Geochemical characteristics of diagenesis fluid in ultra-deep gas reservoir--a case of Cretaceous reservoirs in the Kuqa Depression,Tarim Basin, China

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Abstract: The ultra-deep reservoir in Kuqa depression with properties of ultra-low porosity, ultra-low—low permeability and high production is very important target for gas exploration and development at present. To discover the diagenetic fluid types, evolution and geochemical characteristics of the Cretaceous reservoir, this paper is based on the analysis of electron microprobe composition, inclusions homogenization temperature, X-ray diffraction, scanning electron microscope, confocal laser scanning microscope, casting thin sections, salinity and vapor composition, laser carbon and oxygen isotope of diagenetic mineral, and regional geological background. Results indicated that the crystalline dolomite cement has low concentration of Sr, high concentration of Mn and higher carbon isotope, showing the crystalline dolomite is affected by meteoric fresh water, associated with the tectonic uplift of late Cretaceous. Little changed $\delta^{13}C$ and negative deviated $\delta^{18}O$ with increased diagenesis and combining with the differentiation of the concentration of Fe and Mn, the diagenetic fluid of the vein dolomite cement is homologous with the diagenetic fluid of thecrystalline dolomite cement, temperature and depth are the dominant factors of differential precipitation between these two carbonate cements. Anhydrite cements have high concentration of Na, extremely low concentration of Fe and Mn content. Based on these dates, anhydrite cements can be thought to be related to the alkaline fluid overlying gypsum-salt layer produced by dehydration. The barite vein has abnormally high concentration of Sr, ultra-high homogenization temperature and high-density gas hydrocarbon inclusions, which is speculated to be the forward fluid by intrusion of late natural gas. Coexistence of methane inclusions with CO_2 gas proves existence of acid water during the accumulation of natural gas in the late stages. Therefore, the alkaline environment and associated diagenesis between the meteoric fresh water in epigenesist and carbonic acid in the late diagenesis have dominated the process of diagenesis and reservoir, the secondary porosity and fracture zone formed by gas accumulation is a favorable play for the exploration of ultra-deep reservoirs. Clay mineral content is 5-12% composed by illite and illite-montmorillonite mixed-layer mainly and chlorite secondly. The clay minerals are generated by succession sedimentary water precipitation in early stage of diagenesis and feldspathic dissolution in middle and late stage of diagenesis. The ealy sedimentary clay mineral in the sandstone are mainly enriched in the edge of the delt front or near the top and bottom of the water channel ,and its membrane can effectively inhibit overgrowth of quartz and feldspathic in the ultra-deep reservoir in early and middle stage of diagenesis and preserve matrix pores. The clay matrix of different stage can provide mineral intercrystal micropores with porosity of 1-4% and the intercrystal micropore is one of the main gas reservoir spaces. Clay minerals are the main controlling factor for reducing reservoir permeability. The clay mineral content of 6-9%(especially illite and illite-montmorillonite mixed-layer) can reduce the permeability of ultra-deep reservoir by 10-100 times, and result the overall permeability is 0.01-0.1×10^{-3}μm^2. The content of clay mineral and its occurrence characteristics are the key factors for the well preservation of reservoir in the long time(130-23Ma) shallow buried(<3000m) period, the dramatic decrease of matrix permeability in late(23Ma~) deep buried(>3000m) period and reservoir overall densifying(<0.1×10^{-3}μm^2) . The characteristics and distribution of clay minerals with great geological significance to evaluate the sandstone reservoir properties and to predict the distribution of favorable reservoirs for ultra-deep gas.

Key words: Tarim Basin, Kuqa Depression, Cretaceous, Ultra-deep Reservoir, Diagenetic fluids，Geochemical characteristics.

Reference

Zhou Li, Du Wenxue, Han Xue, et al. 2009. Fractal characteristics of micropore structure for clay mineral. Journal of Heilongjiang Institute of Science ＆ Technology. 19(2): 94~97.

Jia Chengzao, Zheng Min. 2012. Unconventional hydrocarbon resources in China and the prospect of exploration and development . Petroleum Exploration and Development.39 (2)：129~136.

Jia Chengzao.2003． Deposition and reservoir of Tarim Basin. Beijing: Petroleum Industry Press.261~290.

Liu Baojun, Zhang Jinquan. 1992. Sedimentary and Diagenesis. Beijing: Science Press.13~20.

Zhu Guohua. 1992. The formation, evolution and prediction of the pores in the clastic reservoir. Acta Sedimentologica Sinica.10(3):114~132.

Shou JianFeng, Zhang HuiLiang, Shen Yang. 2006. Diagenetic mechanisms of sandstone reservoirs in china oil and gas –bearing basins. Acta Petrologica Sinica, 22(8):2165~2170.

Zhang RongHu, Zhang HuiLiang, Shou JianFeng.2008. Geological analysis on reservoir mechanism of the Lower Cretaceous Ba shi ji qi ke Formation in Dabei area of Kuqa Drepression. Chinese Journal of Geology,43(3):507~518.

Gu Jiayu, Fang Hui, Jia Jinhua. 2001.Diagenesis and Reservoir Characteristics of Cretaceous Braided Delta Sandbody in Kuqa Depression, Tarim Basin. Acta Sedimentologica Sinica.19(4):517~523.

Liu Linyu,Qu Zhihao,SunWei,etal． 1998． Properties of clay mineral of clastic rock in Shanshan oilfield, Xinjiang. Journal of Northwes University(Natural Science Edition) ．28(5):443 446．

Zhang Huiliang, Zhang Ronghu,WangYuehua, *et al*. 2006. Influence of clay minerals membrane on sandstone reservoirs: A clay study on the Lower Donghetang reservoirs of the Devonian of Well Qun6 in the Tarim Basin.Petroleum Geology & Experiment, 28(5):493 498．

Xie Wuren,YangWei, Zhao Xingyuan, et al. 2010. Influences of chloriteon reservoir physical properties of the Xujiahe Formation in the central part of Sichuan Basin. Petroleum Exploration and Development, 37(6):674-679．

Sun Quanli1,Sun Hansen, Jia Bao, et al. 2010. Genesis of chlorites and its relationship with high-quality reservoirs in the Xujiahe Formation tight sandstones, western Sichuan depression. Oil ＆Gas Geology, 33(5):751-757．

Huang Sijing, Xie Wenlian, Zhang Meng, et al . 2004.China Triassic continental sandstone formation mechanism of authigenic chlorite and reservoir pore preservation between. Journal of Chengdu University of Technology(natural science edition) .31 (3) : 273-291.

Pan Yanning, Zhou Fengying, Chen Xiaoming, et al.2001.Compositional variation of chlorites in burial diagenetic

processes. Acta Mineralogica Sinica,21(1):174~178.
Zhang Ronghu, Yang Haijun, Wang Junpeng, etal. The formation mechanism and exploration significance of ultra-deep, low-porosity and tight sandstone reservoirs in Kuqa depression, Tarim Basin.. Acta Petrolei Sinica, 35(6):1057-1069.
Lin Wenji, Tang Dazhen, Xu Fengyin, et al. 2010.Quantitative study on intensity of He 8 reservoir diagenesis in Sulige Gasfield. Journal of Shandong University of Science and Technology:Natural Science, 29(6):30-33,38.
Zhu Ping, Huang Sijing, Li Demin, etal. 2004.Effect and protection of chlorite on clastic reservoir rocks. Journal of Chengdu University of Technology (Science &Technology Edition), 31(2):153 156.
Zhao Xingyuan. 2003. Study of interstratified chlorite-smectite minerals in Tarim Basin. Xinjiang Petroleum Geology, 24(6): 513-516.
Barclay, Worden, S. A. /., & R., H.,2000. Geochemical modelling of diagenetic reactions in a sub-arkosic sandstone. Clay Minerals, 35(1), 57-68.
Beitler B, 2005. Fingerprints of Fluid Flow: Chemical Diagenetic History of the Jurassic Navajo Sandstone, Southern Utah, U.S.A. . Journal of Sedimentary Research, 75(4):547-561.
Biehl B C, Reuning L, Schoenherr J, et al, 2016. Do CO2 -charged fluids contribute to secondary porosity creation in deeply buried carbonates? .Marine & Petroleum Geology, 76:176-186.
Bjørlykke, K.,2014. Relationships between depositional environments, burial history and rock properties. some principal aspects of diagenetic process in sedimentary basins. Sedimentary Geology, 301(3), 1-14.
Bjørlykke, K., & Jahren, J., 2012. Open closed geochemical systems during diagenesis in sedimentary basins: constraints on mass transfer during diagenesis and the prediction of porosity in sandstone and carbonate reservoirs. Aapg Bulletin, 96(12), 2193-2214.
Bodnar, R. J., 1993. Revised equation and table for determining the freezing point depression of H2O-NaCl solutions. Geochimica Et Cosmochimica Acta, 57(3), 683-684.
Booler, J., & Tucker, M. E., 2002. Distribution and geometry of facies and early diagenesis: the key to accommodation space variation and sequence stratigraphy: upper cretaceous congost carbonate platform, Spanish Pyrenees. Sedimentary Geology, 146(3), 225-247.
Budd, D. A., & Land, L. S., 1990. Geochemical imprint of meteoric diagenesis in holocene ooid sands, schooner cays, bahamas: correlation of calcite cement geochemistry with extant groundwaters. Journal of Sedimentary Research, 60(3), 361.
Buggle, B., Glaser, B., Hambach, U., Gerasimenko, N., & Marković, S., 2011. An evaluation of geochemical weathering indices in loess–paleosol studies. Quaternary International, 240(1), 12-21.
Cai Chunfang, Mei Bowen, Ma Ting, et al, 1997. The Source, distribution of organic acids in oilfield waters and their effect on mineral diagenesis in Tarim Basin.Acta Sedimentological Sinica, 15(3):103-104.
Dou, W., Liu, L., Wu, K., Xu, Z., & Feng, X., 2017. Origin and significance of secondary porosity: a case study of upper Triassic tight sandstones of Yanchang formation in ordos basin, china. Journal of Petroleum Science & Engineering, 149, 485-496.
Dutton S P, Loucks R G, 2010.Reprint of: Diagenetic controls on evolution of porosity and permeability in lower Tertiary Wilcox sandstones from shallow to ultra-deep (200–6700 m) burial, Gulf of Mexico Basin, U.S.A.Marine & Petroleum Geology, 27(8):1775-1787.
Fall, A., Eichhubl, P., Cumella, S. P., Bodnar, R. J., Laubach, S. E., & Becker, S. P.,2012. Testing the basin-centered gas accumulation model using fluid inclusion observations: southern piceance basin, colorado. Aapg Bulletin, 96(12), 2297-2318.
Feng Songbao,Xu Wenming,Dun Yapeng, et al,2014.Fluid inclusion characteristics of reservoirs in Kelasu tectonic zone of Kuqa Depression and its accumulation information. Petroleum geology&Experiment,36(2):214-216.
Fitzdiaz, E., 2010. Progressive deformation, fluid flow and water-rock interaction in the mexican fold-thrust belt, central mexico. Dissertations & Theses - Gradworks.
Friedman, I., & O'Neil, J. R., 1977. Data of Geochemistry 6th edn, ch. KK Compilation of Stable Isotope Fractionation Factors of Geochemical Interest. Data of Geochemistry.
George, S. C., Volk, H., & Ahmed, M.,2007. Geochemical analysis techniques and geological applications of oil-bearing fluid inclusions, with some australian case studies. Journal of Petroleum Science & Engineering, 57(1), 119-138.
Glasmann J R, 1989. Geochemical Evidence for the History of Diagenesis and Fluid Migration: Brent Sandstone, Heather Field, North Sea. Clay Minerals, 24(2):255-284.