Research status and characteristics of advanced hydrocarbon trap evaluation

Wei Wang1,2, Guomin Chen2,3*, Kang Deng4, Tangzhong Du4 and Lin Wang2

1The key laboratory of well stability and fluid & rock mechanics in oil and gas reservoir of Shaanxi Province, Xi’an Shiyou University, Xi’an, Shaanxi, 710065, China
2College of Petroleum Engineering, Guangdong University of Petrochemical Technology, Maoming, Guangdong, 525000, China
3Guangdong Research Centre for Unconventional Energy of Engineering & Technology, Maoming, Guangdong, 525000, China
4The 10th Oil Recovery Plant of Changqing Oilfield Co., Ltd of Petrochina. Qingchen County, Gansu, 745100, China
*Corresponding author’s e-mail: chengwarming@gdupt.edu.cn

Abstract: Advanced hydrocarbon trap evaluation is crucial and necessary for the exploration target optimization decision. Its evaluation conclusion is verified by actual drilling results, so its research status has a direct impact on exploration benefits. This paper discusses the essence of advanced hydrocarbon trap evaluation that focuses on the development of quantitative and integration evaluation under the guidance of exploration target decision. Then, from these aspects, such as the theory method system, the basic geological research, the quantitative evaluation, economic evaluation and degree of computer application, their current situation of the development was unraveled one by one, the research status tends to be the higher degree of computer application, the deep involvement of basic geological research, and integration of multi-disciplinary procedure, the higher qualitative evaluation combined with the quantitative evaluation, and also a research chain of predication and decision-making process so that it needed constantly and actively by the support of different multi-disciplines, such as the system engineering theory and evaluation theory, decision-making theory, computer science and other disciplines to improve the evaluation theory and advanced evaluation methods.

1. Introduction

The trap, which is an underground three-dimensional closed geological space for hydrocarbon reservoir and preservation. It is also the direct object of drilling wells and an important object of trap evaluation. The main content of five aspects on comprehensive evaluation, the evaluation of the reliability of each trap, oil-bearing probability, economic evaluation, comprehensive evaluation, and drilling effect analysis, is conducted with the approach of integration and comprehensive quantitative evaluation, which can provide decision support for trap drilling target optimization, to promote furtherly the exploration of the escalating until to uncover the proven potential capability for all traps within a specific play field. Therefore, the research status and scientific degree of trap evaluation can reveal the overall exploration degree and resource potential of the exploration area, and also can reflect the degree of geological workers' understanding of the area and the degree of potential risks.
Trap evaluation is an important part of the oil and gas resource evaluation research system, and its technical method system has been developed and perfected in the integration with exploration practice. The research status of advanced hydrocarbon trap evaluation around the globe is basically in harmony with the practical problems and the historical background of exploration.

In recent years, according to the different types of regional geology and exploration targets, the exploration workers in various hydrocarbon exploration areas in China have developed and deepened the trap evaluation techniques and methods according to local geologic conditions. According to the main contents, target, and task requirements of trap evaluation, to improve the efficiency and scientific rationality of trap evaluation, various advanced mathematical methods have been introduced successively, which greatly improves the accuracy and reliability of trap evaluation results. To adapt to the need of high frequency rolling exploration targets decision, the theory of petroleum system, hydrocarbon bearing and the theory of hydrocarbon expulsion, the hydrocarbon accumulation pattern analysis of research, are all deepened, all kinds of advanced testing and analysis of the introduction of test methods, trap evaluation of the degree of the application of computer technology is higher and higher, the comprehensive evaluation of increasingly outstanding presents the integration of multiple disciplines, qualitative research, quantitative level rising trend [1-2].

The key to influence the research status of trap evaluation is to improve the recognition degree of all aspects of trap attributes with the help of advanced evaluation techniques. Therefore, to improve the credibility of trap evaluation and make the evaluation result conform to the real underground geological situation as far as possible, the key is to form a set of trap evaluation technology method which is suitable for it based on the in-depth study of the regional geological characteristics of the exploration area.

2. Research status and characteristics

Therefore, it is necessary to make an in-depth analysis of the current research status of advanced trap evaluation, and its contents and methods can be summarized into 5 aspects.

2.1. Well developing the system of theories and methods

From the perspective of comprehensive evaluation system analysis, the establishment of trap evaluation parameter system, the processing of evaluation parameter information, the determination of weight, and the study of evaluation method constitute the theoretical method system of trap evaluation. These important aspects of trap evaluation research also constitute the foundation and core of trap evaluation research (Figure 1).

![Figure 1 Pattern of main contents of advanced hydrocarbon trap evaluation](image-url)
2.2. **Strengthening preliminary basic geological research**

The level of preliminary basic geological research determines whether the establishment of the trap evaluation model for a certain exploration area is suitable for geological practice. Consequently, this part of work gets attention increasingly and strengthen. The results are as follows: firstly, the accuracy of trap interpretation and the reliability of trap implementation can be improved by improving the comprehensive geophysical techniques and the quality of seismic data; Especially for lithologic stratigraphic traps, it is very important and urgent to apply rational integrated geophysical techniques. The second is to make full use of the limited comprehensive exploration research data and the prediction and evaluation of oil-producing conditions, such as oil source conditions, trap formation, and development history, reservoir forming supporting relationship, and hydrocarbon preservation conditions, etc., to lay a good foundation for the evaluation of local traps, especially the analysis of key factors of reservoir formation and the study of resource quantity calculation parameters [3].

2.3. **Higher application of computer techniques**

The publication and implementation of SY/T 5520-2019 and other specifications have greatly promoted the standardization and systematization of trap evaluation [4]. To improve evaluation efficiency and reduce human error, various computer trap systems have been successively developed.

Using a computer the characteristics of the large information capacity and fast computing speed, especially because the graphic technology, database technology, visualization technology and the introduction of advanced technology evaluation methods and optimization, utilizing establishing the exploration database, able to quickly access call external chart, trap hydrocarbon reservoir exploration and development infrastructure and recognize achievement, make the whole evaluation process with high maneuverability, the standardization, the trap evaluation results, and the various statements provide the basis for scientific decision-making.

2.4. **Paying more attention to economic evaluation research**

The content of early trap evaluation mainly focuses on the hydrocarbon content of traps and the scale of resources. With the increase of exploration difficulty and the change of exploration thinking concept, as well as the practical requirements of fine exploration and comprehensive exploration, the target of trap evaluation gradually shifts to the question of whether the target of hydrocarbon trap has commercial value. The importance and reality of the economic evaluation of the trap have long attracted people's attention. With the improvement of the contents and methods of economic evaluation, the trap evaluation has developed from a single level evaluation to a multi-level comprehensive evaluation. Trap evaluation has become a comprehensive evaluation system for geological and economic evaluation.

2.5. **Continuously improving the research degree of quantitative evaluation**

Since 1980 s, the exploration targets, the diversity and geological conditions of complex dynamics of normalization and standardization requirements trap evaluation research work, trap quantitative level gradually become the focus of the study, the fuzzy comprehensive evaluation method, the grey system method, neural network and the expert system method advanced quantitative methods, are applied to trap capability evaluation of oil-bearing[5].

In terms of calculation methods of resource volume, some crude calculation methods in the early stage, such as the volume analogy method (similarity coefficient method, trap volume method), have been abandoned and replaced by monte Carlo risk assessment, artificial intelligence assessment, and other advanced calculation methods.

3. **Conclusion**

After many years of exploration, trap evaluation research has developed into a complete and logical technical method system. From the perspective of systems engineering theory, the process tends to be as a quantitative evaluation on basis of qualitative research, based on comprehensive geological research, based on advanced computer technology. It indicated that the advanced hydrocarbon trap evaluation,
based on the deep grasp of trap evaluation connotation and its basic characteristics, combined with exploration degree of evaluation object and understanding degree of concrete analysis, the developing direction should be from the system engineering theory and evaluation theory, decision-making theory refers to the advanced evaluation theory and methods, continuously garnered advanced ideas and methods from the computer science, probability theory and statistics evaluation method and mathematical methods so that the higher level of evaluation research and scientific rationality evaluation conclusions reached.

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References
[1] Chen G.M. (2010) Comprehensive evaluation procedure for hydrocarbon traps (in Chinese). Journal of Chongqing university of science and technology (natural science edition), 12 (2):16-18, 88.
[2] Chen G.M. (2010) Construction of a comprehensive evaluation parameter system for petroleum traps (in Chinese). Journal of Chongqing university of science and technology (natural science edition), 12 (4):10-12.
[3] Song M.S., Xu C.H. (2019) Trap evaluation from hydrocarbon source foci to oil-gas field migration path—A case study of Jiyang Depression (in Chinese). Petroleum geology and recovery, 26(3): 1-8.
[4] Petroleum Geological Exploration Standardization Committee. (2019) SY/T5520—2019 Technical specification for trap evaluation [S]. //http://my678.cn/t-268124-1-1.html
[5] Peng Z.L., Zhang Q., Yang S.L. (2015) A review of comprehensive evaluation theories and methods (in Chinese). China Management Science, 23(S1): 245-256.