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塔里木盆地北部油田水特征离子及意义

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摘要: 塔里木盆地北部西达里亚、塔河 1 号及塔河 3, 4 号油田的油田水具有相近的离子组成, 其可溶物质主要成分与海水一致, 表明其主要为海相成因。油田水中不同的离子组成及浓度指示特定的地质意义: HCO_3^- 与地层密度具有良好的正相关关系, 地层时代愈老, 直线斜率愈大; SO_4^{2-}, Ca^{2+}, Mg^{2+} 浓度的差异预示油田水的不同来源; I^- 含量不受地层岩性影响, 而由原油物性决定, I^- 含量高, 则原油物性就好; Br^- 浓度大于 350 mg/L 的油田水则是凝析油的特征。

关键词: 油田水; 特征离子; 地质意义; 塔北油田

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油田水化学成分及含量的变化与地层的成因、储集性能和油气性质密切相关。塔里木盆地北部经过长期的油气勘探, 积累了丰富的油田水资料。在该地区, 油田水产层较多, 主要为奥陶系、石炭系、三叠系及上第三系中新统苏维依组。不同油田的油田水特征差异明显, 利用这些区别, 可有效解决诸多地质疑点。

1　油田水成分

塔里木盆地北部油田的油田水以 $CaCl_2$ 水型为主, 矿化度为 200×10^3 mg/L 左右。西达里亚、塔河 1 号、塔河 3 号及塔河 4 号的油田水有着相近的离子组成及含量(表 1), 推测它们来自同一水源,

表 1　塔北油田水主要离子含量平均值/mg.L^{-1}

Table. 1　Average value of major ionic contents of oilfield water in North Tarim Basin

油田	Cl^-	$(Na^+ + K^+)$	Ca^{2+}	Mg^{2+}	SO_4^{2-}	HCO_3^-	I^-	Br^-
塔河 3, 4 号(O_1)	111×10^3	49.6×10^3	18.9×10^3	2 445	232	258	11.7	361
塔河 3, 4 号(C_1)	125×10^3	66.5×10^3	11.5×10^3	511	441	152	4.2	89.3
塔河 1 号(T)	130×10^3	69.6×10^3	10.8×10^3	1 210	312	138	4.5	227
塔河 2 号(T)	136×10^3	74×10^3	9.1×10^3	2 072	187	178	4.2	233
雅克拉(K_1)	65.9×10^3	36.8×10^3	2.7×10^3	759	169	853	27.8	120
西达里亚(T)	134×10^3	72.4×10^3	10.7×10^3	1 283	261	128	4.1	257
巴楚(C_2)	48×10^3	48×10^3	2.1×10^3	466	2 350	853	27.8	119

与现代海水离子浓度具有较好的可比性(表 2), 因此, 它们可能源自同一海相成因的地表水。

表 2　塔北油田水与现代海水离子浓度对比表

Table2　Comparison of ionic concentration between oilfield water in North Tarim and sea water

类型	HCO_3^-	SO_4^{2-}	Cl^-	Ca^{2+}	Mg^{2+}	Na^+
现代海水	0.41	7.68	55.04	1.15	3.69	30.62
油田水	0.084	0.16	61.20	5.60	0.07	32.30
河水	58.5	11.2	2.8	15	4.1	6.3

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2　特征离子

2.1　HCO_3^-

油田水中的 HCO_3^- 来源于成岩过程中有机质分解的 CO_2:

$$H_2O + CO_2 \rightleftharpoons H_2CO_3 \quad (1)$$

$$H_2CO_3 \rightleftharpoons HCO_3^- + H^+ \quad (2)$$

$$HCO_3^- + H^+ \rightleftharpoons 2H^+ + CO_3^{2-} \quad (3)$$

pH 值为 5 时(1)式成立, pH 值为 6.3 时(2)式成立, pH 值为 10.3 时(3)式成立。由此可以看出 HCO_3^- 含量与溶液中 H^+ 浓度密切相关。塔北油田

水的 pH 值普遍在 5~ 6 之间(巴什托构造的某些井在 7 左右) , 有利于 HCO_3^- 存在。统计结果表明: 塔河油田水 HCO_3^- 与密度有良好的线性关系, 时代愈老, 线性关系的斜率愈大(图 1, 2, 3) 。

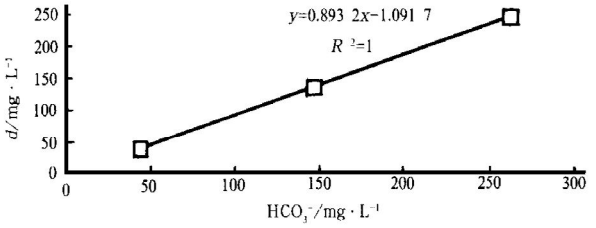

图 1　塔河油田石炭系地层水 HCO_3^- 与密度比值的关系

Fig. 1　Relationship between HCO_3^- of formation water and rock density in Carboniferous Tahe Oilfield

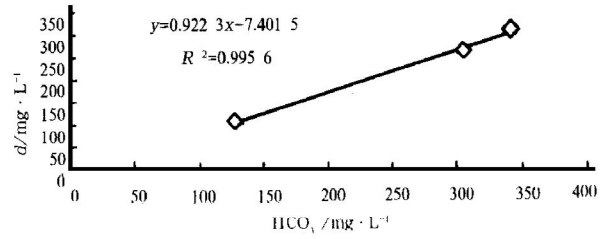

图 2　塔河油田奥陶系地层水 HCO_3^- 与密度比值的关系

Fig. 2　Relationship betwee HCO_3^- of Tertiary formatin water and the specific value rock density in Tahe Oilfields

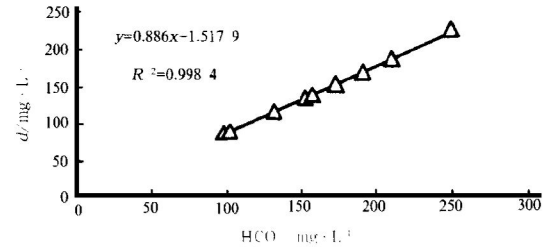

图 3　塔河油田三叠系地层水 HCO_3^- 与密度比值的关系

Fig. 3　Relationship between HCO_3^- of formation water and rock density in Ordovician Tahe Oilfield

2.2　Ca^{2+} , Mg^{2+} , SO_4^{2-}

塔北不同区块的油田水其 Ca^{2+} , Ma^{2+} , SO_4^{2-} 浓度存在明显差异: 巴什托麦 6、麦 4、麦 10 井, 巴参 1 井及塔河 3 号、4 号 S46 等井石炭系油田水的 SO_4^{2-} 浓度比塔北其它区块高一个数量级左右。雅克拉构造上的 YK-1、沙参 2、沙 7 井 SO_4^{2-} 浓度最低, 一般在 100 mg/ L 左右。另外, (Ca^{2+} + Mg^{2+}) 与 SO_4^{2-} 浓度在不同的层位具有不同的关系(图 4) , 据此可以较好区分塔北各油田的油田水。

2.3　I^-

油田水中的 I^- 主要来源于海藻及其它海相有机物, 浓度的高低反应了该地层古代海水中海藻及其它海相有机物的丰度。塔北油田的油田水中, 巴什托油气田石炭系的 I^- 含量最高, 一般在 16 mg/ L 至 50 mg/ L 之间; 雅克拉油田下白垩统的 I^- 含量次之, 在 10 mg/ L 至 15 mg/ L 之间; 其它地区较低。统计结果表明: 塔北油田 I^- 含量与地层岩性无关, 而与原油性质关系密切, 原油密度小 I^- 含量就高。

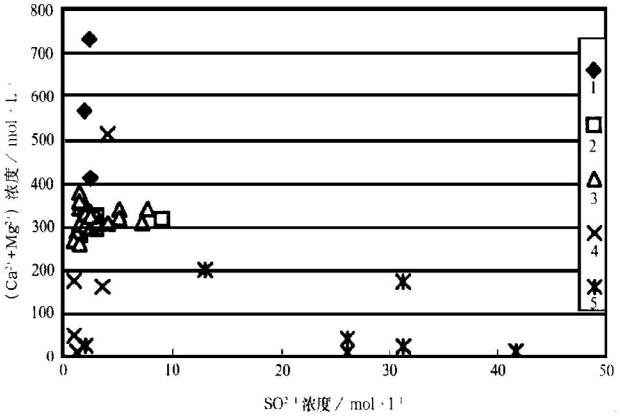

图 4　塔北地层水 SO_4^{2-} 浓度与 Ca^{2+} , Mg^{2+} 浓度关系

Fig. 4　Concentrating relationship between SO_4^{2-} Ca^{2+} and Mg^{2+} of formation water in North Tarim Basin

1 —塔河奥陶系; 2 —塔河石炭系; 3 —塔河三叠系; 4 —塔北下白垩统; 5 —巴楚石炭系

2.4　Br^-

塔北油田水中, Br^- 浓度大于 350 mg/ L 的钻井有 T402 井、TK104 井、S22 井、S32 井、DK10 井及沙参 2 井, 最高可达 900 mg/ L; 另外, Br^- / 总矿物大于 0. 15‰的井有 T402 井、沙参 2 井、TK10 井、麦 4 井、沙 32 井、沙 22 井、DK10 井、沙 38 井、麦 10 井、麦 6 井、沙 29 井及 YK1 井等。上述这些井的原油多为凝析油。因此在塔北油田可以将 Br^- 浓度大于 350 mg/ L, Br^- / 总矿物大于 0. 15‰作为凝析油的判识指标。

3　结论

(1) 塔北油田水主要来自于海相水;

(2) 油田水中 HCO_3^- 浓度与地层密度正相关;

(3) 不同油田水的 Ca^{2+} , Mg^{2+} 与 SO_4^{2-} 相对浓度具有显著差异。

(4) Br^- 浓度可作为判识凝析油的一个指标。

CHARACTERISTIC IONS OF OILFIELD WATER IN NORTHERN TARIM BASIN AND ITS SIGNIFICANCE

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Abstract: The oilfield water in xidaliyia, Tahe-1, Tahe-3 and Tahe-4 Oilfields in Northern Tarim Basin has similar ionic composition, and the principal compositions of soluble materials are consistent with sea water, suggesting its marine origin. The different ionic compositions and concentration indicate different geological features. HCO_3^- has positive coherence with the strata density, the concentration differences of SO_4^{2-}, Ca^{2+}, Mg^{2+} indicate different origin of the water. The content of I^- is determined by physical features of crude oil but not lithologic feature, and bears negative coherence with the density of crude oil. When concentration of Br^- in oilfield water is more than 350 mg/L, the oil would be condensate oil.

Key Words: oilfield water; characteristic ion; geological significance; North Tarim Oilfield

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参 考 文 献

1 Magoon L B, Dow W G. The Petroleum system[A]. In: Magoon L B, Dow W G. From source to trap[C]. AAPG Memoir, 1994, 60: 20~ 21

2 Demaison G, Huizinga B J. Genetic Classification of petroleum system [J]. AAPG Bull, 1991, 75(10): 1 626~ 1 643

3 Perrodon A. Petroleum systems: models and applications[J]. Journal of Petroleum Geology, 1992, 15(3): 319~ 326

4 Perrodon A. Petroleum system and global tectonics[J]. Journal of Petroleum Geology, 1995, 18(4): 471~ 476

ANALYSIS OF PETROLEUM SYSTEM IN NANPU SAG

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Abstract: According to oil-source rock correlation, there are two petroleum systems in Nanpu Depression. One is Shahejie Formation petroleum system, the other one is Dongying Formation petroleum system. The source rocks of Sha-3 member of the first system began oil generation in the late stage of Dongiyng Formation, and formed self generation-self reservoiring oil pools; the source rocks of the system began secondary oil generation in late Minghuazhen Formation, and formed Tertiary secondary oil pools. As for the second system, the source rocks of the third member of Dongying Formation in the south side of Gaoliu Fault started oil generation in the late stage of Minghuazhen Formation, and formed self generation-self reservoiring oil pools of Dongiyng Formation and Tertiary secondary oil pools, but no hydrocarbon pools could be found in the north side of the faults. So it is suggested that hydrocarbon exploration should aimed at the petroleum system of Shahejie Formation in Gaoshangpu and Liuzan areas of the sag, and the Dongying Formation petroleum system in Beipu and Laoyemiao areas.

Key Words: petroleum system; critical moment; hydrocarbon pool; Nanpu Sag