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Formation Mechanism of Potash Deposits in the Kuqa Depression and their Prediction

DENG Xiaolin, WEI Zhao, ZHAO Yuhai and WANG Jian

Geological Institute of China Chemical Geology and Mine Bureau, Zhuozhou 072754

The Kuqa depression in Tarim basin is abundant with petroleum exploration data, and a large number of drill cuttings data are available by drilling. A full use of these data to conduct secondary development is the most effective way to find deep-seated potash deposits. This work is based on reexamination, systematic sampling and various tests of drill cuttings in the Kuqa depression, and sylvite seams were firstly discovered in the Paleogene Kumugeliemu group ($E_{1\text{-}2}k$)(Deng et al., 2011, 2013), indicating a great breakthrough in search for potash deposits in the Tarim basin.

Distribution characteristics of potash salts: The Paleogene salt rock formations in the Kuqa depression are mainly distributed in the Baicheng sag, and the potassium-bearing horizon is the Paleogene Kumugeliemu group gypsum salt rocks. An analysis of drill cuttings from 24 drill holes shows that potassium anomalies (anomaly threshold of K ≧0.52%, i.e., KCl≧1) were detected from 11 wells. These anomalies in the Baicheng sag can be divided into 3 anomaly areas: the Yangta-Quele, well Keshen 1 and well Keshen 5. The maximum potassium content in the Yangta-Quele anomaly area of the south Baicheng sag is far greater than the lower potassium limit of 0.52%, and even its average potassium content exceeds industrial grade or cutoff grade. The high potassium anomaly and high $Br\times10^3/Cl$ coefficients are concentrated around the well blocks Quele 101 and Yangta 4, and thus form two potash-accumulation areas, i.e., the Yangta potash accumulation area and the Quele accumulation area. The Yangta potash accumulation area contains 2.67% potassium content on average, and its $Br\times10^3/Cl$ coefficient is 0.03; the Quele accumulation area has a mean potassium content of 1.09%, and its $Br\times10^3/Cl$ coefficient is 0.04.

The potash seams in the well blocks of Yangta 4, Yangta 6 and Quele 101 are concentrated in the middle-upper part of the Kumugeliemu group gypsum salt rock member. It is thus inferred that, the middle to late Eocene is a major potash-forming stage in the Kuqa depression of the Tarim basin, and the Kumugeliemu group salt rock member is a major potash-prospecting horizon. A comparison of potassium-bearing seams penetrated by the drill holes of Yangta 4, Yangta 6 and Quele 101 in the Yangta and Quele areas indicates that, a complete potassium-bearing salt layer can be divided into the upper, middle and lower mineralization sections. The wells Yangta 4 and Quele 101 mainly drilled through halite rocks in the Paleogene salt-forming period, containing well-developed mud and little gypsum in the bottom, and pure salt in the upper. These three seams are representative of three potash-forming stages. The early potash-forming stage is difficult to form thick potash seams as affected by mudstone or gypsum layers; the middle-late stage is favorable to from middle to thick potash seams due to the decreasing mud and increasing K content. The well Yangta 4 possesses better potash-forming conditions than the well Quele 101, and it contains three sylvite layers with an accumulative thickness of 18 m and grades exceeding industrial grade.

Potash-forming mechanism: In the late Palaeozoic, the Tianshan geosyncline uplifted and experienced strong folding, and the fault structures were reactivated due to the Variscan tectonic movement. Thus, the transitional zone between the south Tianshan and Tarim platform underwent rift and subsidence to form the Kuqa depression. It is a long and narrow basin controlled by basement faults, and its long axis is parallel to the Tianshan fold belt, with an EW direction. In the late Cretaceous, the basin basement suffered uneven uplift, resulting in regional disconformities or unconformity between the Paleogene and Cretaceous strata. Then the depression underwent intensive rifting, and subsequent transgression occurred, which made the Kuqa depression a sea basin far from wide sea but inside the continent, and filled it with mega-thick

* Corresponding author. E-mail: dxl@hgdyy.com.cn

gypsum deposition.

The Kuqa depression is a Meso-Cenozoic basin developed on two different natures of basements. Bounded by the Qiulitage fault, it is a geosynclinal fold basement in the north and Proterozoic crystalline basement in the south and east. This depression is thus a transitional tectonic unit between the geosyncline and platform. During the long geological periods, the north Tianshan experienced continuous folding and uplifting, and the depositional center of the depression migrated southward. Structures in the depression control the palaeogeographic framework, affect the evolution of the depression, and thus exert a critical role on salt deposition. The Kuqa depression was generally in a marine environment in the Paleocene and Eocene, and in the Oligocene sea water discharged to begin an arid intercontinental environment.

In the Paleocene-Eocene, the depositional center of the depression was in the Baicheng sag due to its faulted subsidence, and the depression was in a lagoon depositional environment in a dry and hot climate. In the early to middle Eocene, the Kuqa depression was in a relatively calm tectonic environment favorable for salt formation, and developed thick and wide rock salt deposition. During this stage, salt-forming brine was mainly distributed in the Baicheng sag as controlled by depositional and settlement center. As shown in Fig. 1, gypsum salt rock in the Baicheng sag can reach as thick as 1000 m, and becomes thin in the south.

In the Eocene-Oligocene, orogenic belt north of the Kuqa depression rejuvenated, tectonic activities tended to be strong, and concentrated brine gradually migrated southward. High values of potassium and $Br\times10^3/Cl$ coefficients are observed in the south of the Baicheng sag (Fig. 2).

The potash formation in the Kuqa depression is a comprehensive result of paleogeographic environment, tectonic evolution, material source and paleoclimate. The Paleocene seawater flew through Awati channel, and extended to the Kuqa depression south of Tianshan. The gradual uplifting of the Tianshan fold belt resulted in the uplift of the Kuqa depression, and led to a closed or semi-closed salty lake and saline lake environment for the depression, depositing salt deposits. The subsequent continuous dry and hot climate led to concentrated lake water and a great thickness of rock salts. In the salt lake stage, the late brine was rich in potassium, and accumulated in the subsags north of the Baicheng sag. The Kuqa depression underwent uneven uplifting due to the Himalayaian movement, resulting a southward tilt, and the potassium-rich brines migrated southward (Fig. 2) to form potassium-bearing seams in low-lying areas south of the Baicheng sag (wells Yangta 4 and Quele 101).

Potash-forming prediction: Two potash accumulation areas, i.e., the Yangta and Quele areas have been discovered in the Yangta-Quele potential potash-forming areas south of the Baichang sag. These two accumulation areas are both located in areas with high potassium and $Br\times10^3/Cl$ coefficients, potassium mineralization or anomalies were detected, and negative gravity anomalies representative of subsag or salt bodies were also discovered. Drill holes and seismic interpretation suggest thick rock salt in the Kumugeliemu group, indicative of a good potential for prospecting potash. Thickness and grade data from the ore-intersected wells of Yangta 4, Yangta 6 and Quele 101 indicates that, the potential potash resources in the Yangta-Quele area amount to several

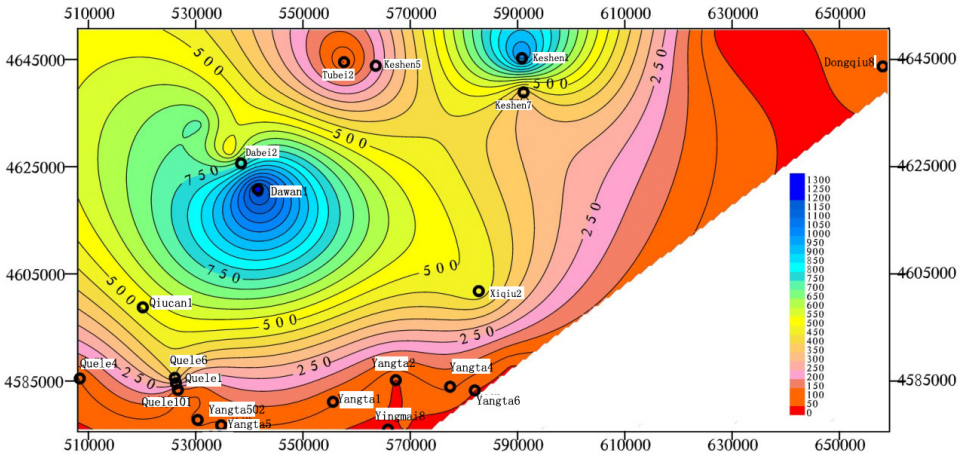

Fig. 1. Contour of gypsum rock thickness in the Kuqa depression.

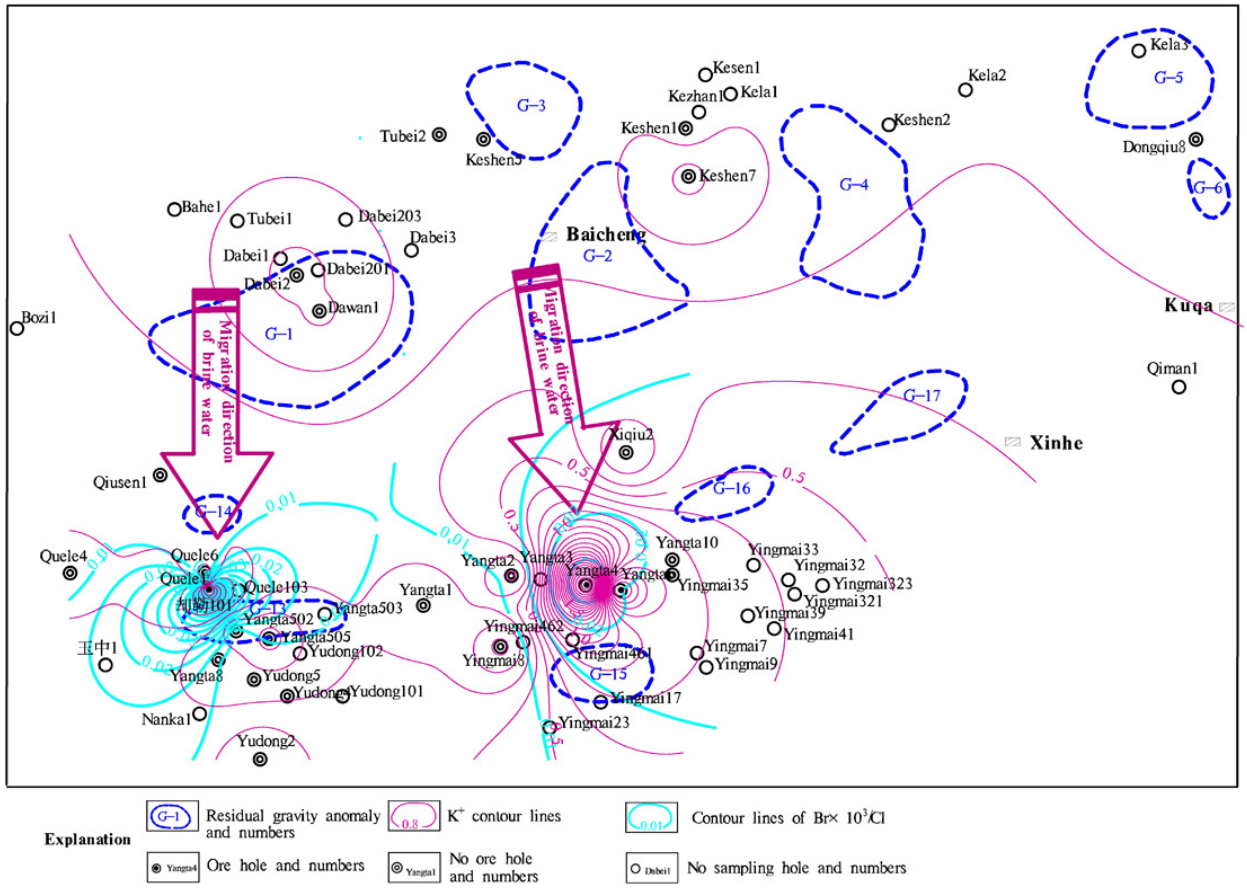

Fig. 2. Sketch showing potash formation in the Kuqa depression.

hundreds of millions of tons.

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