HYDROGEN SULFIDE ACCUMULATION FACTORS IN COAL MINE OF SOUTHEASTERN MARGIN OF JUNGGAR BASIN IN CHINA

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Abstract. Hydrogen sulfide provides an abundance anomaly in many coal mines (districts) in southeastern margin of Junggar basin in China. There are three sets of source rocks in this area, where the coal bearing strata mainly involve low metamorphic bituminous coals of the Xishan formation and the Badaowan formation with less than 45°C geotemperature, which is beneficial to the propagation of Sulfate-Reducing Bacteria. The average Sulfate-Reducing Bacteria value of samples is 791 grams / sample. Along with the runoff direction, the salinity and pH value of groundwater gradually increase. And the hydrochemical types of groundwater are evolved into HCO_3-SO_4-Cl-Na by HCO_3-Ca-Na and HCO_3-SO_4-Na-Ca, with the main components of $NaHCO_3$. In a reducing environment and with the hydrocarbon abundance, the bacterial sulfate reduction is prone to occur and H_2S is likely to form. Meanwhile, the better pore types of the reservoir are mainly the intergranular pore and intragranular dissolved pore. The average porosity of each coal seam is about 8.5% / porosity values are medium, the average permeability is (5.36×10-3~11.6×10-3) um2 / permeability values are low. The top and bottom slates of coal seam are mainly composed of fine clastic rock and low permeability barrier with the characteristics of good sealing ability. All of this provides a wide space for the reservoir of H_2S, under the action of groove type subsidence structure, uplift type relief structures and the hydrodynamic control of methane. Two types of H_2S accumulation mode of northward monoclinic and imbricated fan-shaped ware formed in specific geological condition.
Keywords: hydrogen sulfide (H_2S), control factors, accumulation model, underground water, regional structure

Introduction

Many mining areas in the southeastern margin of the Junggar basin are abundant anomaly with H_2S, resulting in many casualties (Deng et al., 2017). The accumulation model of H_2S in regional coal mines is explored to study the formation, accumulation, and preservation of H_2S in the area in order to provide geology-geochemical basis for occurrence characteristics and prevention of H_2S in coal rock. At present, domestic and foreign scholars have conducted many researches on the H_2S accumulation model in oil and gas from the aspects of regional structure, reservoir characteristics, sedimentary

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systems, etc. (Zhu et al., 2006; Fei et al., 2010; Fu et al., 2006; Cai et al., 2009). However, there are few studies on the accumulation mode of H_2S in coal mine. The purpose of this study is to find the controlling factors of hydrogen sulfide occurrence in this region and provide the research basis for the treatment and the genesis of hydrogen sulfide.

Methods

Collect data according to drilling data, seismic interpretation data, engineering geology, etc. Analyze features of regional geological, sedimentary and structural evolution. Identify regional features and hydrogen sulfide distribution status.

According to the regional geological characteristics, combined with the nature of hydrogen sulfide reservoir, underground water activities in coal mine and chemical characteristics of underground water (hot spring), the storage conditions of hydrogen sulfide gas and the control factors of abnormal enrichment were identified.

Structural geological background

The southeastern margin of Junggar basin lies between the Santun river and the Sigong river in Fukang county. Located in the middle-east section of the Urumchi front depression, its structural division belongs to the front depression area of south margin of Junggar basin with the formation of north steep slope (dip angle of 70~80°) and the shape of the southern latitude (dip angle 40~50°) (Qin, 1987). Regional distribution ranges from Liuhuanggou in the east to Shuimogou and Sigong River in the west via Toutun river, Xishan coal mine and north of Urumchi city. The regional geology conditions is summarized in *Figure 1*.

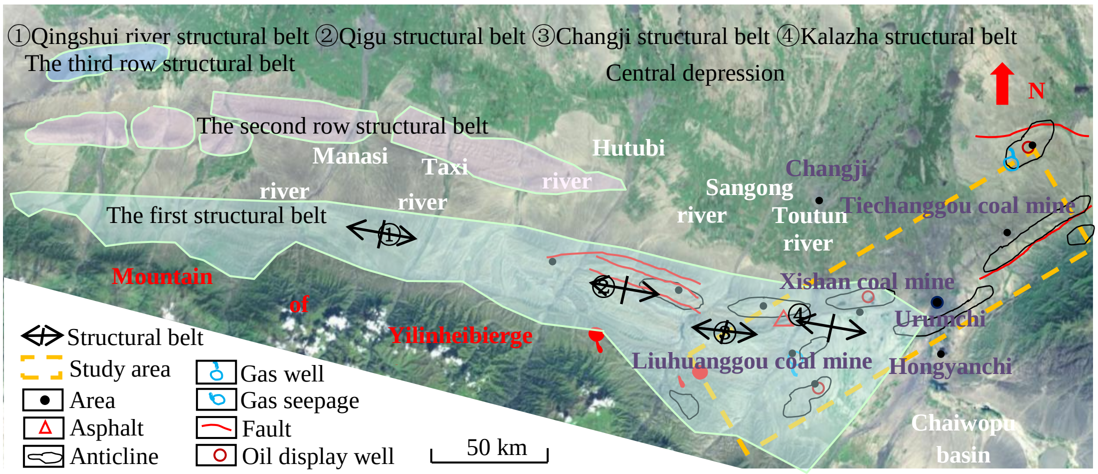

Figure 1. *Regional geology conditions*

The low-metamorphic bituminous coal was mainly developed in Xishanyao formation (J_2x) and Badaowan formation (J_1b) of early-middle Jurassic (Tian and Yang, 2011) in this district. The Badaowan formation contains 8~50 layers of coal seams with 8~12 layers of minable coal seams and its total thickness of 14.9~22.8 m. Xishanyao formation contains 3~57 layers of coal seams with 12~20 layers of minable coal seams and its total thickness of 35.6~145.8 m.

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Formation mode of H_2S

H_2S can be generated through biochemical degradation of early peat accumulation, bacterial sulfate reduction (BSR) in peat accumulation period and at the stage of coal formation, thermochemical sulfate reduction (TSR) during coal evolution, thermal decomposition sulfides (TDS) and magma (volcanic eruption) activity (Liu et al., 2012; Machel, 2001; Worden et al., 1995).

This region have formed 3 sets of effective source rocks of the Lower Cretaceous Tugulu Group, Middle and Lower Jurassic Period (Badaowan formation and Xishanyao formation) and Middle Permain (Guo et al., 2013). The intensity of source rocks gas-generation in the Middle Permian can reach to 5.0×10^8~40.0×10^8 m^3/km^2. The average organic carbon content of dark mudstone in source rocks in the Middle-Lower Jurassic is 15.51%. And the average organic carbon content in coal is as high as 64.49%. The source rocks isopaches of Lower Jurassic is shown in *Figure 2*, in which the organic matrix of Xishanyao formation, mainly composed of 0-II humus, is in a low mature-mature stage. The abundant source rocks provide a solid material basis for the production of H_2S.

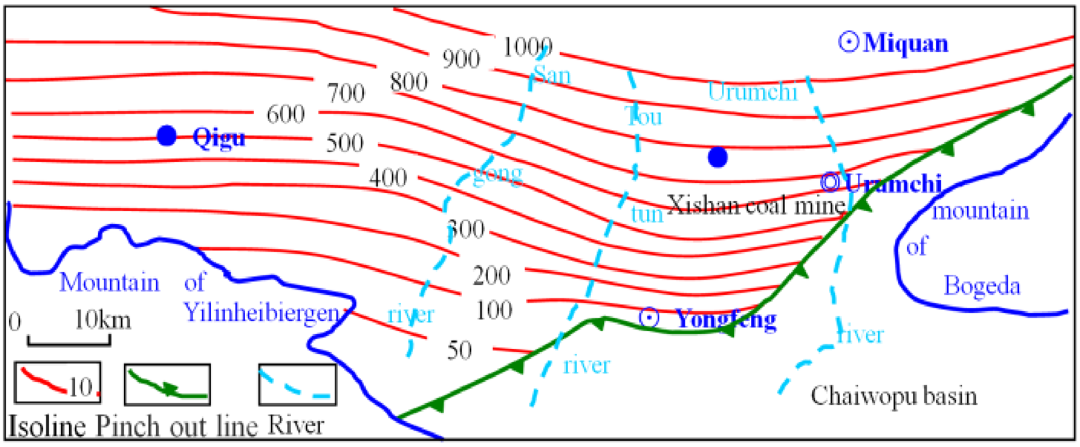

***Figure 2.** Source rocks isopaches of Lower Jurassic*

In southern region, the melted snow and ice on the peak of Yilinheibiergen Mountain and Bogeda Mountain flow along the direction of runoff. During its infiltration and runoff, the water dissolves and lixiviates with the anorthite and albite, which is likely to occur chemical reactions, as shown in *Equations 1-4*. Under strong drought evaporation, it may form the high salinity waters type of HCO_3-Ca-Na, HCO_3-SO_4-Na-Ca and HCO_3-SO_4-Cl-Na-K.

$$CaCO_3\cdot 2Al_2O_3\cdot 4SiO_2(\text{Anorthite})+2CO_2+5H_2O \rightarrow 2HCO_3^-+Ca^{2+}+2H_4Al_2Si_2O_9 \quad \text{(Eq.1)}$$

$$Na_2Al_2Si_6O_{16}(\text{Albite})+2CO_2+3H_2O\rightarrow 2HCO_3^-+2Na^{2+}+2H_4Al_2Si_2O_9+4SiO_2 \quad \text{(Eq.2)}$$

$$CaSO_4\rightarrow Ca^{2+}+SO_4^{2-} \quad \text{(Eq.3)}$$

$$NaCl\rightarrow Na^++Cl^- \quad \text{(Eq.4)}$$

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Most of coal seams are low rank coal with the shallow buried depth in the region. And in the coal and rock formations, the microbial activity is more common. From the sampling depth of 254~750 m in each mine, the measured number of Sulfate-Reducing Bacteria (SRB) was (100~3500) /g·samples with an average of 791 /g·samples. In the Xiaolongkou coal mine, the measured number of SRBs was 3500 /g·samples at 312 m below the well. The number of SRBs was 528 /g·samples at 750 m below in the Xishan coal mine and the number of SRBs was 650 /g·samples at 209.5 m below in the Beishan coal mine. It shows that the current depth of mining is conducive to the proliferation of SRB (Deng et al., 2018).

The groundwater environment of coal mine in the region is well-sealed. In the reducing environment, the influence of SRB and the sufficient hydrocarbon organic matter (∑CH, C), BSR may occur (Headd and Engel, 2013), and then H_2S is formed. Its possible reactions are showed in *Equations 5-8*.

$$\sum CH(C)+SO_4^{2-}+H_2O \rightarrow H_2S\uparrow+CO_2\uparrow+CO_3^{2-} \quad \text{(Eq.5)}$$

$$CH_4+SO_4^{2-} \rightarrow HS^-+HCO_3^-+H_2O \quad \text{(Eq.6)}$$

$$CH_4+CaSO_4 \rightarrow CaCO_3\downarrow+H_2S\uparrow+H_2O \quad \text{(Eq.7)}$$

$$CH_4+SO_4^{2-} \rightarrow CO_2\uparrow+S^{2-}+2H_2O \quad \text{(Eq.8)}$$

A series of BSR actions will promote calcium ions in water to form calcium carbonate crystals, which are conducive to the positive direction of the reaction. From the south to the north in the coal mine of the area, the cation of Ca^{2+} decreases from 57.8% to 21.2% of deep confined water, which confirms the above reaction process. The underground (spring) water in the area mostly is alkaline water, and the H_2S is soluble in water, so there may be two ionization balance formulas shown in *Equations 9-11*.

$$H_2S+OH^- \leftrightarrow HS^-+H_2O,\ HS^-+OH^- \leftrightarrow S^{2-}+H_2O \quad \text{(Eq.9)}$$

$$H_2S \leftrightarrow H^++HS^-,\ E_1=c(H^+)\cdot c(HS^-)/c(H_2S)=5.7\times10^{-8} \quad \text{(Eq.10)}$$

$$HS^- \leftrightarrow H^++S^{2-},\ E_2=c'(H^+)\cdot c(S^{2-})/c(HS^-)=1.2\times10^{-15} \quad \text{(Eq.11)}$$

In above equations, the E_1, E_2 is an ionization equilibrium constant of H_2S and HS^-. $c(H^+)$, $c(HS^-)$ is the concentration of H^+ and HS^-, which is ionization produced by H_2S. $c(H_2S)$ is the H_2S concentration of unionized. $c'(H^+)$, $c(S^{2-})$ is the concentration of H^+ and S^{2-}, which is ionization produced by HS^-. According to the *Equation 10* and *Equation 11*, a relationship between molar ratio of three form sulfur with pH value in the aqueous solution can be drawed, shown in *Figure 3*. So, with the rising of sulfide (H_2S) content, the concentration of HS^- increases respectively, and so does the concentration of OH^- with the hydrolysis of HS^-, namely, the increase of pH value can also promote the further ionization or dissolution of H_2S, further then the solution of H_2S prompts the continuous increase of content of S^{2-}. Thereby, the formation water in this region goes into a cyclic process in which the amount of sulfide content (H_2S) raises continuously and a process in which the pH value will rise slowly.

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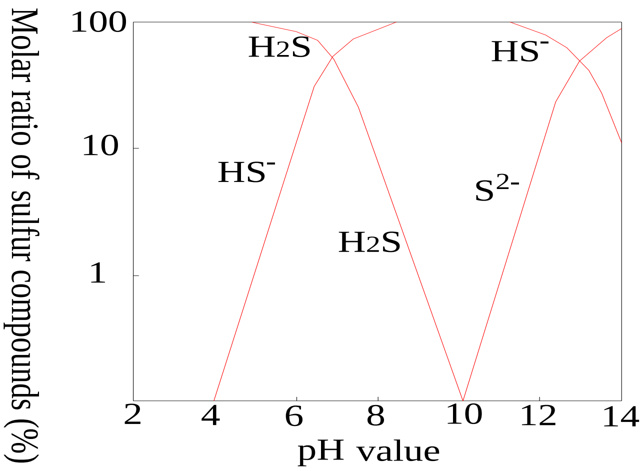

Figure 3. *The relationship between molar ratio of sulfur with pH value*

After recharging the surface water (ice and snow), the groundwater flows centripetally from the south to the north and gradually flows into the deep. At the same time, the poor continuity of the surrounding rock sand body leads to the slow or stagnant of the underground water in the coal bearing area. Therefore, up-escaping H_2S was blocked in the coal rock. Meanwhile, the slow motion of groundwater carrying H_2S to deep migration is blocked, which results in H_2S abundant enrichment in the coal rock and water. In the vicinity of the fault, the formation water is blocked and the water containing H_2S is exposed to the surface. The formation mode of H_2S in the region is shown in *Figure 4*.

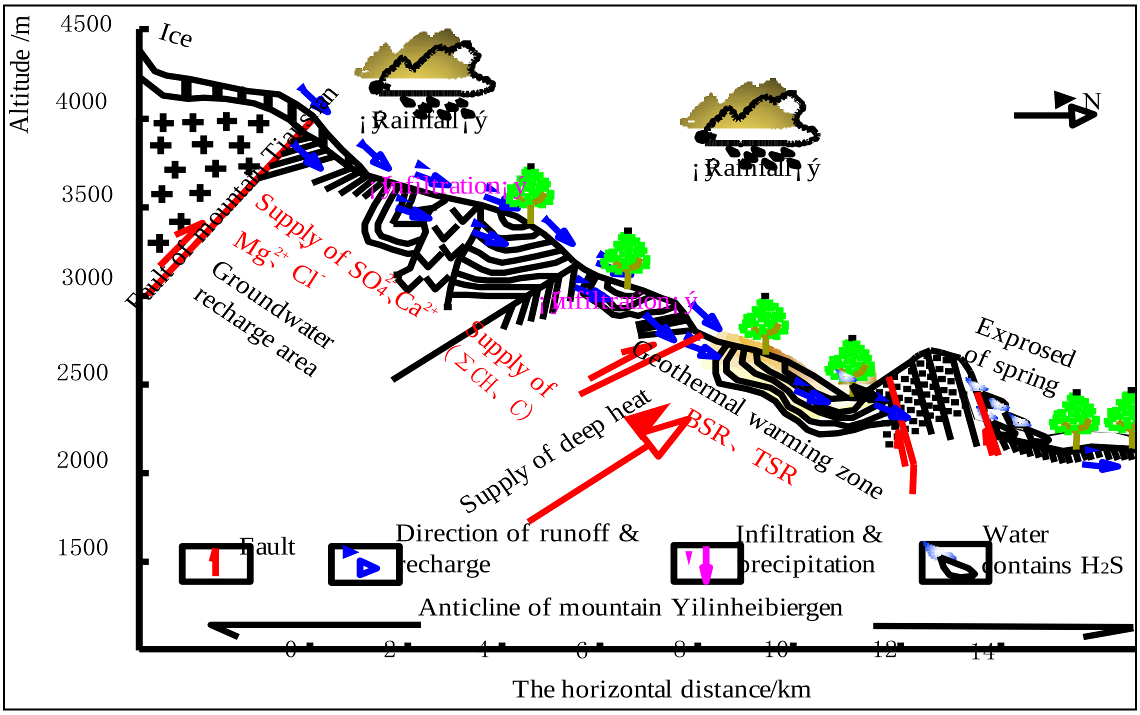

Figure 4. *Formation mode of H_2S in study area*

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Control factors of H_2S accumulation

Control effect of regional structure on H_2S accumulation

Palaeotectus and neotectonics are two main factors controlling H_2S distribution and reservoir (Zhu et al., 2006; Cai et al., 2009). The southeastern margin of Junggar basin, as the succession of depression structure of Mesozoic and Cenozoic, experienced polycyclic tectonic, deposited a thick deposit of source reservoir cap assemblage, created many sets of H_2S-friendly source reservoir cap assemblage, and formed a variety of favorable gas traps. The forelang thrust belt structure leads to the strong extrusion, the universal development of the reverse fault, the coexistence of the anticline and the fractures or the cut from the fractures, which is indusive to the preservation of H_2S. Due to the compression and torsion of the Himalayan movement, the closed-architectural structure of the study area was mainly characterized by broken anticline traps and broken nose traps with the main features of more layers, larger areas, and higher closure. There are many inversion tectonic movements in the region, and the anticline formed by reverse structure is directly covered by the sag of H_2S in the raw storage, which is beneficial to the preservation of H_2S. The long-term faults caused by various tectonic movements provide the necessary access and extensive storage space for H_2S migration, which is beneficial to the reservoir of H_2S.

Regional tectonic movement controls the distribution of H_2S reservoir. The development of structure has created many favorable traps of gas. Abundant source rocks have provided a solid material foundation for the formation of H_2S. The depression structure has created favorable geological conditions for H_2S reservoir. Therefore, the region has a good configuration relationship in the space of H_2S generation, migration and enrichment conditions (source reservoir cap assemblage).

Control effect of the development of caprock on H_2S accumulation

The performance of the caprock in the study area is relatively stable and there are three sets of favorable reservoir and caprock combinations. In each layer, shore-lacustrine, fluvial and delta facies are widely developed, and there widely exist sandstone, siltstone and alluvial fan conglomerate, glutenite and other coarse detrital deposits. Among them, the Mesozoic coal source is the main source rock, with the basic feature of self-generated self-storage combination. In the Sangonghe formation, the Xishanyao formation and the Toutunhe formation of Jurassic, the reservoir lithology is a proven good reservoir which mainly are fine sandstone and quartz feldspar lithic sandstone and mixed sandstone. The porosity of each coal seam in the south of Changji is 0.21~16.42% and the average is 8.41%. The permeability is between 0.22×10^{-3}~23.2×10^{-3} um^2, the average is 11.6×10^{-3} um^2. The porosity of each coal seam in the Liuhuanggou mining area is 4.12~15.91% and the average is 8.71% and the average permeability is 2.12×10^{-3} um^2. The average porosity of each coal seam in the east of the Urumchi river is 8.51%, the average permeability is 5.36×10^{-3} um^2 and the physical characteristics of the regional reservoir are shown in *Table 1* (Deng, 2015; Deng et al., 2017) The reservoir is mainly composed of intergranular pores and intragranular dissolved pores with the characteristics of medium porosity and low permeability reservoir, fractured pore type and the low cap rock permeability. It is clear that the regional medium - good reservoir has a wide range of distribution, which provides a broad favorable space for the reservoir of H_2S.

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Table 1. *Reservoir bed properties of foreland thrust belt in study area*

Horizon	Lithology	Average thickness (m)	Porosity (%)	Permeability (10^{-3} um^2)
Tugulu group (K_1tg)	Mainly with purple red, gray green mudstone and siltstone	449~1525	6.60	18.86
Kalazha formation (J_3k)	Gray, yellow massive gray wacke, siltstone are cross bedding	50~750	16.12	122.30
Qigu formation (J_3q)	Brown red, purple red mudstone with purple red, gray green sandy mudstone and tuff	183~824	9.53	15.38
Toutunhe formation (J_2t)	Variegated sandy mudstone, sandstone and fine conglomerate	210~804	10.49	57.51
Xishanyao formation (J_2x)	Grey green, yellow, black & gray fine sandstone, siltstone, sandstone and coal seam	380~1080	7.91	0.16
Sangonghe formation (J_1s)	Gray, gray yellow, green mudstone, sandstone, a small number of thin coal seams	565~782	8.31	5.13
Badaowan formation (J_1b)	Sandstone, siltstone, mudstone and thin coal seam	245~850	9.00	3.25
Xiaoquangou group ($T_{2+3}xq$)	miscellaneous sand, muddy debris, and the lower part of coarse clastic rock and miscellaneous sandstone	500~1000	5.95	0.15

According to the observation and data collection of the fracture from the original coal seam, the fissure development characteristics of the original coal seam are shown in *Table 2* (Deng, 2015; Deng et al., 2017). The fracture of coal seam mostly is primary structure. The distribution of fracture density is up to (50~250) /m with the good openess and connectedness of the fracture. Most of them are not filled with minerals, which increase the permeability of coal seams. Hence, it provides a favorable space for the migration and storage of H_2S in coal seams.

Table 2. *Fractured situation of raw coalbed in area*

Observation point	Type of coal and rock	Fracture group	Fracture frequency	Length (cm)	High (cm)
Xishan	Bright and semi bright coal	Main fissure	18strip/10cm	>10.0	4~7
		Secondary fissure	6strip/10cm		<1
Dapugou	Bright coal	Main fissure	25strip/15cm	>10.0	2~5
		Secondary fissure	22strip/8cm	0.2~4.0	<1
Shengli	Semi bright coal	Main fissure	7strip/10cm	27.0	3~8
			9strip/10cm		
Qianshui river mining area	Bright coal	Main fissure	15strip/15cm	25.0	>10
		Secondary fissure	22strip/10cm	0.3~3.0	<1
	Semi bright coal	Main fissure	10strip/10cm	>10.0	1~4
		Secondary fissure	8strip/10cm		<1

It is known that the development of the coal and rock type from bright to semi bright, half dark and dim in microfissures gradually diminishes. The coal seams in the region are mainly bright coal and semi-bright coal, indicating that regional coal reservoirs are conducive to the accumulation of H_2S in coal reservoirs.

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The lithology combination of the coal seam roof and bottom is classified into two categories. The first type is coarse clastic rock, including conglomerate, coarse sandstone and medium sandstone. The second type is fine clastic rock, including siltstone, mudstone, and shale. According to the classification method mentioned above, the results of the lithology of the roof and floor of the main coal seams in the region are shown in *Figure 5*.

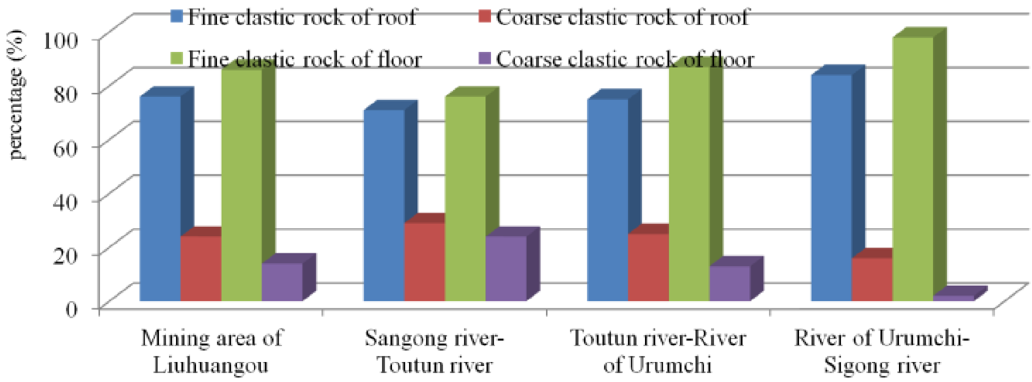

Figure 5. *Proportions schematic of roof and floor lithological in regional coal seam*

It is shown that the ratio of top and bottom microclastic rock accounts for over 67.2%, and the bottom plate from the Urumchi river to Sigong river reaches 98.1%. In the Toutun river area and the Liuhuanggou mining area, the proportion of roof clastics are 75.4% and 76.2%, respectively and the ratio of clastic rock are 87.0% and 86.3% in the bottom plateau. It is known that the roof and bottom slate of the coal seam mainly composed of microclastic rock is a low permeability barrier layer with poor permeability and good sealing condition. Therefore, the combination of the roof and bottom slate in the regional of Jurassic coal seam is an effective combination of source reservoir cap assemblage of H_2S.

Control effect of buried depth and ground temperature on H_2S accumulation

The contents of hydrogen sulfide and gas were determined by sampling in different buried coal seam of Xishan coal mine in 2013. When the coal seam depth is less than 350 m, the content of gas and H_2S is generally small in each coal mine. When the buried depth is less than 420 m, the methane concentration in the gas components is generally less than 80%. When the buried depth is more than 420 m, the methane fraction of the gas is more than 80%, indicating that the depth of the coal seam gas weathering zone is about 420 m. When the buried depth of coal seam is more than 650 m, the content of gas and H_2S increases rapidly. With the increase of buried depth of coal seam, the gas content of coal seam becomes better, the component of methane rises and the content of H_2S becomes larger. It shows that the content of H_2S has a positive correlation with the buried depth.

Barker and Pawlewicz established the relationship between the maximum paleo temperature and the vitrinite reflectance of coal (Barker and Pawlewicz, 1986):

$$\mathrm{Ln}R_0=0.0078*T_{\max} - 1.2 \qquad \text{(Eq.12)}$$

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In the formula, R_0 is the vitrinite reflectivity of coal, T_{max} is the maximum paleo temperature. The isoline of the region R_0 distribution feature is shown in *Figure 6*. It can be deduced that the maximum paleogeo-temperature range of the coal formation stage is approximately between 80.0 °C and 110.0 °C.

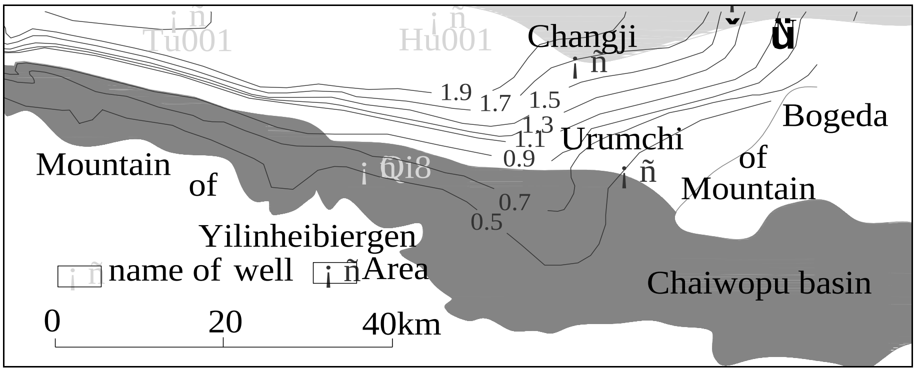

Figure 6. *Choropleth of vitrinite reflectance of coal*

The current geotempreture gradient in the region is (1.4~2.0) °C/100m (Guo, 2010; Wang et al., 2000). It can be inferred that the temperature distribution of the 3000 m coal rock layer in the current depth is shown in *Figure 7*. The depth of coal seam buried at present is generally 200~1500 m and the geotempreture is less than 45 °C, which is beneficial to the reproduction of SRB.

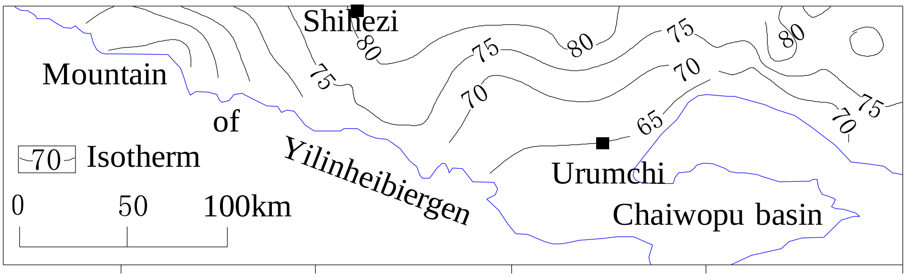

Figure 7. *Contours of temperature in 3000 m depth of Junggar basin*

Control effect of groundwater on H_2S accumulation

The attitude of water storage structure in the front of the piedmont is influenced by neotectonic. The activity of groundwater affects the enrichment and migration of H_2S. The basement of the regional plain mainly consists of two kinds of groove settlement and uplift, as shown in *Figure 8*. In the piedmont depression or fault zone, a huge sand-gravel layer (aquifer) was accumulated in the Quaternary Period. And above and below the coal-bearing strata of Xishanyao formation, there are good water-retaining layers. The water converges into the basin depression under the action of gravity, resulting in a stagnant and closed state of the groundwater in the coal reservoir within the zone. The H_2S is sealed and stored under the effect of hydrodynamic sealing and gas control.

The salinity of underground water of regional coal mine is between 1.2 g/L and 7.1 g/L with the feature of weak alkaline. In Toutunhe basin, along the runoff direction, the hydrochemical types of groundwater are evolved into HCO_3-SO_4-Cl-Na by HCO_3-Ca-

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Na and HCO_3-SO_4-Na-Ca, with the main components of $NaHCO_3$. Salinity and hardness increase from low to high, salinity rapidly from less than 1.0 g/L to more than 7.0 g/L; and the pH, from 8.1 to 9.3 (Duan et al., 2007; Tian et al., 2017; Li et al., 2016; Chen et al., 2013). The chemical characteristics of the groundwater in each coal mine (area) from the south to north basin are shown in *Table 3* (Deng, 2015; Deng et al., 2017). $NaHCO_3$ type-water often indicates stable water environment. Water formed under the environmental conditions of the mainland is also a sign of oil in the oil and gas fields and one of the important symbols of reducing environment, which indicates that the underground aquifers are in a reducing environment in the region.

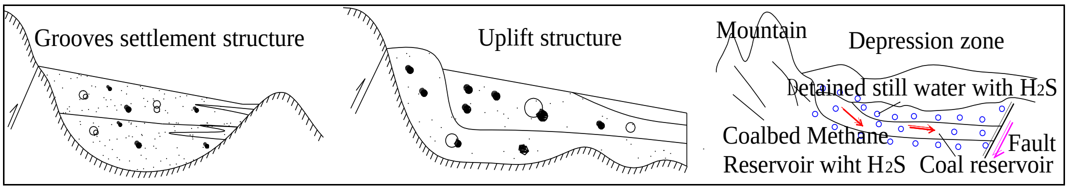

Figure 8. *Changes schematic of piedmont base and hydrodynamic action of coal bed methane*

Table 3. *Groundwater chemical characteristics*

Mining area	**Daxigou area**	**Qianshui river area**	**Liuhuanggou mining area**	**Xishan coal mine**
Hydrochemical type	SO_4-Cl-HCO_3-Ca	SO_4-Cl-Na	SO_4-Cl-K+Na	Cl-SO_4-K+Na
Salinity(g/L)	1.1	1.6	3.5	6.2
H_2S content (mg/L)	7.89~25.32	9.26~51.29	23.89~69.45	41.89~259.63
pH	8.3	8.5	8.5	9.0

Accumulation model of H_2S

Geological structure controls the source reservoir cap assemblage of hydrogen sulfide. Under special geological conditions, two types of H_2S accumulation patterns are formed in the region of the northward monoclinic and the imbricated fan-shaped.

H_2S accumulation model of northward monoclinic

The north single oblique H_2S accumulation model is widely distributed in the east of Urumchi. Hydrogen sulfide accumulation is mostly controlled by hydrogeological conditions. The monoclinic south-wing collects the water from rivers and glaciers. The environment of the detention zone of well sealed, the high degree of groundwater salinity and the poor water flow is conducive to the proliferation of SRB. On the water vapor (solid) interface, the occurrence of BSR action forms H_2S, then it is dissolved into water or diffused into the gas, and it migrates with the flow of water to the deep part of the coal bedrock (Cross et al., 2004; Krouse et al., 1988; Cody et al., 2000; Wei et al., 2014). Meanwhile, the poor continuity of the surrounding rock sand-body causes the slowness or the stagnant of the groundwater of the coal-bearing areas. Therefore, the H_2S diffusing upward in coal rock will be blocked. At the same time, the slowness of groundwater carries H_2S to the deep part and H_2S will be blocked, resulting in anomalous enrichment of H_2S in coal rock and water (Zhu et al., 2010; Zhu et al., 2014; Dai et al., 2004; Qiao et al., 2005). The H_2S accumulation model of northward monoclinic is shown in *Figure 9*.

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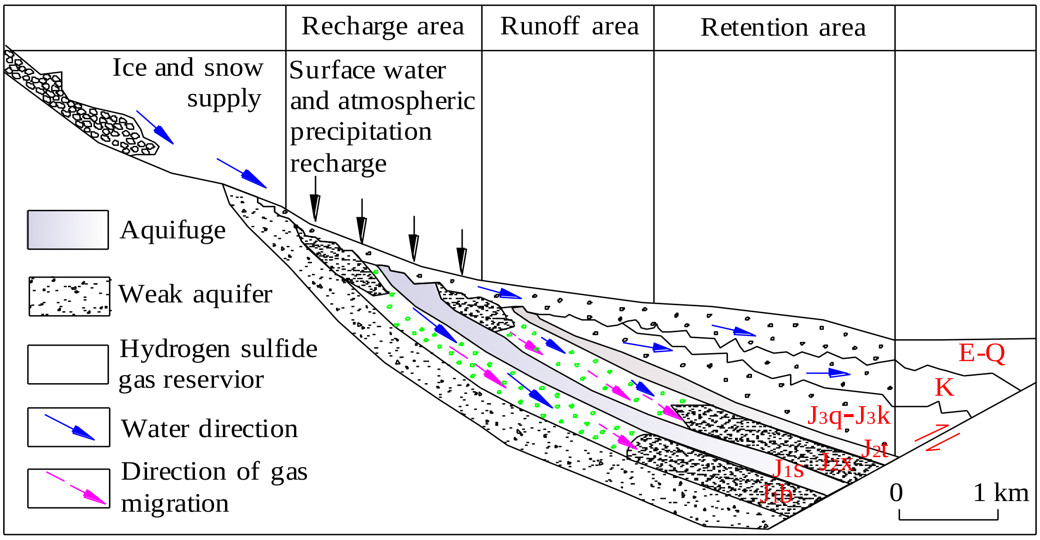

Figure 9. *H_2S accumulation model of northward monoclinic*

H_2S accumulation mode of imbricate type

The imbricate pattern of H_2S accumulation mainly occurs in the Xishan coal mine area of west Urumchi. The area is affected by Urumchi -Miquan strike slip fault, which developes trust nappe structure belt. It is a kind of fracture where one side of the fracture breaks perpendicular to the fracture surface. The most obvious structural feature is echelon anticline distribution, which is in a strong, imbricate pattern (Fan et al., 2012; Wang et al., 2013; Deng et al., 2002; Xu et al., 2001; Qu et al., 2009; Fang et al., 2006). It is shown in *Figure 10*.

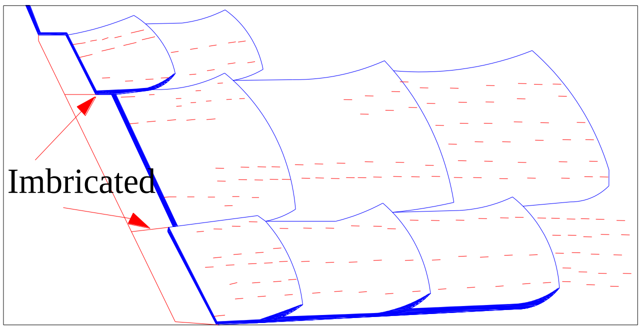

Figure 10. *The schematic diagram of imbrication*

The H_2S is produced by the action of BSR. Part of H_2S meets the metal ions and reacts with them and form a new product. Part of H_2S is integrated into the water, which moves slowly to the deep and forms hydrosulphuric acid so that the water is rich in H_2S. Part of H_2S is mixed into the gas of coal and rock strata, vertical or longitudinal migration along the gas source fracture to the depression part, resulting in an abnormal H_2S enrichment in coal rock strata. Most of the regional faults are relatively independent structural systems and are mainly thrust faults. The H_2S accumulates of imbricated fan-shaped is shown in *Figure 11*.

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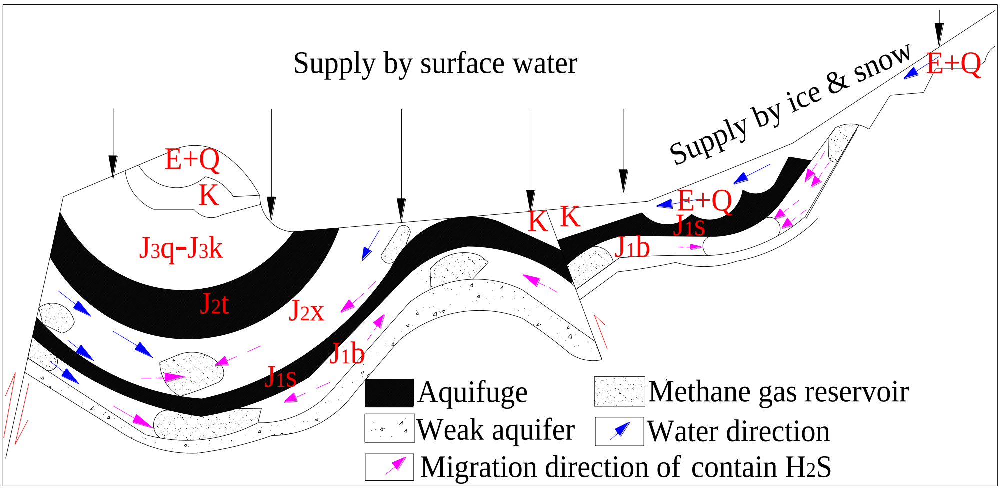

***Figure 11.** H_2S accumulation model of imbricated fan-shaped*

Discussion

BSR, TSR and magmatic activity are the main genetic types of hydrogen sulfide in coal mine. The genetic recognition pattern of hydrogen sulfide in coal mine can be established according to the characteristics of coal environment, coal rock thermal evolution history and gas composition.

The depth of coal seam buried at present is generally 200~1500 m and the geotempreture is less than 45 °C, which is beneficial to the reproduction of SRB. Along with the runoff direction, the salinity and pH value of groundwater gradually increase.

According to the characteristics of reservoir lithology, chemical characteristics of groundwater, temperature of coal-series strata, analysis of gas component, bacterial detection of SRB, the BSR is prone to occur and is likely to form the H_2S. However, coal fire in this region has a long history and part of H_2S may be produced by the burning of coal-series strata, which needs futher identification.

Conclusion

The hydrogen sulfide are abundant anomaly in many coal mines (districts) in southeastern margin of Junggar basin in China. There are three sets of source rocks in the Tugulu formation of Lower Cretaceous, Middle-Lower Jurassic and Middle Permian in the region. Most of the buried depth of coal seams are 200~1500 m and the temperature of the formation is less than 45 ℃, which is beneficial to the propagation of SRB. The average SRB value of samples is 791 grams / sample. Along the runoff direction, the salinity and pH value of groundwater gradually increase. And the hydrochemical types of groundwater are evolved into HCO_3-SO_4-Cl-Na by HCO_3-Ca-Na and HCO_3-SO_4-Na-Ca, with the main components of $NaHCO_3$. In a reducing environment and the rich hydrocarbon, the BSR is prone to occur and is likely to form the H_2S.

In the region, as the succession of depression structure of Mesozoic and Cenozoic, experienced polycyclic tectonic, deposited a thick deposit of source reservoir cap assemblage, created many sets of H_2S-friendly source reservoir cap assemblage, and formed a variety of favorable gas traps. Meanwhile, the better pore types of the

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reservoir are mainly the intergranular pore and intragranular dissolved pore, which is a reservoir of medium porosity and low permeability. The top and bottom slate of coal seam are mainly composed of fine clastic rock and low permeability barrier with the characteristics of good sealing ability. Which provides a wide space for the reservoir of H_2S, under the action of groove type subsidence structure, uplift type relief structures and the hydrodynamic control methane.

Under special geological conditions, there are two types of H_2S accumulation modes which are the northward monoclinic and the imbricated fan-shaped.

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