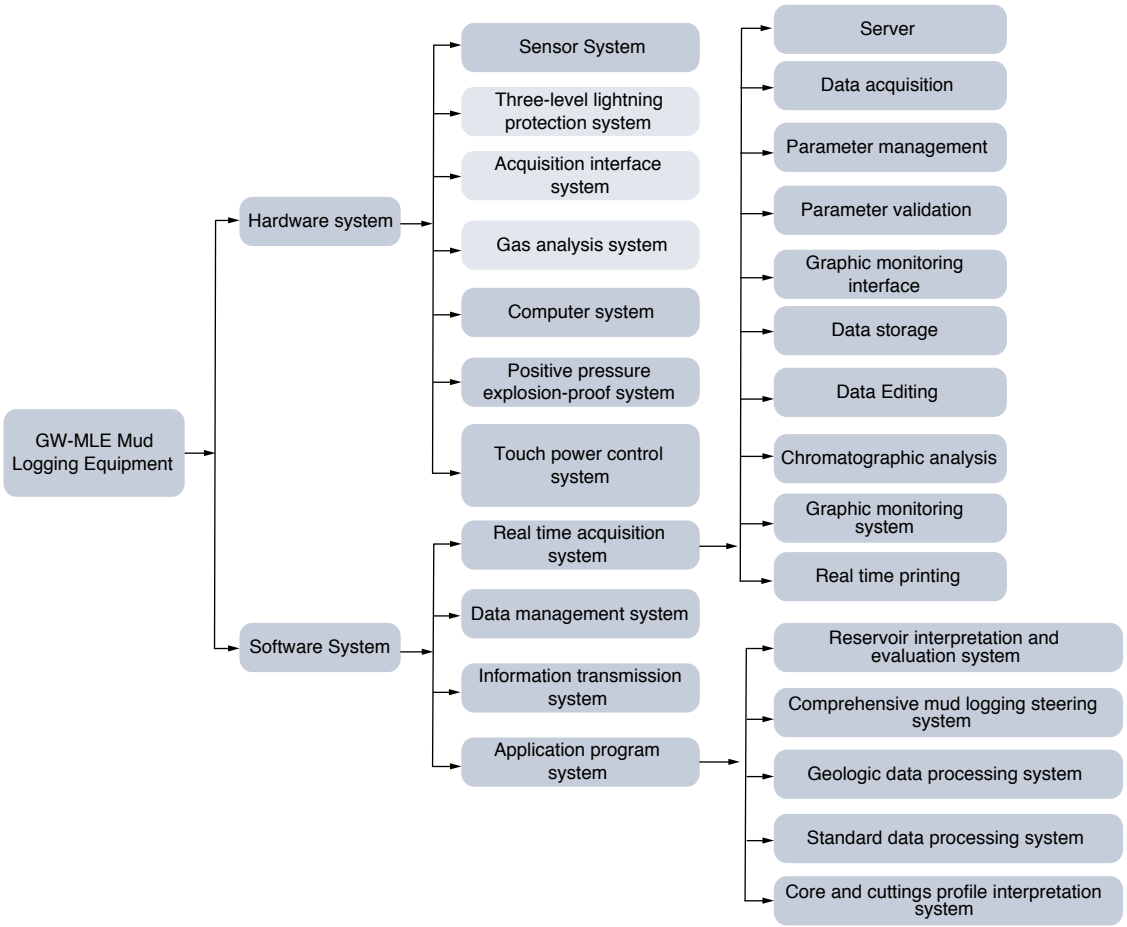
1 INTRODUCTION

Mud logging equipment is used to continuously acquire the parameters during petroleum drilling including the oil and gas show of the drilled formation, drilling data, mud property, etc., identify oil, gas and water layers, evaluate formations, monitor drilling operations, test formation pressure, optimize drilling and carry out scientific drilling.

GW-MLE(GREAT WALL-MUD LOGGING EQUIPMENT) has quick chromatographic analysis technology and is suitable for many advanced technologies including explosion-proof broadband voltage power system, lightning protection technology, etc. in multiple complex environments as well as characteristic software systems such as PM3.0 data acquisition system, comprehensive mud logging steering system, comprehensive reservoir interpretation and evaluation system, mud logging data processing system, etc. GW-MLE is the information center of a drilling site and plays an important role in petroleum exploration and development.



Topological Graph of GW-MLE mud logging equipment



Technical framework of GW-MLE mud logging equipment

Appearance of GW-MLE mud logging equipment

Main specifications

Room body dimension: 8.4m×2.6m×2.6m (Length × Width × Height)
Certification level: DNV2.7-1 & DNV2.7-2, AO, Zone 1
Power input: 3-phase 220V/380V/440V/480V, 35~65 Hz
Power output: 3-phase 380V, Two-phase 220V/110V
Chromatographic detection concentration: 10ppm-100%;
Repeatability error: < 5%; Degree of separation: > 0.95
Data acquisition rate: 50Hz (AI), 15kHz (FI)
Data transmission bandwidth: 153kb/s (CDMA), 7.2M (3G)
Data acquisition channels: 43 channels (expandable)
Transmission mode: network transmission (wired, wireless, satellite)
Application area: land, desert, ocean

2 CHARACTERISTIC TECHNOLOGIES

2.1 Hardware System

The hardware system consists of power distribution system, positive pressure explosion-proof system, lightning protection system, gas analysis system, German P+F signal acquisition system, sensor system, computer acquisition and processing system, wireless transmission system, etc.

Positive pressure explosion-proof system

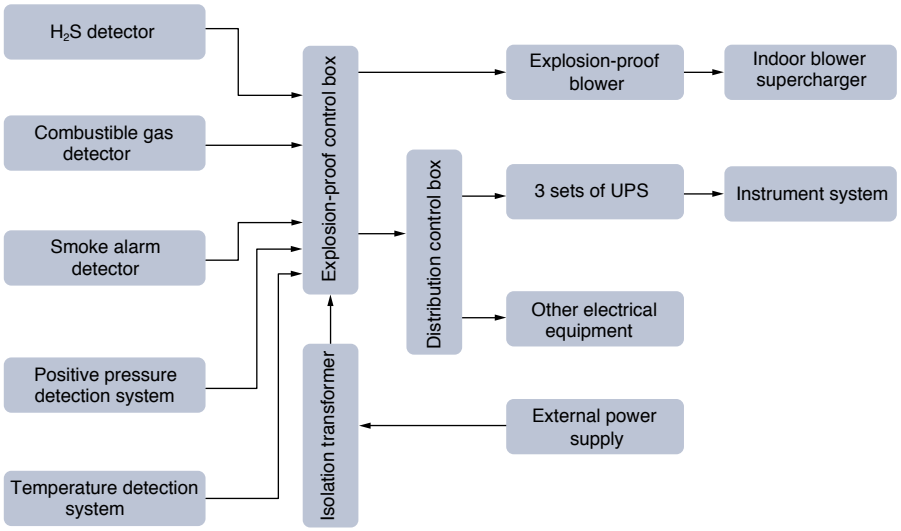
The positive pressure explosion-proof and fire-proof (A-O grade) instrument room can be used in land petroleum exploration and hazard areas in offshore platform exploration, and its design and construction meet IE-C79-13 specification and API standard.

Benchmarking contents	Imported from USA	Imported from France	Homemade mud logging equipment	GW-MLE
Explosion-proof level	DNV2.7-1 DNV2.7-2	DNV2.7-1 DNV2.7-2	Shanghai DNV	DNV2.7-1 DNV2.7-2
Maximum air conditioning temperature	53℃	53℃	53℃	53℃
Power supply control	Mechanical, manual	Mechanical, manual	Mechanical, manual	Simulated, automatic
Channel expandability	Hot swap	Adding acquisition boards	Adding contacts	Hot swap
Acquisition rate	Pulse: 400Hz	Pulse: 150Hz	Pulse: 400Hz	Pulse: 150Hz
	Simulation: 10Hz	Simulation: 50Hz	Simulation: 10Hz	Simulation: 50Hz
Chromatographic pressure/ flow control	Manual	Manual	Manual	Automatic
Lightning protection level	None	None	Level I	Level III
Comprehensive steering software	None	None	None	Powerful independent function

to be continue

Benchmarking contents	Imported from USA	Imported from France	Homemade mud logging equipment	GW-MLE
Reservoir interpretation and evaluation software	Available; single interpretation	Available; single interpretation	Available; single interpretation	Available; comprehensive interpretation
Real time graphic monitoring software	Network browsing	Repeater browsing	Repeater browsing	Network browsing
Remote transmission mode	CDMA\GPRS\3G Satellite	CDMA\GPRS\3G Satellite	CDMA\GPRS\3G Satellite	CDMA\GPRS\3G Satellite
System acquisition software languages	English	English	Chinese, English, Russian	Chinese, English, Spanish

Benchmarking analysis

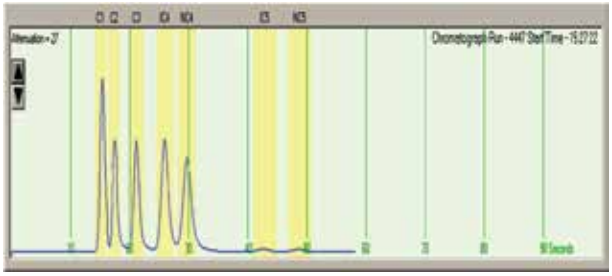


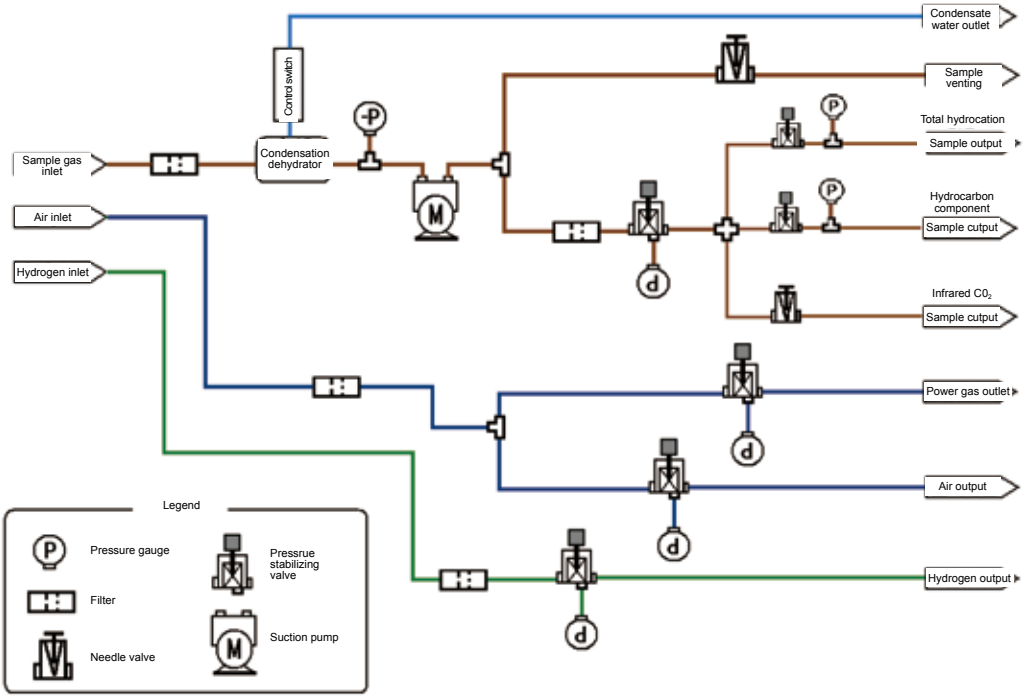
Flow chart of explosion-proof control system

Gas chromatograph

It uses the automatic verification mode. The total hydrocarbon analysis range is 0.001%~100% and the error is less than 1%. The component analysis and detection range is 0.0005%~100% and the error is less than 1%. The chromatographic cycle can be controlled to be less than 30s. The analysis result in each cycle can be saved in data and graphic models and has high degree of separation.

Gas chromatograph

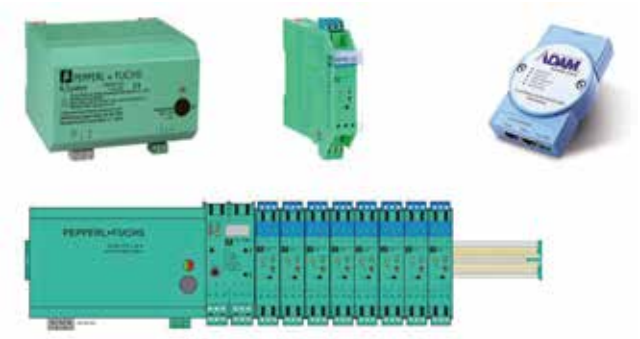




Chromatographic analysis system

Signal acquisition system

The system is installed and set simply and maintained conveniently. Module expansion channels can be added. The system can conveniently acquire different types of active signals or passive signals (4~20mA.0~10V. digital signals). The system can be placed in safety areas or hazard areas and is connected indoors via network cables.



Signal acquisition system

Power control system

Alarm threshold, monitoring current and monitoring voltage can be set;

Manual control for convenience of use during commissioning;

Shunt circuit time-delay opening or closing to reduce impaction on the power grid and prevent main switch trip caused by transient current increase;

Can connect temperature module and current and voltage detection module to obtain the ambient temperature, power, etc. in the panel in real time.

Power control system

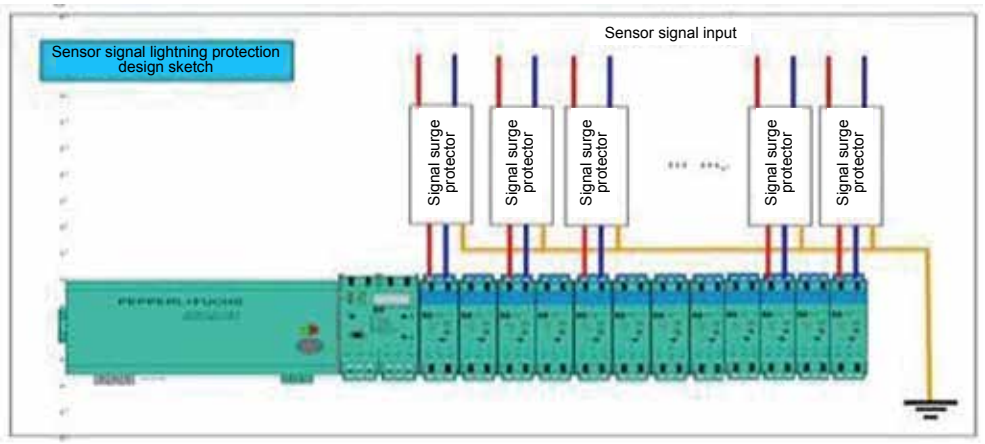
Lightning protection system

Lightning protection of external power supply and degasser power supply;

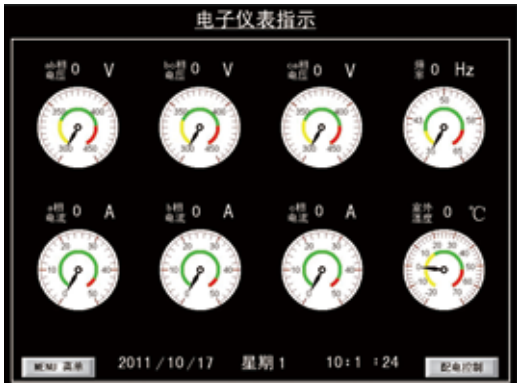
Lightning protection of acquisition module;

Lightning protection of internal network, video terminal and telephone;

Effectively prevent the tool from being damaged by lightning stroke in severe environment and ensure safety operation.



Lightning protection system



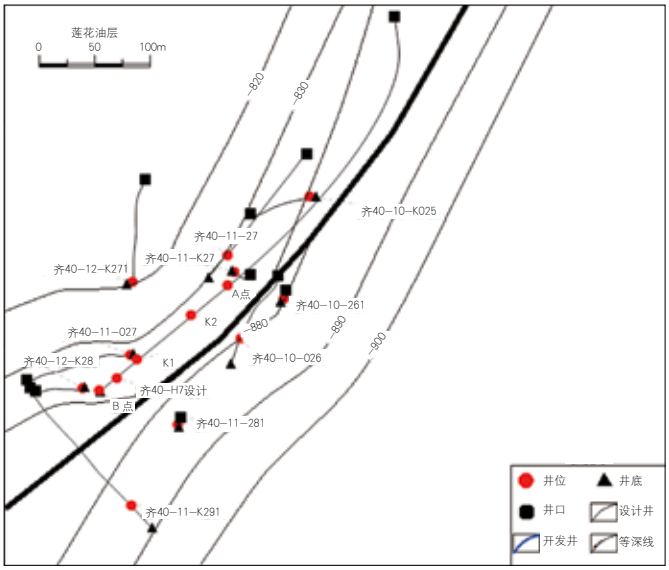
2.2 Software System

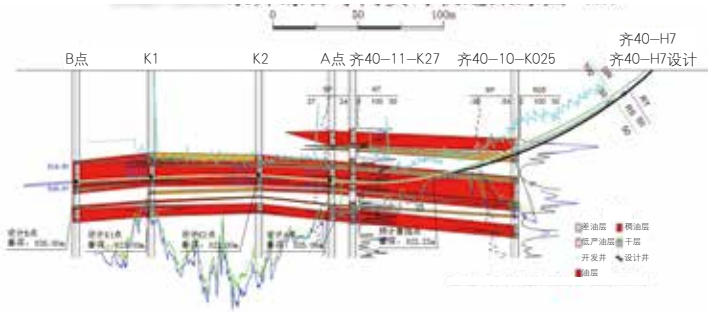
GW-MLE software system has three language versions such as Chinese, English and Spanish and consists of real time acquisition, data management, application program, information transmission systems, etc. The software system uses the industrially originally created technologies including deepwater dual-depth compensation, lag time correction with equivalent hole diameter, displacement correction with specific value method, real time calculation of vertical well depth with constant curvature method, storage in multiple operating conditions, etc., thus improving data acquisition accuracy.

Acquisition software system

Comprehensive mud logging steering system

Optimize horizontal section trajectory by establishing the pre-drilling geologic model; adjust the model during drilling in real time and track and control trajectory; carry out comprehensive evaluation and analysis and accumulate experience after drilling, thus providing customers with accurate comprehensive mud logging steering services.

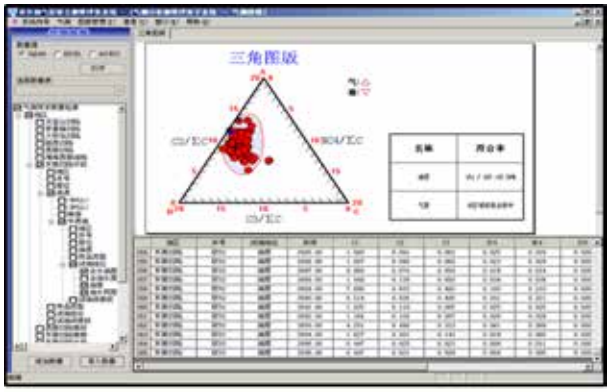




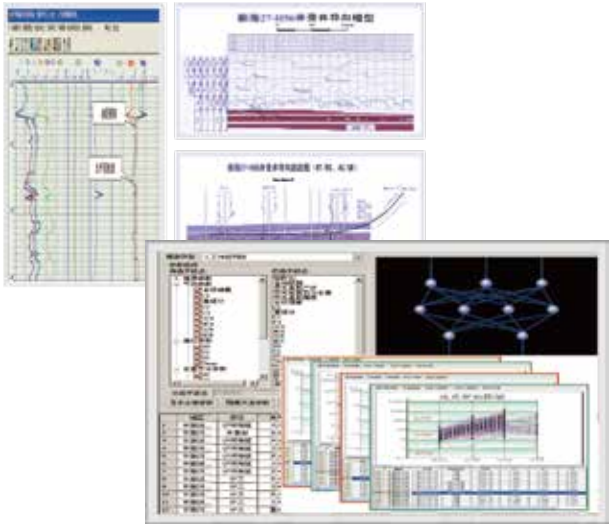
Comprehensive steering analysis system

Comprehensive reservoir interpretation and evaluation system

The reservoir interpretation and evaluation technology is used to interpret and evaluate reservoir fluid properties based on mud logging data involving geologic logging, gas logging, quantitative fluorescent logging, geochemical logging, NMR lugging, geologic analysis, etc., thereby providing important bases for discovering reservoirs and selecting test horizons.



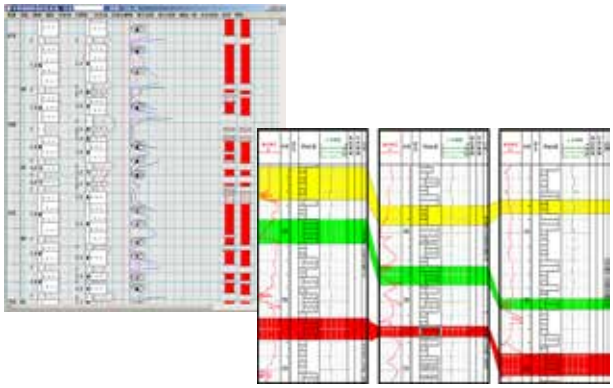
Gas logging evaluation



Geochemical logging analysis

Geologic data processing system

The system can input and output the site data and report forms involving geologic logging basic data, geologic layering data, tripping and making a connection, comprehensive mud logging aftereffect, lag time, anomaly prediction, etc., thereby realizing standardized, intelligent and digital mud logging data processing.



Graphic monitoring system

The graphic monitoring system (GMS) is used in real time data monitoring and browsing, and users can classify and self-define monitoring templates. The system uses WEB real time information release form and network browsing can be realized at any place. The system has infinitely customized grid formats; mixing time with depth monitoring and value range can be adjusted at random; metric units, API or combined units can be selected; real time data and curves can be viewed and browsed quickly.

Technological features

◆ Self-designed user templates, unlimited grid design

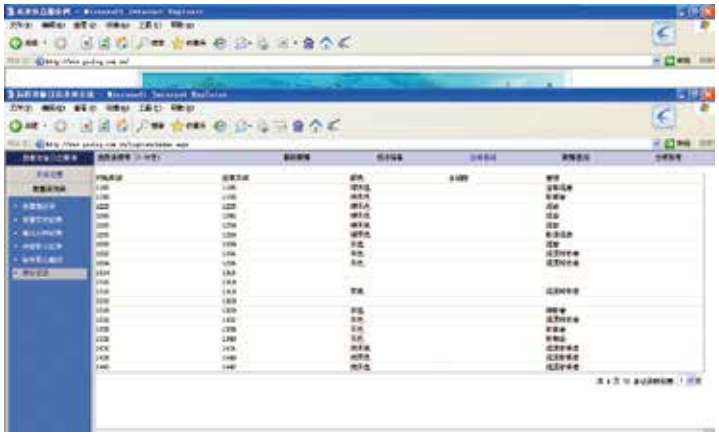
◆ Plentiful display parameters, remarkable sound and light alarm

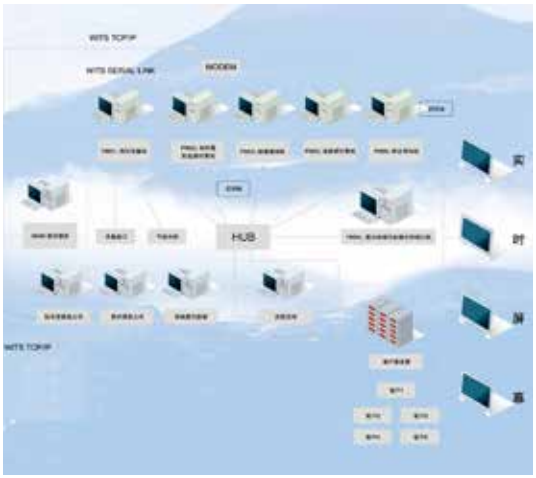
◆ Applicable to site users of different authorities, meeting different needs

◆ Real time data release using WWW browsing mode

Network information service system

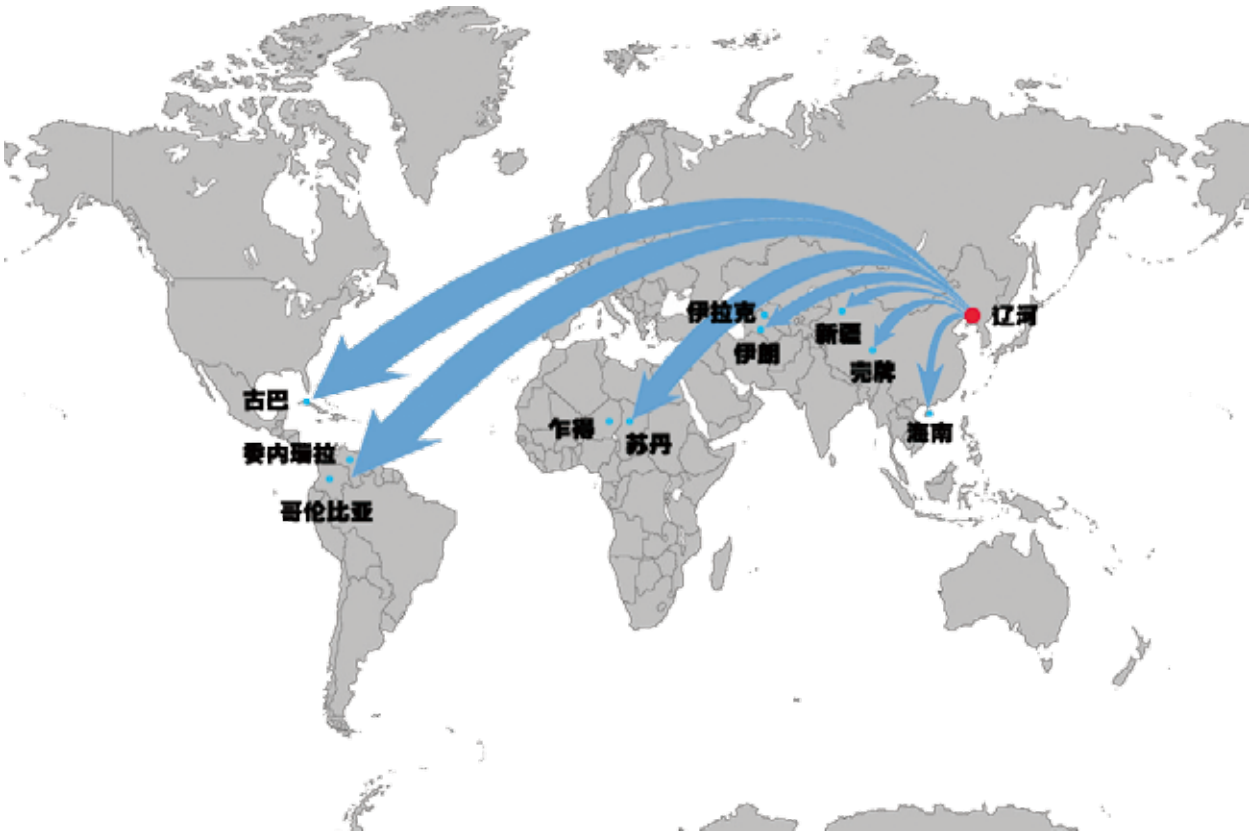
The network information service system consists of site parameter acquisition, remote data management, information network architecture platform, multi-well information analysis service, etc. and realizes well site LAN architecture platform and information center with the MLE as the core on site.





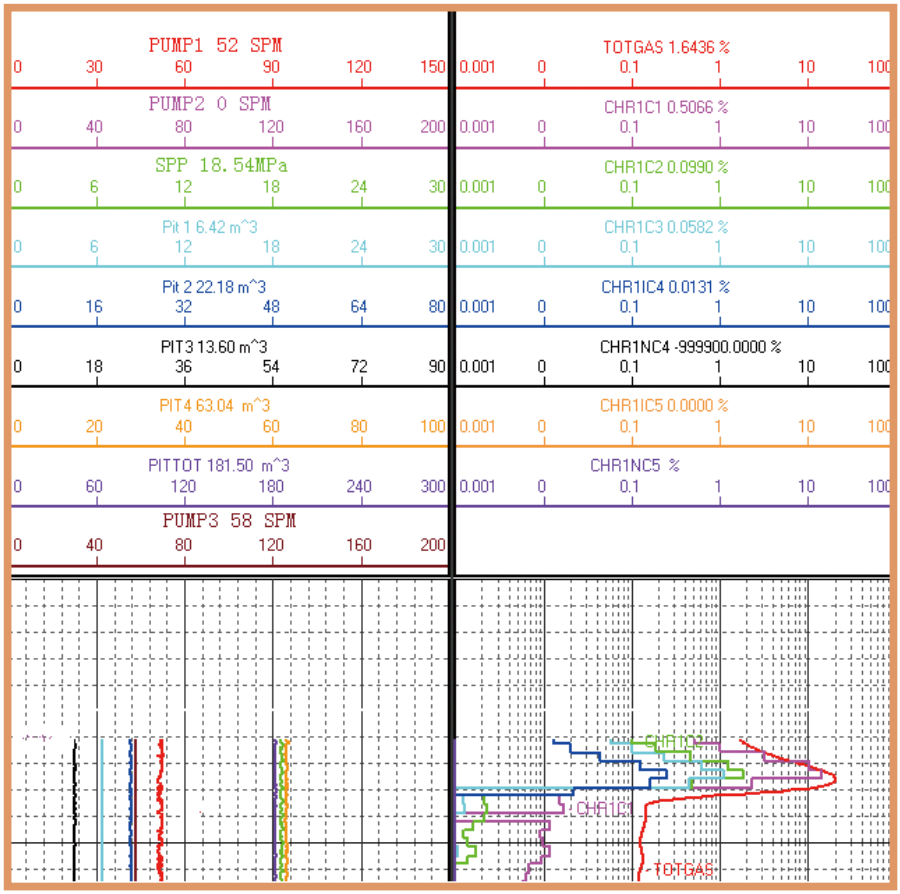
3 TYPICAL CASES

GW-MLE has provided services to international renowned companies such as Shell, Iran IEOC, Venezuela PDVSA, etc., and has been popularized and applied in totally 93 wells. The reservoir discovery ratio is 100%, the timeliness ratio of quick reservoir interpretation is 100%, and the number of engineering anomaly forecasts is over 600 and the accurate ratio of it is over 95%. The GW-MLE has stable performance.



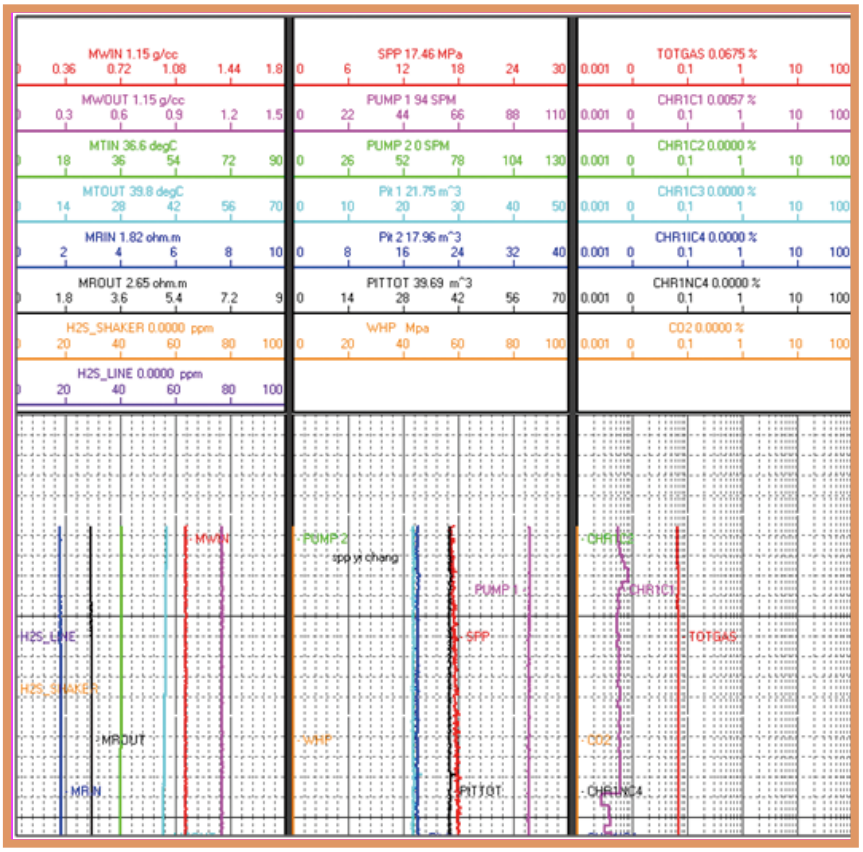
3.1 Accurate Detection of Oil and Gas Shows

In Mar. 2010, when reaching the depth of well XG-xx 4867.27m and its lag depth 2740.98m, the gas analysis system of GW-MLE detected the gas logging total hydrocarbon value increased from base value 0.1612% to 21.0125% as well as the maximum values of the following components: C1:8.4383%, C2:0.9794%, C3:0.4195%, IC4: 0.1159% and NC4:0.1741%. Oil and gas shows were timely found depending upon accurate detection with a gas chromatograph when drilling time had no obvious change.



3.2 Timely Engineering Early-warning

In May 2011, when well Da-xx was normally drilled to 2039.73m, standpipe pressure parameter anomaly was timely found depending upon the speed advantage of GW-MLE acquisition module and the perfect alarm system. The standpipe pressure was decreased from 17.88MPa during normal drilling to 17.07MPa, whereas other parameters had no obvious change. The drilling supervisor and driller were immediately notified to take pertinent measures, thus avoiding a major accident.



4 SCIENTIFIC RESEARCH EQUIPMENT

CNPC has testing laboratory and software testing laboratory as well as matching professional testing equipment involving commissioning, verification, detection, etc. According to industrial standards, GW-MLE has passed the metering detection and production verification by a national authoritative inspection organization.

Automatic pressure calibration unit

Ultrasonic calibrator

Displacement tester

Conductivity tester

Software test laboratory

5 QUALIFICATION STANDARDS

5.1 Standards

16 industrial standards are adopted and 1 standard has been formed. A perfect quality guarantee has been established; a standard testing laboratory has been built; equipment manufacturing process flow has been perfected.

(1) Technical specifications for petroleum mud logging units	SY/T 5190-2007
(2) Calibration methods for mud logging units	SY/T 6679.1-2007
(3) Technical specifications for mud logging units	Q/SY-GWDC 0032-2011
(4) GW-MLE Mud Logging Equipment	Q/SY-GWDC 0034-2011

5.2 Patents

1 invention patent, 4 utility model patents and 7 registered software copyrights have been obtained.

Patent name	Patent type	Patent No.
A geologic logging interpretation method	Invention patent	ZL200710158655.1
Drilling site information display	Utility model patent	ZL200620089297.4
Quantitative cuttings sampling device	Utility model patent	ZL200720016939.2
A wireless video acquisition and transmission integrated cable	Utility model patent	ZL200720016935.4
A sampler gas filter at gas drilling site	Utility model patent	ZL200920013370.3

7 software copyrights

No.	Name of intellectual property rights	Date of authorization	Registration No.
1	LH2003 geologic data processing system	20040311	2004SR02168
2	Comprehensive mud logging geosteering analysis system for horizontal wells	20060705	2006SR08679
3	Intelligent interpretation system for geologic logging core and cuttings profile	20040311	2004SR02166
4	QSY128-2005 standard data processing system	20070403	2007SR04804
5	Comprehensive interpretation and evaluation system for mud logging reservoirs	20100114	2010SR002264
6	RM data acquisition system V2.0	20100329	2010SR014061
7	Gas chromatograph and comprehensive mud logging interface protocol software V1.0	20100329	2010SR014060

6 EXPERT TEAM

Wang Yuetian

Professor level senior engineer. He has been engaged in geologic logging work for over 20 years. He has successively taken charge of completing the projects such as SKSQ-924 FID Chlorine Tester, TDC-Mud Logging Unit Computer System Modification, SK-3Q01 FID Chromatograph Application, Popularization and Application of New Drilling Time Logging System, Application and Popularization of ALS-2 Mud Logging Technology, Development, Popularization and Application of LH-1 Geologic Data Acquisition Unit, Modification of TDC Mud Logging Unit and Popularization and Application of ALS-2 Mud Logging Unit, Development, Popularization and Application of Crude Oil Fluorescence Detector, Study and Application of Reservoir Geochemistry Logging Technology, Development and Application Study of Comprehensive Mud Logging Information Acquisition and Processing System, etc. He was responsible for the overall design of GW-MLE R&D project.

Tel: 010-59285859
Email: wangyt.gwdc@cnpc.com.cn

Tian Wenwu

Professor level senior engineer. He has been engaged in drilling engineering for 25 years. The papers including Development and Application of Mud Logging Information Service System, Construction of Comprehensive Mud Logging Information Application System and Research on Matching Technologies, etc. written by him have been successively published. He has participated in completing the projects such as Development and Application Study of Comprehensive Mud Logging Information Acquisition and Processing System, Study and Application of Reservoir Geochemistry Logging Technology, Mud Logging Information and Oilfield Production Service System, Study and

Development of LH-2000A Gas Logging Unit, Mud Logging Service Technology, etc. He has obtained 3 provincial/ ministerial science and technology achievement prizes, 1 grade II bureau level prize and 1 bureau level advantageous characteristic technology prize, 1 national utility model patent and 2 registered computer software copyrights. 2 papers written by him have been published, and he has drafted 1 industrial standard. He was responsible for comprehensive review of GW-MLE R&D project.
Tel: 010-59286358
Email: tianww.gwdc@cnpc.com.cn

Wang Dongsheng

Senior engineer. He has been engaged in geologic logging work for over 20 years. He has successively taken charge of completing the projects such as Development, Popularization and Application of LH-1 Geologic Data Acquisition Unit, Modification of TDC Mud Logging Unit and Popularization and Application of ALS-2 Mud Logging Unit, Development, Popularization and Application of Crude Oil Fluorescence Detector, Study and Application of Reservoir Geochemistry Logging Technology, Development and Application Study of Comprehensive Mud Logging Information Acquisition and Processing System, etc. He was responsible for overall review of GW-MLE R&D project.
Tel: 0427-7803414
Email: wangds.gwdc@cnpc.com.cnd

Lü Wenqi

Professor level senior engineer. He has participated in completing the projects such as Development and Application Study of Comprehensive Mud Logging Information Acquisition and Processing System, Study and Application of Reservoir Geochemistry Logging Technology, Mud Logging Information and Oilfield Production Service System, Study and Development of LH-2000A Gas Logging Unit, Mud Logging Service Technology, etc. He was responsible for organization and implementation of GW-MLE R&D project.

Tel: 0427-7832089
Email: lüwq.gwdc@cnpc.com.cn

Liu Jianxin

Senior engineer. He has successively participated in completing the projects such as SKSQ-924 FID Chlorine Tester, TDC-Mud Logging Unit Computer System Modification, SK-3Q01 FID Chromatograph Application, Popularization and Application of New Drilling Time Logging System, Application and Popularization of ALS-2 Mud Logging Technology, Development, Popularization and Application of Crude Oil Fluorescence Detector, Development and Application Study of Comprehensive Mud Logging Information Acquisition and Processing System, etc. He was responsible for organization and implementation of GW-MLE R&D project.

Tel: 0427-7822413
Email: liujx.gwdc@cnpc.com.cn

Xiaoguang

Senior engineer. He was responsible for implementation of GW-MLE R&D project, routine work arrangement of the project group and project process control.
Tel: 0427-7800052
Email: moxg.gwdc@cnpc.com.cn

Liang Bao'an

Senior engineer. He was responsible for implementation of GW-MLE R&D project and for the project implementation scheme.
Tel: 0427-7853488
Email: lh_liangba@cnpc.com.cn

Ren Huiliang

Senior engineer. He was responsible for implementation of GW-MLE R&D project, assisting in project process control and organizing field tests.
Tel: 0427-7853489
Email: lh_renhl@cnpc.com.cn

CNPC
中国石油

技术依托单位联系人：

孙海钢　先生

电　话：0427-7853490

Email: shaig.gwdc@cnpc.com.cn

中国石油科技管理部联系人：

刁　顺／窦红波　先生

电　话：86-10-59986059/59982528

Email: sdiao@cnpc.com.cn/ douhb@cnpc.com.cn

Contact of the Technical Support Unit :

Mr. Sun Haigang

Tel: 0427-7853490

Email: shaig.gwdc@cnpc.com.cn

Contact of Science&Technology Management Department,CNPC :

Mr. Diao Shun/Dou Hongbo

Tel: 86-10-59986059/59982528

Email: sdiao@cnpc.com.cn/ douhb@cnpc.com.cn