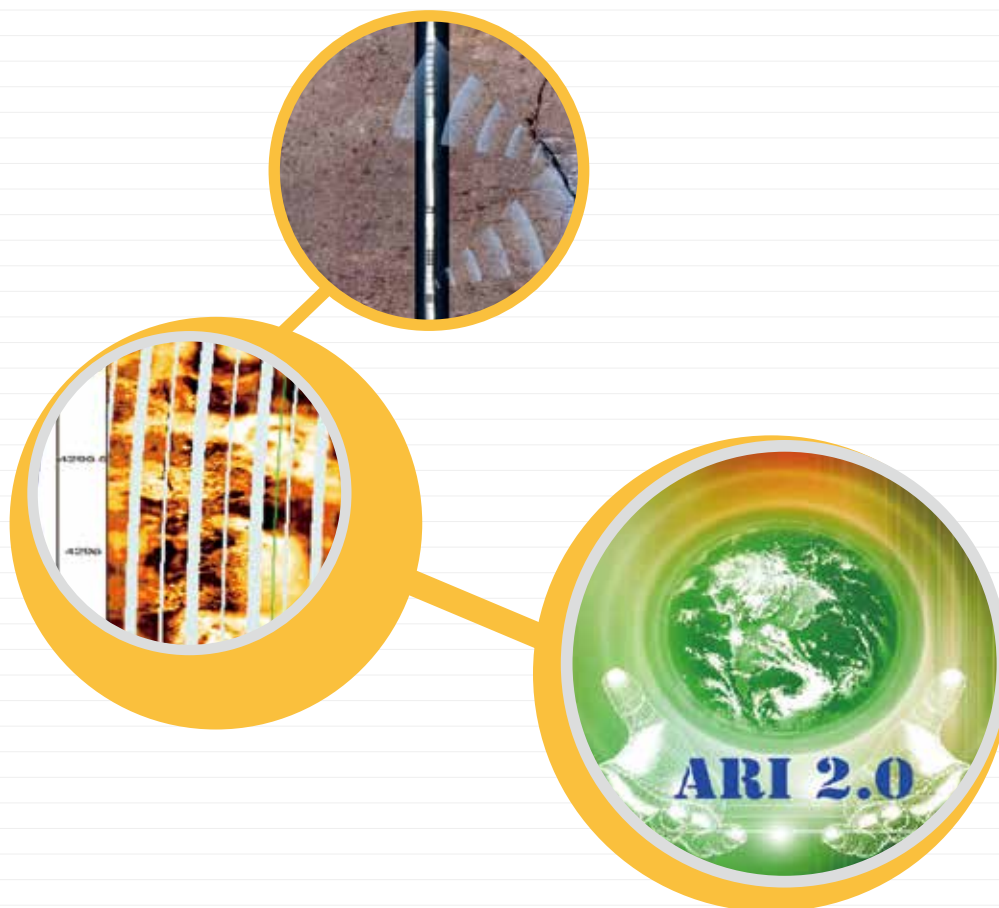




# **BH-ARI Remote Detection Acoustic Reflection Imaging Logging Technology**

Science & Technology Management Department, CNPC

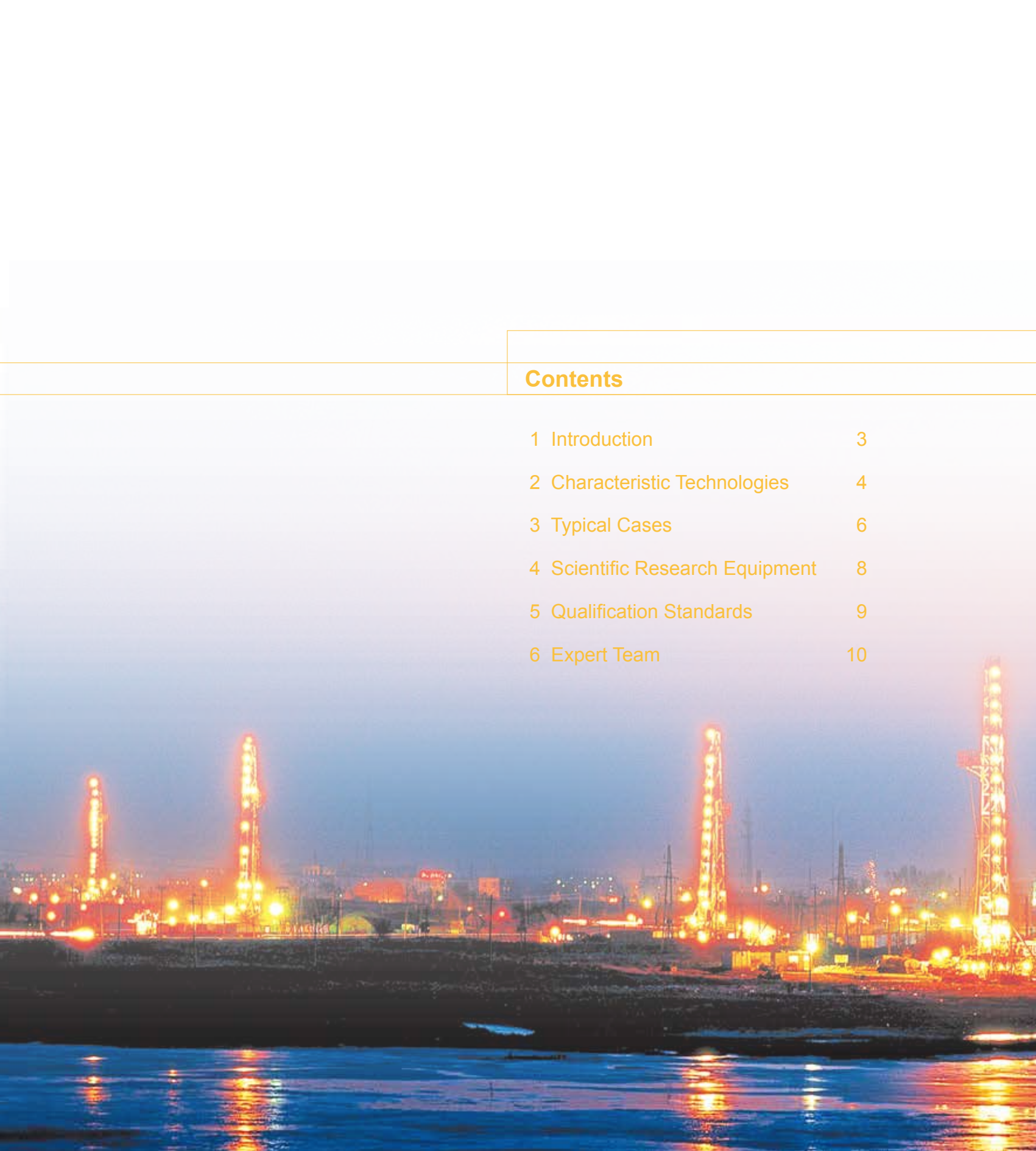
2015



CHINA NATIONAL PETROLEUM CORPORATION

*BH-ARI Builds the Bridge between Logging  
and Seismic and Realizes Borehole-side  
Microscopic Fine Measurement*





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**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 reorganized 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.

**BH-ARI Remote Detection Acoustic Reflection Imaging Logging Technology** is one of representatives for major innovations of CNPC.

## OFFERING ENERGY SOURCES, CREATING HARMONY

# 1

## INTRODUCTION

BH-ARI Remote Detection Acoustic Reflection Imaging Logging Technology is a brand new logging technology of CNPC with complete proprietary intellectual property rights that has been studied and development for ten years in order to make up for the defects such as shallow logging detection depth and low seismic exploration resolution. The Remote Detection Acoustic Reflection Imaging Logging Technology is a new logging geologic evaluation technology integrating method and instrument, data processing, software R&D and comprehensive interpretation, evaluation and research and can

detect the information on the fractured and cavern reservoirs within the scope of 10m around a well, thus greatly breaking through the limitation that other logging tools cannot exceed 3m and providing new high precision identification means for fine description of complex oil and gas reservoirs.

BH-ARI Remote Detection Acoustic Reflection Imaging Logging Technology has been applied in logging of totally over 70 wells in oilfields including Tarim, SINOPEC Northwest Company, Daqing, Sichuan, Huabei, Dagang, etc.



# 2

## CHARACTERISTIC TECHNOLOGIES

### 2.1 Variable-source distance remote detection acoustic reflection acquisition system

The acoustic system source distance can be adjusted by changing the quantity and connection sequence of sound insulators, centralizers and flexible subs between source distances according to formation characteristics.

### 2.2 Adjustable two-phased transmitting system

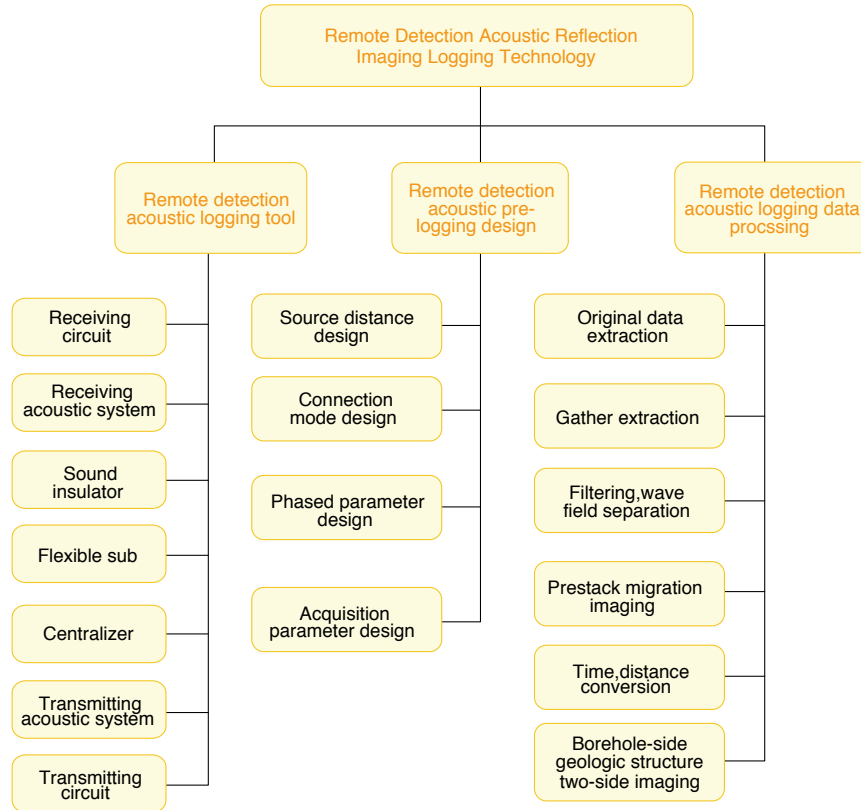
An adjustable two-phased transmitting

technology is used and can meet the requirements of identification characteristics of formations with different propagation speeds. According to the acoustic velocity features of the measured formation, the phased acoustic beam deflection angle can be adjusted, thus realizing remote high precision detection and acquisition.

### 2.3 Reflection logging digital processing technology

A complete set of high precision reflection imaging logging data processing system has been developed in combination with seismic exploration signal processing technology.

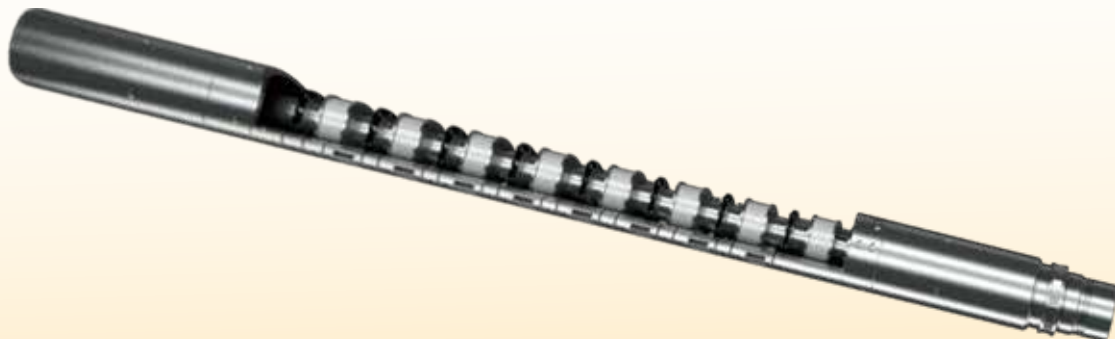




Remote detection acoustic reflection imaging logging tool technology framework

## 2.4 Technical Specifications

- ◆ Temperature resistance: 175°C
- ◆ Pressure resistance: 140 Mpa
- ◆ Radial detection depth: <10m
- ◆ Logging speed: ≤ 9m/min
- ◆ Total tool length: 17.9 ~ 30m;
- ◆ Source distance regulating range: 2.8 ~ 13.71m;
- ◆ Tool diameter: 90 ~ 102mm;



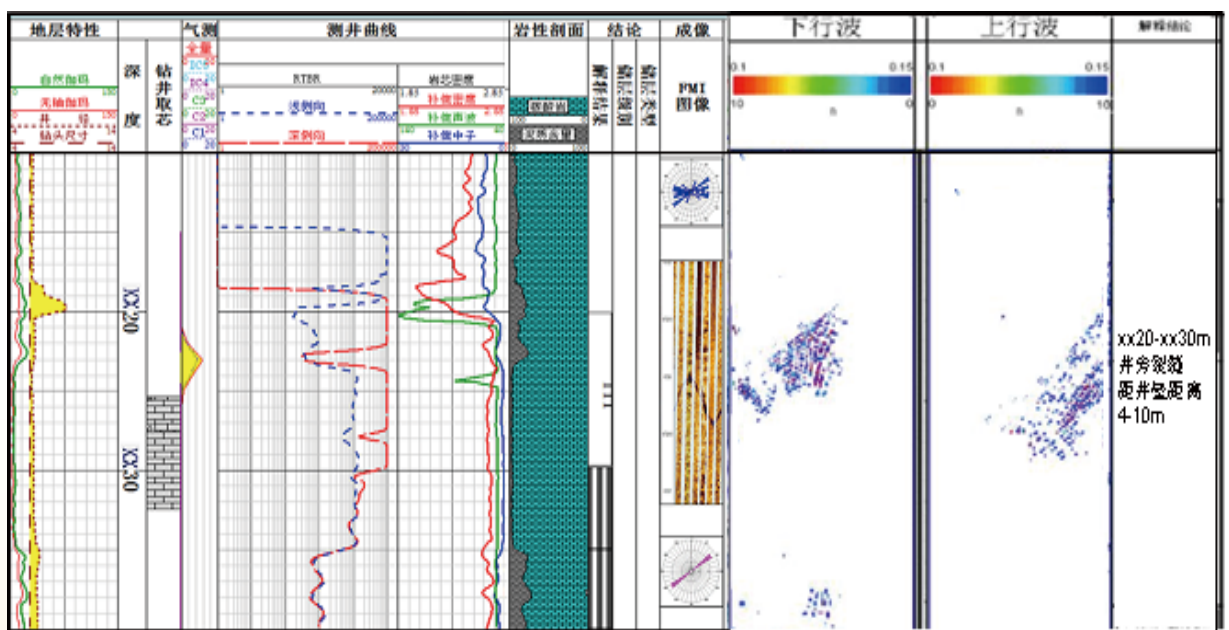
# 3

## TYPICAL CASES

### 3.1 Breaking through the detection depth limitation of the existing logging technologies and obtaining borehole-side significant geologic discoveries

Well A is a carbonate well in Tarim oilfield. An international renowned logging company carried out full series of logging operation of this well and no obvious oil and gas show was found in the early stage. Party A decided to try to carry out remote

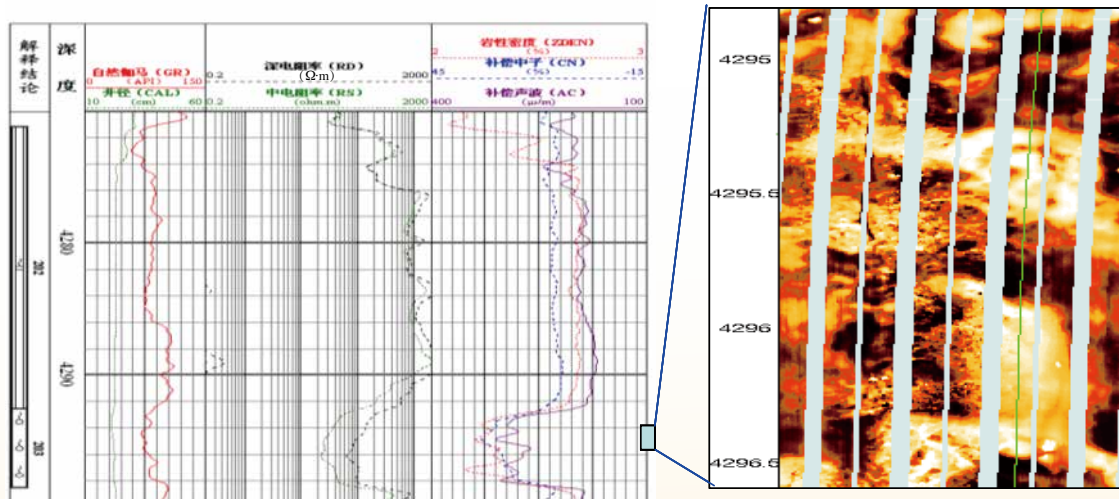
detection acoustic reflection imaging logging operation, and then obvious reflection information was found within the range of 3 ~ 10m in the interval xx20-xx28m. After interpretation and processing by technical personnel, there were high-angle borehole-side fractures. It was proposed to carry out production test and acid fracturing. After acid fracturing by Party A, the daily gas production is over 10000m<sup>3</sup> and the daily oil production over 10m<sup>3</sup> with a 6mm choke.



### 3.2 Breaking through the detection depth limitation of the existing logging technologies and enlarging the effective thickness of reservoirs

Well B is an appraisal well in Xudong slope belt in Xujiaweizi fault depression of the southwest fault depression area in Songliao basin. The main drilling purpose is to evaluate the hydrocarbon bearing property of volcanic reservoirs in Yingcheng Fm. The reservoir space includes gas holes and

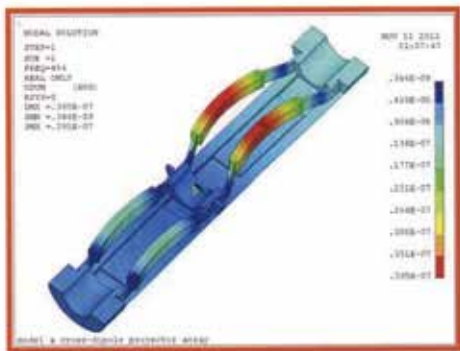
fractures. 203# reservoir was determined to be effective reservoir in conventional and imaging data interpretation. After remote detection item measurement and data analysis, the reservoir thickness has been increased by 14m. Afterwards, the daily gas production of the enlarged reservoir interval was 3178 m<sup>3</sup> during production test and 81153 m<sup>3</sup> after fracturing stimulation. This fully indicates that remote detection acoustic reflection imaging logging can effectively reflect the reservoir information outside borehole wall.



SCIENTIFIC  
RESEARCH  
EQUIPMENT

## 4.1 National acoustic laboratory

It has the largest anechoic tank in China and can perform underwater acoustic transducer inspection and testing.



## 4.2 National acoustic software R&D center

It can measure multiple parameters such as directivity, center frequency, pulse response, sensitivity, etc. of transmitting and receiving acoustic transducers and acoustic phased arrays, evaluate the performance of different subs of downhole acoustic logging tools and perform acoustic logging, seismic exploration, simulation experiment on acoustics detecting, etc.



# 5

## QUALIFICATION STANDARDS

### 5.1 5 invention patents and 4 utility model patents have been obtained

#### Invention patents

- Reflection imaging logging tool and logging method (patent No.: 02131410.1 )
- A device for transmitting phased array acoustic transducer excitation signals (patent No.: 200510056763.9)
- A method for scanning and radiating 2D acoustic field in formations outside borehole (patent No.: 200510058891.7)
- Amplitude weighted circuit excited by acoustic logging phased array (patent No.: 200610098676.4)
- A control method for two-way acoustic transmitting device (patent No.: 2007101191192.8 )

#### Utility model patents

- Reflection wave imaging logging tool (patent No.: 02257275.9)
- Probe connecting device (patent No.: 200620176006.5)
- A connecting device for acoustic system of acoustic logging tool (patent No.: 200620176005.0)
- Source distance adjustable acoustic system of acoustic logging tool (patent No.: Z1201320044239.X)

### 5.2 Rewarding

- Grade II CNPC science & technology invention prize
- One of top ten science and technology advances of CNPC
- Recognized as the independently innovative significant product of CNPC
- A candidate for “World Petroleum Prize”
- Grade III science and technology advance prize of Tianjin City

# 6

## EXPERT TEAM



**Chai Xiyuan**

Professor level senior engineer. He is engaged mainly in technical research on logging, interpretation and evaluation, perforation, etc. He has taken charge of completing the study of the project “BH-ARI Remote Detection Acoustic Reflection Imaging Logging Technology”.

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**Qiao Wenxiao**

Doctor, Ph.D.candidate supervisor, member of ASC, member of Detecting Acoustics Branch of ASC, member of Physical Acoustics Branch of ASC, member of SEG. He is engaged in the study of acoustic logging methods. He has participated in organizing the development of multipole array acoustic imaging logging tool and azimuth acoustic logging technology and made a pioneering study of phased acoustic logging.

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**Tao Guo**

Professor, Ph.D. candidate supervisor. He is engaged in the study of rock physics, elastic wave theory, numerical simulation, mechanics, acoustics, electric parameter measurement and relevant computer software. He has undertaken national “863” high-tech research projects, national natural science foundation projects and multiple key research subjects of CNPC many times.

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**Li Guoying**

She is responsible for development, study, application and perfecting of the remote detection acoustic reflection imaging logging tool. She has obtained multiple ministerial and bureau level scientific research prizes. She has multiple patents and nearly 20 years of experience in development, application, maintenance and perfecting of downhole tools.

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**Zhu Zhensheng**

Senior engineer. He has been long engaged in the study of logging technologies. He has participated in completing the project “BH-ARI Remote Detection Acoustic Reflection Imaging Logging Technology” and is the main researcher of the project.

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**Liu Bingzhong**

He is responsible for development, study, application and perfecting of the remote detection acoustic reflection imaging logging tool. He has nearly 30 years of experience in development, application, maintenance and perfecting of downhole tools. He has obtained 4 patents.

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