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Origin of Formation Water Salinity Variation and Its Geological Significance in Chang 9 Stratum, Jiyuan Oilfield

(Punca Pembentukan Variasi Kemasinan Air dan Kepentingan Geologi Chang 9 Stratum di Lapangan Minyak Jiyuan)

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ABSTRACT

The origin of formation water salinity variation in Chang 9 stratum, Jiyuan oilfield, Ordos basin is studied here. 91 formation water samples show that water salinity is characterized by a wide range and a complex plane distribution. In order to find out the main cause of such distribution complexity and reveal the relationship between formation water and evolution of reservoir traps, core data, chemical analysis result of formation water and log data are analyzed from perspectives of diagenesis and tectonism. And then, their characteristics are presented as the followings. In high salinity area, tuffaceous mudstone interlayer is found growing. Besides, the condition of Na^++K^+ *is opposite to that of* Ca^{2+}*, for its rate of concentration increase slows down with total salinity accumulating. In low salinity area, while, with fracture and faults developing, some formation water of* $CaCl_2$ *type turns into* $MgCl_2$*,* $NaHCO_3$ *or* Na_2SO_4 *type. The cause is thus proposed to be composed of two aspects. One covers tuff alteration and later diagenesis for the high salinity. To be specific, montmorillonite, developed from tuff alteration, absorbs cation selectively and then ions migrate, during which more* Na^++K^+ *get lost, while more* Ca^{2+} *reserved. Afterwards, those reserved* Ca^{2+} *get released with montmorillonite transforming to illite, which results in a loss of* Na^++K^+ *and accumulation of* Ca^{2+}*. Lots of ions are released into formation water during that process and later diagenetic process, which leads to the high water salinity. The other aspect is the development of faults and fractures, through which, the upper low salinity formation water gets connected. And that is the main cause of low salinity. At last, geological significance is discussed from two angles. Firstly, tuff alteration and later diagenesis are pivotal to reservoir reconstruction; and secondly, faults and fractures play an important role in oil transportation and storage.*

Keywords: Chang 9 stratum; fault and fracture; formation water salinity; geological significance; Jiyuan oilfield; origin; tuff alteration

ABSTRAK

Asal usul variasi kemasinan formasi air di Chang 9 Stratum, lapangan minyak Jiyuan di basin Ordos dikaji. 91 sampel formasi air menunjukkan bahawa kemasinan air dicirikan melalui julat yang besar dan satah yang kompleks. Untuk mengetahui punca utama yang menyebabkan taburan kekompleksan dan menunjukkan hubungan antara formasi air dan evolusi perangkap empangan, data teras, keputusan analisis kimia daripada formasi air dan data log dianalisis daripada perspektif diagnesis dan tektonisme. Seterusnya, ciri berikut diberikan: Dalam kawasan kemasinan tinggi, tuf antara lapisan batu lumpur dilihat berkembang. Di samping itu, keadaan Na^++K^+ *adalah bertentangan dengan* Ca^{2+} *kerana tahap kenaikan kepekatan menurun dengan pengumpulan jumlah kemasinan. Di kawasan kemasinan yang rendah dengan retak dan sesar berkembang, sebahagian formasi air jenis* $CaCl_2$ *bertukar menjadi jenis* $MgCl_2$*,* $NaHCO_3$ *atau* Na_2SO_4*. Punca utama yang dicadangkan mengambil kira dua aspek. Pertama ialah perubahan tuf dan diagnesis untuk kemasinan tinggi. Untuk lebih tepat lagi, montmorilonit yang dibangunkan daripada perubahan tuf memilih menyerap kation dan selepas itu migrasi ion yang menunjukkan kehilangan* Na^++K^+ *yang banyak manakala lebih banyak* Ca^{2+} *disimpan. Selepas itu,* Ca^{2+} *yang disimpan dibebaskan dengan montmorilonit berubah menjadi batuan ilit dan mengakibatkan kehilangan* Na^++K^+ *dan* Ca^{2+} *terkumpul. Proses ini telah menyebabkan banyak ion dibebaskan dalam formasi air dan kemudian sewaktu proses diagenetik yang membawa kepada tahap kemasinan air yang tinggi. Aspek yang kedua ialah perkembangan sesar dan retak yang menyebabkan bahagian atas formasi air kemasinan rendah berhubung. Ini adalah punca utama kemasinan yang rendah. Akhirnya, kepentingan geologi dibincangkan daripada dua sudut. Pertama, perubahan tuf dan kemudian diagenesis adalah penting untuk pembinaan semula takungan dan kedua sesar dan retak yang memainkan peranan penting dalam pengangkutan dan penyimpanan minyak.*

Kata kunci: Chang 9 stratum; formasi kemasinan air; kepentingan geologi; lapangan minyak Jiyuan; perubahan tuf; punca; sesar dan retak

INTRODUCTION

Formation water, a kind of basin fluids, is so important that it deserves attention during the whole process of hydrocarbon generation, transportation and storage. Underground, existing among the rock pores, it takes on different types. Sun (2001) regards its physical and chemical properties as a mirror of various geological processes during basin evolution (Ashraf et al. 2013).

Consequently, the study on formation water has attracted scholars both locally and abroad. Abroad, researches on its origin have already been carried out for quite some time. Clayton et al. (1966) collected 95 formation water samples from Illinois, Michigan, Alberta basins and the Gulf Coast. He then proposed that the water was predominantly of local meteoric origin. Billings et al. (1969) and Hitchon et al. (1971) on the basis of research in Alberta, believe that diagenesis and cation exchange on clay surface can also influence the nature of formation water. By means of isotopes of hydrogen and oxygen, Collins (1975) insisted on a close relation between formation water and freshwater injection. Also, he pointed out that formation water salinity mainly depend on factors as hydraulic gradient, depth, distance from outcrop, activity of soluble chemical elements, soluble substances in formation, ion exchange reaction and clay membrane filtration. Knauth and Beeunas (1986) regard evaporated seawater as the origin of formation water, based on studies of Palo Duro Basin samples. According to materials on formation water and geology, Connolly et al. (1990), Hitchon and Friedman (1969) and Kharaka et al. (1986) point out that formation water is the mixture of freshwater and concentrated seawater after evaporation. In recent years, the discussion on the present topic was around the isotope composition analysis. Lüders et al. (2010) proposed that seawater evaporation is the first cause of formation water salinity in Rotliegend and upper Carboniferous of northern German basin). However, Pinti et al. (2011) believed halite dissolution is the main source after the study of isotopic composition in St-Lawrence lowlands, Québec, Canada. In 2013, by means of Ca/Mg versus Ca/Sr diagrams, a strong dolomintization in Messinian Ca-Cl brines was discovered by Tiziano Boschetti group (Batool et al. 2015; Boschetti et al. 2013).

In China, many scholars also try to solve the problem by analyzing the data from different areas. Generally, opinions on origin of formation water focus on factors like evaporation-concentration, meteoric water leaching, organic matter hydrocarbon generation and complex water-rock interaction (Chen et al. 2013; Li et al. 2012, 2010, 2001; Liu et al. 2013; Ma et al. 2013; Shen et al. 2012; Wang et al. 1998; Xie et al. 2006; Zhang et al. 2003). Furthermore, Gao (1994) mentioned a relation between high formation water salinity and volcanogenic tuffs, without any further explanation, however.

In the present study, the study area was narrowed down to Jiyuan oilfield (Figure 1), which, located in the northeastern part of Ordos basin, spans northern Shanxi and Tianhuan depression. The group was divided into 10 layers and the 10 layers were reclassified into 9 ones named as Chang 1, Chang 2, … Chang 4+5, … and Chang 10 from the top to the bottom. Among them, Chang 7 stratum exists between 1900 to 2800 m below the wellhead in different wells. The material composition of it is mostly source rock and the generated oil and water in Chang 7 flow downward under an extremely high pressure (Liu et al. 2011). Meng et al. (2012) pointed out that Chang 9 reservoir is of a typical kind with both low porosity and permeability. It was made up of feldspar lithic sandstone and lithic arkose mainly and chlorite, laumontite, siliceous and calcareous cements form its major interstitial materials. In addition, delta plain intrafacies were developed in Chang 9 stratum as well.

Here, 91 formation water samples were collected and analyzed. The data showed that their water salinity ranges widely, from 5 to 95 g/L with an average of 29.24 g/L. Meanwhile, plane distribution contour map of formation water salinity in Chang 9 stratum was drawn (Figure 1) by Geomap software. Judging by the colour distribution, the complexity of its plane distribution becomes apparent. Areas with high salinity (in dark), mainly assembling at the northern part of Jiyuan Oilfield, present a discontinuous distribution. Their salinity is generally higher than 45 g/L. Contrary to the former, those with salinity lower than 15 g/L (in light) spread in the East and West.

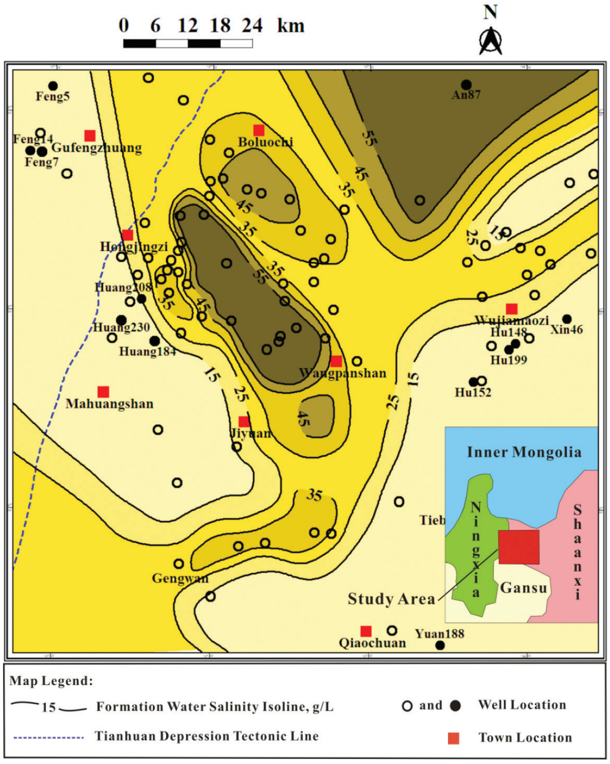

FIGURE 1. Plane distribution contour map of formation water salinity in Chang 9 stratum (Depth of samples: 2100 ~3000 m in different wells)

In order to clarify the main cause of such complex variation, the research was carried out by two steps. First, statistics were studied in combination with diagenesis and tectonism, to name the three of them all, characteristics and regularity of core data, chemical analysis result of formation water and log data. Second, the causes were deduced from aspects of high salinity and low salinity, respectively. For the former, tuff alteration and later diagenesis were proposed as the main caused from perspectives of water-rock interaction, cation exchange and ion migration. For the latter, the presence of faults and fractures turns to be the main caused for it to connect the upper low salinity formation water to surface water. Thus the relationship between formation water and evolution of the reservoir traps was further shown.

Samples and Methods

In this study, 91 formation water samples were collected from Chang 9 stratum, Yanchang group, Triassic by method of wellhead sampling, a common operation in oil industry (Collins 1975). All of them mainly come from 2100 to 3000 m in prospecting wells and development wells located at the northern part of study area (Figure 1).

All of these formation water samples were sent to test laboratory for normal chemical ion (Na^++K^+, Ca^{2+}, Mg^{2+}, Cl^-, SO_4^{2-}, HCO_3^- and CO_3^{2-}) concentration analysis in time. As shown in Appendix, the experimental data were displayed. According to SY/T 5523-2006 national standard, the concentration of both cations and anions were basically measured by solution titration (National Development and Reform Commission 2006). The corresponding analytical precisions for Ca^{2+}, Cl^- and SO_4^{2-} were less than 1.9, 1.7 and 5%, respectively, while the rest were relevant to ion concentration. Based on the measurements, total dissolved solids (TDS) were calculated by the sum of cations and anions. Its analytical precision was generally less than 5% (Ibrahim et al. 2014).

Causes of Formation Water in High Salinity Area

Chemical Characteristics of Formation Water

A positive correlation was found between salinity and concentration of Na^++K^+ and Ca^{2+} after the analysis of formation water chemical data. To be specific, with water formation salinity increasing, their concentration accordingly rises (Qureshi et al. 2015). When the salinity was lower than 40 g/L, the concentration of Na^++K^+ and Ca^{2+} have a linear relation with salinity, which can be seen from the trending lines in Figure 2(a) and 2(b). Such phenomenon of Na^+ loss and Ca^{2+} accumulation was common in Yanchang group, Jiyuan oilfield, which was brought by albitization of plagioclase during diagenetic process (White 1965; Yang & Qiu 2002). Taking anorthite as an example, its specific chemical equation can be expressed as:

$$2CaAl_2Si_2\mathrm{O}_2 + 2Na^+ + 4H_2O + 6SiO_2 = 2NaAlSi_3\mathrm{O}_2 + CaAl_2Si_4O_{12} \times 4H_2O + Ca^{2+}, \tag{1}$$

where $CaAl_2Si_2O_8$ stands for anorthite; $NaAlSi_3O_8$ albite; and $CaAl_2Si_4O_{12} \times 4H_2O$ laumontite.

When the salinity was higher than 40 g/L, however, the difference happened. As opposed to the condition of Ca^{2+}, the rate that the concentration of Na^++K^+ rises with salinity decreases obviously. Consequently, the concentration value of Na^++K^+ approaches to or even drops below that of Ca^{2+}, as was shown by the red points in Figure 2(a) and 2(b). It indicates that in addition to albitization of plagioclase, some other factors might contribute to such specialty that Ca^{2+} appears opposite to Na^++K^+ in quantity increase. Such unusual phenomenon only happened in high salinity area. The aforementioned unknown factors were thus inferred as the principal causes of high formation water salinity.

(a) (b)

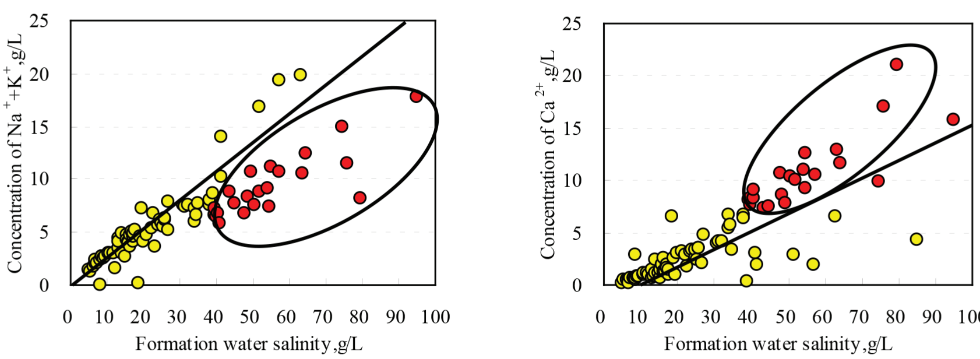

FIGURE 2. (a) Cross plot of Na^++K^+ concentration and formation water salinity and (b) Cross plot of Ca^{2+} concentration and formation water salinity

DEVELOPMENT OF TUFFACEOUS MUDSTONE INTERLAYERS

Qiu (2008) analysed the core scanning electron microscope (SEM) data of non-reservoir interval in Chang 9 stratum of Well Feng 4, located near the northern part of the study area and found tuff existing there mainly in the forms of flaky illite, illite/smectite formation and fragmented feldspar (Figure 3). The shaded parts in Figure 4(a) show a great change in conventional log response characters of mudstone after being mixed with tuff in Chang 9 of Well Feng 4. The change covers an obvious expansion in borehole diameter, high natural gamma ray values, slightly lower resistivity compared with adjacent mudstones, high acoustic travel time, high neutron porosity and low density.

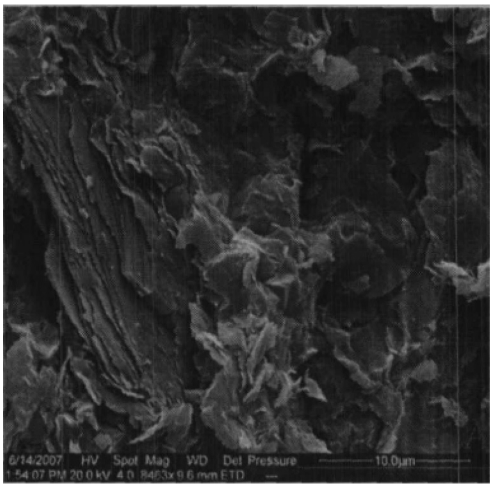

FIGURE 3. A SEM photomicrograph of non-reservoir interval in Chang 9 stratum of Well Feng 4 (Qiu 2008)

After analysis of conventional log data in Chang 9 stratum, the above mentioned mudstone interlayer of a special kind was found developed in most high salinity wells. As shown in Figure 4(b), the shaded part was just the special interlayer discussed before and the salinity of Chang 9 stratum, well An 87 (Figure 1) reaches 79.45 g/L.

Therefore, it can be inferred that in high salinity area, the tuffaceous mudstone interlayers develop in Chang 9 stratum of most wells.

CAUSES OF HIGH FORMATION WATER SALINITY

Based on the aforementioned anomalous variation of cation and the existence of tuffaceous mudstone interlayer, it was thus proposed that tuff alteration and later diagenesis was the main cause of anomalous cation variation and high formation water salinity. Their influence on ion migration and salinity falls into the following phases:

The first was the formation of montmorillonite from tuff alteration in early diagenetic stage. Qiu (2008) points out that in this area, damouritization forms the dominant part of tuff alteration and its major products were montmorillonite and illite/smectite formation. Hence, it was inferred that fallen ashes form into tuff after deposition (Surhio et al. 2014). Immersed in the water for a long time, shard contained in the tuff transforms into montmorillonite after devitrification, hydration and recrystallization. Take how plagioclase transforms into montmorillonite as an example. The process can be written as the following chemical equation:

$$\begin{aligned}&0.5Na_{0.6}Ca_{0.4}Al_{1.4}Si_{2.6}O_8 + 4.2Al^{3+} + 0.15Mg^{2+}\\&+ 0.15Fe^{2+} + 5.7SiO_2 + 8.6OH^- + nH_2O\ldots\\&\ldots = [Na_{0.3}, Ca_{0.2}][Al_{3.9}, Mg_{0.15}, Fe_{0.15}][Si_7, Al]O_{20}(OH)_4\\&\times nH_2O + 4.6H^+,\end{aligned} \tag{2}$$

where $[Na_{0.3},Ca_{0.2}][Al_{3.9}, Mg_{0.15}, Fe_{0.15}][Si_7, Al]O_{20}(OH)_4 \times nH_2O$ represents montmorillonite; and $Na_{0.6}Ca_{0.4}Al_{1.4}Si_{2.6}O_8$ plagioclase (Schlumberger 1988).

The second is Montmorillonite's selective absorption on cations and ion migration. Montmorillonite, produced from tuff alteration, possesses adsorptive capacity to cations. The force between adsorbed cations and the structural unit layer turns out to be relatively weak, which resulted in interchangeability of cations between different layers. The particle adsorption capacity of common cations in Chang 9 stratum was listed in ascending order:

$Na^+ < K^+ < Mg^{2+} < Ca^{2+}$ (Lai & Mortland 1961).

The relation showed that lower valent cations like Na^+ and K^+ are easy to be replaced by those higher ones like Ca^{2+} and Mg^{2+} to form more stable montmorillonite compounds. For example, chemical equation of Ca^{2+} exchanging with Na^+ in montmorillonite can be expressed as:

$$Na_2 - R + Ca^{2+} \rightleftharpoons Ca - R + 2Na^+,$$

where $-R^{2-}$ represents the montmorillonite.

Equation (3) shows that more Na^+ and K^+ were accumulated in the solution. Along with the formation water movement and ion migration, more Na^+ and K^+ were taken away while more Ca^{2+} reserved.

The third was later diagenesis process from period B of early diagenetic stage. With burial depth increasing, montmorillonite, from tuff alteration, constantly transforms into illite in period B of early diagenetic stage. At last, illite or illite/smectite formation was generated. The chemical equation of this process can be written as:

$$\begin{aligned}&[Na_{0.3}, Ca_{0.2}][Al_{3.9}, Mg_{0.15}, Fe_{0.15}][Si_7, Al]O_{20}(OH)_4 \times\\&nH_2O + 1.5K^+ = 0.3Na^+ + 0.2Ca^{2+} + \ldots\\&\ldots + K_{1.5}[Al_{3.8}, Mg_{0.02}, Fe_{0.03}][Si_7, Al]O_{20}(OH)_4 + 0.1Al^{3+}\\&+ Mg^{2+} + 0.12Fe^{2+} + nH_2O,\end{aligned} \tag{4}$$

where $[Na_{0.3}, Ca_{0.2}][Al_{3.9}, Mg_{0.15}, Fe_{0.15}][Si_7, Al]O_{20}(OH)_4 \times nH_2O$ refers to montmorillonite; and $K_{1.5}[Al_{3.8}, Mg_{0.02}, Fe_{0.03}][Si_7, Al]O_{20}(OH)_4$ [illite (Schlumberger 1988).

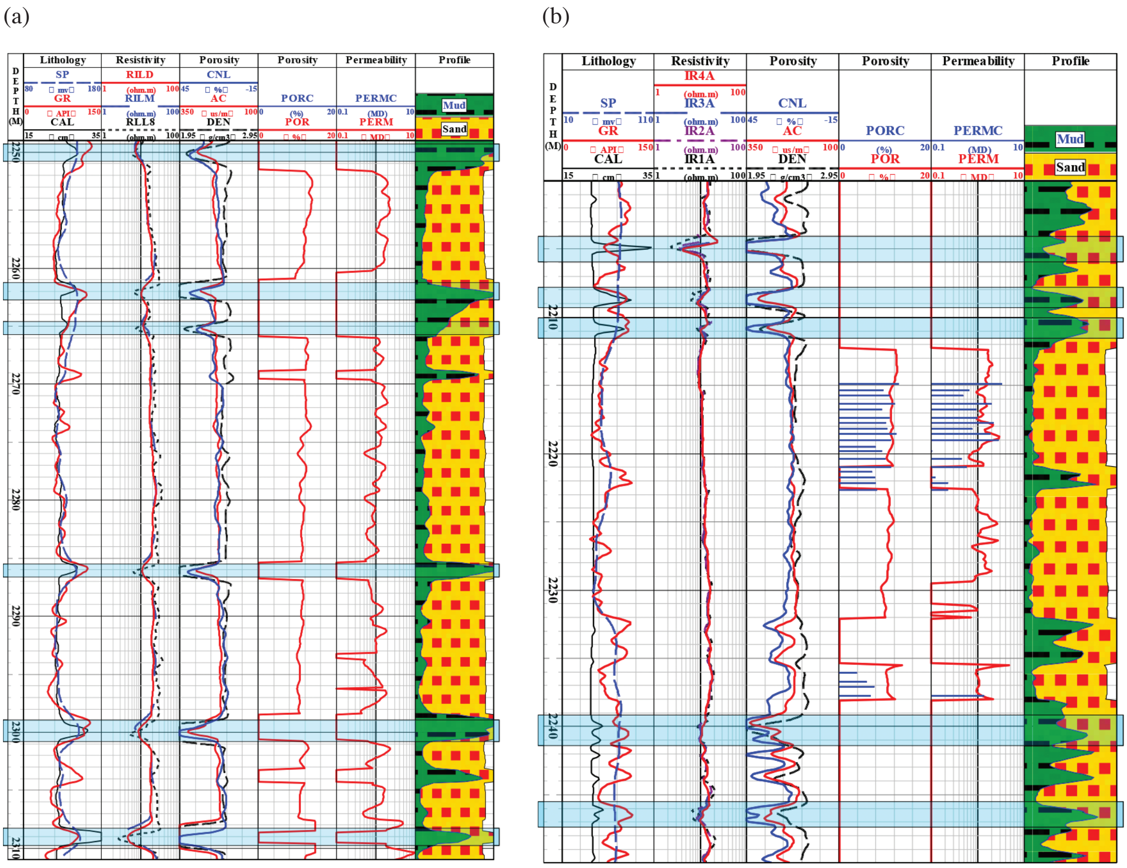

FIGURE 4. (a) Log interpretation plot of Chang 9 stratum in well Feng 4 and (b) Log interpretation plot of Chang 9 stratum in well An 87

It shows that during that process, Ca^{2+}, Mg^{2+} and Fe^{2+} get extracted, among which, Mg^{2+} and Fe^{2+} form into chlorite precipitation with silicate while Ca^{2+} , combined with silicate, becomes laumontite filling the pores at the same period.

The process of Chlorite precipitation formation reads as the following:

$$2Mg^{1+} + 2Fe^{1+} + 8Al^{1+} + 6SiO_1 + 32OH^- = [Mg_1, Fe_2, Al_6][Si_6, Al_2]O_{20}(OH)_{16} + 8H_2O, \tag{5}$$

where $[Mg_2, Fe_2, Al_6][Si_6, Al_2]O_{20}(OH)_{16}$ represents Chlorite (Schlumberger 1988).

The chemical equation which describes the process of Laumontite formation can be expressed as:

$$Ca^{2+} + 2Al^{3+} + 4SiO_2 + 8OH^- = Ca(Al_2Si_4O_{12}) \times 4H_2O, \tag{6}$$

where $Ca(Al_2Si_4O_{12}) \times 4H_2O$ stands for Laumontite (Schlumberger 1988).

Equations (5) and (6) reflect the consumption of Ca^{2+}, Mg^{2+} and Fe^{2+} in diagenesis process. During period A of late diagenetic stage, the effect of laumonite corrosion becomes obvious for a large amount of secondary pores were generated with Ca^{2+} released. Meanwhile, the connectivity of pore fluid drops and the chances of ion migration become smaller. Therefore, more Ca^{2+} get conserved in the formation water and an obvious variation of cation thus happens as shown previously. During all the above mentioned processes, ions in great numbers get released into water, which makes the formation water salinity even higher.

Hence, tuff alteration and later diagenesis were the main causes of high formation water salinity in Chang 9 stratum.

CAUSE OF LOW FORMATION WATER SALINITY

Low salinity area mainly located at the Eastern and Western part of Jiyuan oilfield, the western section of which spans Tianhuan Depression. Mostly, Chang 9 Reservoirs develop around three areas as Gu Fengzhaung, Hong Jingzi and Wu Jiamaozi (Figure 1). The formation water salinity there is generally lower than 15 g/L.

Among the 91 samples, 80 were $CaCl_2$ type isolated water. The rest belong to $MgCl_2$, $NaHCO_3$ or Na_2SO_4 type and they all come from low salinity area (Table 1). According to СулиН's formation water classification definition (Collins 1975), these water type changes were relevant to upper low salinity water. The difference of water

TABLE 1. Statistics of wells with unusual formation water types in Chang 9 stratum

Well name	Located Area	Salinity (g/L)	Water type
Hu 148	Wu Jiamaozi	4.83	Na_2SO_4
Hu 152	Wu Jiamaozi	5.55	Na_2SO_4
Hu 199	Wu Jiamaozi	6.90	Na_2SO_4
Xin 46	Wu Jiamaozi	15.38	$MgCl_2$
Feng 14	Gu Fengzhuang	8.53	Na_2SO_4
Feng 7	Gu Fengzhuang	8.73	$MgCl_2$
Feng 5	Gu Fengzhuang	8.80	Na_2SO_4
Huang 208	Hong Jingzi	10.67	$MgCl_2$
Huang 184	Hong Jingzi	14.09	$MgCl_2$
Huang 230	Hong Jingzi	19.51	$NaHCO_3$
Yuan 188	Qiao Chuan	13.38	$MgCl_2$

type between the adjacent wells with each other was due to the existence of faults and lithologic pinchout (Ma et al. 2013; Zulkifley et al. 2014a).

Adjacent to and above Chang 9 stratum, Chang 8 develops structural fractures diagenetic facies (Shi et al. 2011). Mainly, the fractures are perpendicular and appear in groups. Furthermore, Zheng (2006, unpublished) found 6 faults crossing Chang 7 and Chang 9 stratums in Gu Fengzhuang area (Duan et al. 2009). Besides, Cheng et al. (2012) discovered 21 normal faults in Chang 9, along Hong Jingzi area. These showed that fractures and faults exist between Chang 7 to Chang 9 in low salinity area.

From the above, it was raised that the development of fractures and faults in low salinity area made the hydrodynamic force get stronger, which resulted from the connection between formation water in Chang 9 stratum and upper low salinity water and that is the main cause of low formation water salinity.

GEOLOGICAL SIGNIFICANCE OF FORMATION WATER SALINITY COMPLEX VARIATION

Tuff alteration and later diagenesis bring Ca^{2+} to an unusually high level in formation water of high salinity area. Abundant Ca^{2+} was necessary for laumonite formation. By comparing the core slices from different areas in Chang 9 stratum, the laumonite cement content was found generally higher in high salinity area than that in other sections. Laumonite has an apparent effect on reservoir reconstruction. On the one hand, the formation and filling of laumonite cement prevent reservoirs from being further compacted. On the other hand, newly developed secondary pores from corrosion efficiently improve the storage capacity of low porosity and low permeability sandstone reservoir.

Due to poor physical property of Chang 8 reservoir, it was difficult for oil to directly flow from Chang 7 source rock to Chang 9 stratum through the connecting pores. However, the development of fractures and faults in low salinity area provided the transportation for the process. The test showed that most of the pay zones of Chang 9 stratum were located in or adjacent to low salinity areas, which corresponds to the viewpoints above (Zulkifley et al. 2014b).

Hence, Tuff alteration and later diagenesis were critical to reservoir reconstruction. Newly developed faults and fractures become an important role in oil transportation and storage.

CONCLUSION

Based on what has been studied in Chang 9 statum, Jiyuan oilfield, the following conclusions can be drawn:

In high salinity area, the rate of Na^{+}+K^{+} concentration increase slows down with total salinity accumulating, which is opposed to that of Ca^{2+}. Tuffaceous mudstone interlayers grow in most mudstone sections. In low salinity area, water types of some wells change from $CaCl_2$ to $MgCl_2$, $NaHCO_3$ or Na_2SO_4 type. In addition, fractures and faults develop here. Montmorillonite comes from tuff alteration. Its selective absorption on cation and ion migration result in a relative loss of Na^{+}+K^{+} and accumulation of Ca^{2+}, mainly. In the meantime, tuff alteration and later diagenetic process produce a large number of ions into formation water and those are the main causes of high formation water salinity. The development of fractures and faults in low salinity area enables formation water in Chang 9 connected with upper low salinity formation water and the hydrodynamic conditions gets improved accordingly, which leads to the low formation water salinity. Tuff alteration and later diagenesis have significance for reservoir reconstruction. The developed faults and fractures serve as both shipper and container during oil transportation and storage.

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APPENDIX

Statistics of wells with normal chemical analysis in Chang 9 stratum

Well name	K^++Na^+ (mg/L)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Cl^- (mg/L)	SO_4^{2-} (mg/L)	CO_3^{2-} (mg/L)	HCO_3^- (mg/L)	Salinity (g/L)
Hu 148	1436	147	52	1970	740	0	486	4.83
Hu 152	1288	453	75	1000	2666	9	54	5.55
Yuan 152	1800	491	5	3290	23	0	590	6.20
Yuan 153	2004	460	62	3799	122	0	333	6.78
Hu 199	2307	224	40	3482	582	0	268	6.90
Hu 157	2068	587	61	3713	611	0	414	7.45
Feng 10	2328	675	32	4738	124	0	76	7.97
An 65	16	2930	31	5133	0	0	283	8.39
Feng 14	2608	533	5	3926	1311	0	143	8.53
Feng 7	2747	453	37	4242	1111	0	139	8.73
Feng 5	2687	574	0	4138	1310	0	90	8.80
Huang 162	2495	840	57	5016	560	0	117	9.09
Huang 50	2645	824	85	5208	711	0	85	9.56
Huang 153	2997	930	66	4980	1573	0	107	10.65
Huang 208	2974	956	0	5062	1527	0	146	10.67
Xin 36	2967	1040	60	6270	119	0	394	10.85
Huang 149	3033	1149	166	6061	1442	0	115	11.97
Huang 138	1524	1028	958	8543	205	0	105	12.36
Geng 73	3401	1412	122	7752	300	0	212	13.20
An 67	4389	671	5	7480	178	101	404	13.23
Yuan 188	4026	865	30	6242	1873	0	341	13.38
Huang 184	4857	1121	0	7542	448	0	122	14.09
Xin 15	2935	2362	6	8597	16	0	193	14.11
Yuan 108	2613	1170	67	10781	22	0	485	15.14
Xin 46	4679	632	256	7300	2021	0	491	15.38
Chi 40	4234	1424	35	6645	2968	226	0	15.54
Feng 6	4129	1891	31	9297	613	0	87	16.05
Luo 29	3896	1988	143	9854	0	0	179	16.06
Chi 64	4791	1238	90	9265	356	0	532	16.27
Gao 13	3554	2475	90	9605	594	0	131	16.45
Feng 2	5002	1202	61	9225	733	0	428	16.65
An 205	4126	985	99	11702	404	0	153	17.47
Geng 80	4572	1927	24	9991	644	0	106	17.26
An 83	4575	1927	24	9991	644	0	106	17.27
Zheng 18	4945	1583	24	9479	841	0	214	17.09
An 98	4945	1583	24	9749	841	0	214	17.36
Huang 129	5141	1411	19	9068	1849	0	73	17.56
Luo 8	117	6608	31	11891	2	0	113	18.76
Chi 13	4522	2556	62	11385	95	0	375	19.00
Huang 230	7281	1023	426	8354	2301	0	120	19.51
Luo 225	4166	3064	133	11555	787	0	160	19.87
Chi 39	4789	3137	24	12820	0	0	314	21.08
Huang 157	5389	2826	99	12561	1156	0	307	22.34
An 25	6760	1713	67	12400	1369	0	406	22.72

An 26	3594	3151	10	16332	32	0	290	23.41
Huang 142	5600	3380	60	14674	0	0	191	23.91
Huang 223	6210	2495	354	13202	2363	0	124	24.75
Huang 167	5884	3269	189	14537	1119	0	65	25.06
An 40	5526	2395	298	16624	536	0	155	25.53
Feng 11	6107	3529	95	15695	249	0	92	25.77
Luo 6	6313	3427	24	14871	1273	0	90	26.00
Zheng 23	7864	2134	55	15048	768	0	757	26.63
An 75	5171	4840	61	16489	0	0	382	26.94
Feng 12	7511	3998	182	19118	6	0	100	30.92
Huang 255	7394	4125	183	18119	1447	0	68	31.34
Huang 41	7580	4211	150	17317	2968	0	107	32.33
Luo 34	7193	5451	114	20207	1057	0	130	34.15
Chi 38	5961	6703	46	21256	0	0	96	34.06
Huang 156	6542	5759	378	20465	1119	0	139	34.40
Chi 50	7647	3417	1481	21946	0	0	351	34.84
Luo 51	7509	6641	32	22382	1263	0	171	38.00
Feng 3	8066	6371	0	23631	38	0	76	38.18
Huang 114	8632	391	3873	22883	3146	0	156	39.08
Chi 24	6677	8134	0	24567	38	0	148	39.56
Chi 46	7185	7692	31	24667	14	0	161	39.75
Chi 232	6450	8216	78	24572	247	0	255	39.82
Huang 176	6743	8320	107	25311	0	0	194	40.68
An 66	5889	9041	150	24767	890	0	145	40.88
Chi 83	10254	3058	845	25461	1452	0	138	41.21
Luo 45	13934	1961	113	24879	448	0	115	41.45
Chi 238	8836	7344	92	26172	843	0	143	43.43
Huang 143	7773	7425	901	25056	3559	0	102	44.82
Feng 13	6795	10727	210	29691	415	0	107	47.95
Chi 237	8299	8608	853	29324	1263	163	0	48.51
Chi 48	10739	7730	67	29246	1513	47	7	49.35
Yang 41	7575	10428	189	26205	5968	0	109	50.47
Chi 63	16765	2868	157	29778	1921	0	299	51.79
Chi 60	8880	10110	128	29902	2618	0	188	51.83
Huang 206	9067	10997	33	32288	1573	0	131	54.09
Chi 70	11217	9227	178	33960	29	0	253	54.86
Chi 45	7347	12656	152	34394	0	0	48	54.60
Chi 47	19301	1974	419	31905	3218	0	317	57.13
An 45	10761	10436	192	34721	1136	0	80	57.33
Huang 234	19806	6539	183	35928	0	0	652	63.11
Chi 81	10483	12870	200	38246	1582	0	160	63.54
Huang 53	12349	11637	146	39350	768	0	219	64.47
Chi 270	14962	9930	194	28856	1633	0	19160	74.74
An 68	11441	16999	24	47566	0	0	60	76.09
An 87	8107	20942	146	49258	817	0	181	79.45
Chi 55	27375	4290	701	50112	1977	0	437	84.89
Chi 86	17775	15840	1201	55332	4745	0	146	95.04