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Progress in Research Methods on "Fluid-Diagenesis" Interactions of Fractures in Tight Reservoirs

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1 Introduction

Fractures in tight reservoirs have always attracted general petroleum geologists' attentions due to their importance in the processes of hydrocarbon enrichment and oil-gas exploration. Fractures can not only act as main pathways of hydrocarbon migration and fluid flow, but also provide major reservoir spaces for hydrocarbon accumulation. Hence, the distribution and development characteristics of them control the distribution and accumulation of oil-gas in reservoirs, especially in tight reservoirs. Current research achievements on fractures in reservoirs, however, are mainly focus on fracture mechanics (geometry, kinematics, and dynamics), yet chemical processes (geofluid effects and diagenesis) within growing fractures and their influences on fracture attributes are somewhat neglected. Recently, with the improvement and perfection of research techniques and analysis methods, some systematic researches on "fluid-diagenesis" interactions of fractures in reservoirs have drawn a wide attention and the research scope and understanding degree to fractures attributes are deepening gradually (Laubach et al., 2004, 2010; Anders et al., 2014; Fall et al., 2015). Nevertheless, this work has a little been done in China.

2 The Status of "Fluid-Diagenesis" Interactions of Fractures in Geological Processes

For a long time, research objects of geosciences have been limited to solid substances in crust, but as the research on geofluids increases, geologists more deeply realized that geofluids determine the movement and exchange of substances and energy in crust, meanwhile, the geological processes and the mechanism and evolution of geodynamics within crust, to a great extent, are also controlled by geofluids (Zheng, 1996). In the case of fractures in reservoirs of petroliferous basins, chemical diagenesis (mineral precipitation and dissolution) occurred in the presence of geofluids, have important influences on the formation and evolution of fractures. Especially in tight reservoirs, the filling characteristics and evolution of pore textures of fractures are directly controlled by fluids and diagenetic environments, which in turn determine the seepage characteristics of fractures and their contributions to hydrocarbon accumulation. Thus, based on analysis on fracture mechanical properties, strengthening the research on "fluid-diagenesis" interactions of fractures, will be beneficial to more deeply understand fracture attributes: origin, timing, forming environments, filling characteristics, dynamic evolution of porosity and permeability of fractures, etc, (Laubach et al., 2006, 2010; Fall et al., 2015), which can provide a strong guarantee for the quantitative research on hydrocarbon accumulation and successful implementation of oil-gas exploration and development.

3 Important Research Methods Related to "Fluid-Diagenesis" Interactions of Fractures

Research on "fluid-diagenesis" interactions of fractures, by definition, includes two aspects, namely geofluid analysis and diagenetic analysis. Among them, SEM-based cathodoluminescence (SEM-CL) is very useful in the process of diagenetic analysis, and the application of fluid inclusion analytical technique is crucial to fluid analysis in petroliferous basins. Therefore, these two techniques have laid the foundation for in-depth study on "fluid-diagenesis" interactions of fractures.

3.1 SEM-CL

Using CL can effectively distinguish cement sequences and recognize alteration processes of filling minerals in fractures, and applying SEM to obtain the micro-area information has many advantages, such as high resolution,

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high magnification, large depth of field, and strong three-dimensional sense. Yet in recent years, with the advent of SEM-CL technique consisting of SEM and CL, it is conducive to observe the CL features of filling minerals or cements within fractures under high-magnification and high-resolution conditions, and obtain the more-refined microstructural characteristics of fractures, including mineral bridges and crack-seal textures (Laubach et al., 2004, 2010; Fall et al., 2012, 2015). Thus, SEM-CL technique can provide an important basis for the quantitative analysis of filling evolution history of fractures.

3.2 Fluid inclusion analytical techniques

Fluid inclusion, which is known to many as the fossil of paleo-fluid, is a direct and high-accuracy method for obtaining the geochemical information of fluid (temperature, pressure, fluid property, etc.) existed in sedimentary or diagenetic process of reservoir in petroliferous basin. Based on the pre-analysis for filling minerals and cements within fractures used by SEM-CL technique, combined with systematic analysis on fluid inclusions, we can acquire the evolution characteristics of diagenetic fluids within fractures in much smaller time scales compared with the traditional approaches, which provide more accurate physicochemical parameters for reconstructing the fluid environments during the formation and evolution processes of fractures. Especially in recent years, in addition to microthermometry, analytical techniques of single fluid inclusion (including conventional/UV/in-situ cryogenic Raman spectroscopy, LA-ICP-MS, etc.) have been improved and perfected continuously, which can help to semi-quantitatively determined the compositions of fluids (major elements, trace elements, ion types, concentrations, etc.), even quantitatively. Moreover, it's worth mentioning that the fluid inclusion plane (FIP) in reservoir minerals should be taken seriously. FIP is formed from trapping fluids in the healing processes of microfractures in reservoir minerals, which record dual information about structure and fluid, thus, it is the unity combining structural event and fluid evolution (Ni, et al., 2001). Studies of FIP orientations can provide valuable information on the characteristics of regional stress fields related to certain fluid activities, meanwhile, fluid inclusions existed in FIP are useful in providing evidences for the properties of paleo-fluids corresponding to certain regional stress fields (Anders et al., 2014). Therefore, FIP is of great importance to study on "fluid-diagenesis" interactions of fractures.

4 Directions for Future Researches on "Fluid-Diagenesis" Interactions of Fractures

According to current research situation, future researches on "fluid-diagenesis" interactions of fractures should be focused on following aspects: (1) Strengthen the basic researches on fluid inclusion analytical techniques, specifically including establishing effective methods to determine the salinity of aqueous inclusions used by conventional/ in-situ cryogenic Raman spectroscopy, and building calibration curve of homogenization temperature of fluid inclusions in sedimentary basin, etc. (2) Improve the experimental study on water-rock reaction and numerical simulation of "fluid-diagenesis" interactions of fractures, in order to deepen understanding of filling mechanism of fractures. (3) Attach equal importance to basic researches and applied researches on "fluid-diagenesis" interactions of fractures, so as to provide optimal technical supports and services for improving the actual exploration and development efficiency of tight oil-gas reservoirs.

In addition, we put forward a methodology on studying the "fluid-diagenesis" interactions of fractures. Namely, based on the core guiding ideology — systematic perspective, carrying out the relevant researches from various aspects, including macro- and micro-observation, univariate and multivariate analysis, static and dynamic characterization, qualitative and quantitative analysis, combined multiple technical means, and paying equal attention to basic and applied researches. Only then can we better achieve the correct understanding on "fluid-diagenesis" interactions of fractures in tight reservoirs and their effects on hydrocarbon accumulation.

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