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Nano-Geology and Unconventional Oil and Gas

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Numerous Striking achievements have been made in micro and macro geology after the development for hundreds of years. Two trends branches of geology are divided into microcosmic nano-geology and macroeconomic astrono-geology with the enormous technology progress. The unique characteristics related to the nano-particles and nano-pores may be significant for formation, evolution and accumulation of rocks in the geological process. Nano-geology and the related metallogenic and accumulation are currently research frontier and hot topics in nanoscience and geology. Nanoparticles and pores in various rocks are analyzed by the means of nanotechnology and geology tools, to clarify the geological effects and dynamic mechanism, and to reveal its accumulation and metallogenic mechanism. As an emerging highly-integrated interdisciplinary, Nano-geology seems difficult to define as a single subject to research, however combined sciences count. Researchers initiated the nano-geology dating back to 1980s, and had been at the forefront of the world in the stages. At present, various research has been implemented for the appeared science issues in the field of nano-geological, and relative findings has been achieved.

In-depth study the nano-Geology (nano-Earth Sciences) will inevitably bring a new understanding of geology (Hochella, 2002), and will promote the development of unconventional oil and gas geological theory and have a significant effect on unconventional energy industry exploration, greenhouse gas emissions and coal mine disaster control. With increasing energy demand for the economic and social growth and consumption of conventional oil and gas resources, the conflict of energy supply and demand have become increasingly prominent, therefore, basic scientific research and critical technical innovations in unconventional energy exploration and development in nano-scale may be of great importance. Global climate continues to warm, the world and the various international environmental organizations are

calling for the use of clean energy, by (1) the development of greenhouse gas capture, resource utilization and sequestration technology or efficient nano-scale greenhouse gas absorbers, reducing greenhouse gas or emissions of harmful gases and particulate matter in the atmosphere; (2) improving nano-catalyst to improve the conversion efficiency and utilization of coal and oil and other energy sources; (3) exploiting unconventional gas, coal bed methane and other clean energy, optimizing energy structure, and maximize efficiency of energy utilization and greenhouse gas emissions. Additionally, in order to reduce heavy casualties and economic losses caused by frequent gas accidents in the coal mining process, a deeper understanding of the coal structure and dynamic mechanism of gas outburst in the perspective of nanometer geology seems to be essential, which attribute to prevention of coal and gas outburst disasters. Thus, research on nano-scale geological problems will greatly promote the development of earth sciences.

Development of the oil and gas industry will experience the breakthrough of conventional oil and gas, conventional and unconventional oil and gas and unconventional oil and gas both three stages, currently in the stage of break from conventional oil to unconventional oil and gas. Data shows that: global unconventional oil and gas resources is approximately $6200 \times 10^8 \text{ t}$, roughly equivalent to conventional oil resources, global unconventional gas resource is estimated about $4000 \times 10^{12} \text{ m}^3$, eight times that of conventional natural gas resources. Global Unconventional breakthrough has been achieved, shale gas, shale oil, coal bed methane, tight sands oil and gas has become the focus of unconventional oil and gas field development. Continuous hydrocarbon accumulation in nanostructures reservoir is considered as the main gathering mode of unconventional oil and gas (Zou et al., 2013). In the 21st century, innovations of the following three critical aspect would be achieved, if breakthrough would be obtained: (1) Deep understanding of nano-porous reservoir space, breaking the poor capacity of coal and

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shale reservoirs in the traditional theory. (2) The realization of micro and nano porosity reservoir stimulation to increase the permeability in unconventional reservoirs. (3) the relative research in the number of nanoscale pores, and pore size change and its connectivity in source rocks to resolve evaluation and prediction issues of GIP in nanometer-scale (including gas volume in closed pores). Shale gas revolution of US set off the worldwide unconventional energy climax.

China has an abundant unconventional resources, and in recent years has made a breakthrough in terms of tight oil and gas, coalbed methane and shale gas. The tight oil and gas and coal-bed methane have started industrial development, and shale gas production has reached 200 million cubic meters. Thus, it indicates that China has entered the critical stage of scientific and technological innovation in unconventional oil and gas. Complex geological conditions in China, result in strong heterogeneity of reservoir in different sedimentary environments, and tectonic deformation of the reservoir shearing of different types and intensity almost always induce a certain brittle fracture or ductile deformation (Sun et al 2005; Ju et al. 2014), which may be one of the main reasons that it is far harder to exploit the unconventional energy resource in China than US. Abnormal variation of the structure and physical properties in unconventional reservoirs not only have a greater relationship with the microstructure, but also with the evolution of the micro and nano-structures are closely related (Ju et al., 2005). Previous research results showed that the nano-structured of reservoir include mineral structure, organic macromolecular structure, nano-pore structure abbreviated from the nano scale pore structure, which is a major space of adsorption and diffusion of coal bed methane and shale gas (Ju et al. 2005; 2014). How Shale mineral structure, organic matter macromolecular structure and nano pore structure evolve at different temperature and pressure (especially the tectonic stress)? How to range maturity and deformation environment of unconventional reservoirs effectively, and which temperature and pressure factors play a major role or act together? what's the characteristics and gas accumulation mechanism with structural evolution of unconventional reservoirs? How to clarify unconventional hydrocarbon reservoir form mechanism set, and oil and gas -rich region enriched pattern formation process, how to optimize beneficial rich region? How to build oil and gas permeable flow model and reveal the mechanism, as the nano-pores in the reservoir is not well developed? Improved stimulation of reservoir according to such research may elevate the efficiency of oil recovery and production of unconventional oil and gas. The scientific issues of the unconventional reservoir structure evolution in nanometer effects and mechanisms of hydrocarbon accumulation and penetration are urgent and significant

problems to be solved.

Nanotechnology will bring a new leap forward for the development of geology in the 21st century, some breakthrough in the ultra-microscopic scale may be came. Although nano-geological studies by the previous researcher have been obtained to a certain degree, however, the theoretical system of nano geology seems still inadequate, and a comprehensive understanding of nano accumulation has not been elucidated. Especially as remarkable development has been achieved in unconventional oil and gas industry, the unconventional reservoir structure evolution in nanometer effects and mechanisms of hydrocarbon accumulation and penetration are urgent to settle. Based on the nano earth sciences in domestic and overseas, the research intended to a more micro level, deeply revealing of unconventional reservoirs structure evolution in nano scale: Nano mineral and organic matter in surface structure and reactivity issue; Unconventional reservoir structure of micro and nano-scale tectonic deformation; Micro-nano process and mechanism of deformation; the flow mechanism of unconventional oil and gas reservoirs under restrict of nano pores enrichment; The formation of oil and gas in rich region and reservoir stimulation issues, focus on and settle the key issues and frontier in unconventional oil and gas field, thus enriching and developing nano geological theory and methods, and provide an important scientific foundation for the exploration and development of energy and mineral resources.

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