Acta Geologica Sinica (English Edition), 2021, 95(4): 1423–1425

Research Advances

^{14}C Chronology and Circulation of Potassium-rich Brine in Lop Nur Playa, Xinjiang, Northwestern China

LIU Chenglin[1, *], JIAO Pengcheng[1], ZHANG Hua[1] and DUAN Baoqian[2]

[1] *MNR Key Laboratory of Metallogeny and Mineral Assessment, Institute of Mineral Resources, Chinese Academy of Geological Sciences, Beijing 100037, China*

[2] *Institute of Hydrogeology and Environmental Geology, Chinese Academy of Geological Sciences, Shijiazhuang 050061, China*

Citation: Liu et al., 2021. ^{14}C Chronology and Circulation of Potassium-rich Brine in Lop Nur Playa, Xinjiang, Northwestern China. Acta Geologica Sinica (English Edition), 95(4): 1423–1425. DOI: 10.1111/1755-6724.14750

Objective

Lop Nur is one of the world's largest Quaternary salt lakes and is currently a playa. In this lake, unique giant glauberite deposits occur, of which the intercrystalline pores host super-large liquid potash deposits. Recently, it has been thought that the potassium-rich brine was formed when the enormous quantity of glauberite deposited. To clarify this issue ^{14}C dating for brine is used to provide new evidence of chronology illustrating the relationship of potassium-rich brine with the host glauberite rock and improve our understanding of the formation mechanism of the brine in Lop Nur playa.

Methods

It is still a challenge to collect underground water samples with high salinity for ^{14}C dating. This is the case for the Luobei Sag in the northern Lop Nur, where brine is characterized by high contents of total dissolved solids (TDS) and SO_4^{2-}, with mean values of > 300 g/L and 70.40 g/L, respectively, and a low HCO_3^- content ranging from 0.092–0.484 g/L with mean content of 0.209 g/L. In this study, brine samples for ^{14}C-dating were collected using an improved vacuum set provided by Jiao et al. (2003) and were measured with the method of synthesizing with benzene. The inorganic carbon dissolved in the brine samples was first transferred into CO_2 gas, which then was used to react with Li to form carbonizing matter under high-temperature conditions. After this process, benzene was produced by means of hydrolyzation. Finally, a chronology analysis was conducted on a 1220 Quantulus liquid scintillation mass spectrometer with ultra-lower bench marks made by PerkinElmer, Inc., in the Institute of Hydrogeology and Environmental Geology, Chinese Academy of Geological Sciences, Shijiazhuang, China. The measurement results of modern carbon are presented with wt% (pMC). The ^{14}C dates were calculated using a combination of the empirical estimate and Pearson's isotope mixing calibration models. Sampling sites is shown in Figs. 1 and 2.

* Corresponding author. E-mail: liuchengl@263.net

Results

The eight obtained ^{14}C age data are listed in Table 1. The modern carbon content (wt%) of the brine samples ranges from 9.31%–58.15% and the calibrated dates of the brine range from 4.48–19.62 ka.

Two samples were collected in the Big Ear Lake with a stratigraphic depth interval of 0.40–50.00 m and 2.50–150.00 m, respectively. The brine sample 201011LBP-C1 from Well ZK1103 yields the youngest date of 4.48 ka, implying a mixture of modern water or favorable runoff exchange. The oldest date of 19.62 ka of brine sample 201011LBP-C2 comes from the artesian well ZK0404 and might represent the true age of the confined aquifer, suggesting a slow and inflexible runoff of the deeper brine.

The other six brine samples were collected from the exploitation wells in Luobei Sag. The brine sample 201011LBP-C3 obtained at a stratigraphic depth interval of 4.80–100.00 m yields a ^{14}C date of 8.57 ka, which represents the mixed age of all three confined aquifers and the phreatic aquifer. Sample 201011LBP-C4 was collected at a depth interval of 6.00–60.00 m and had a ^{14}C date of 6.08 ka, representing a mixed age of the phreatic aquifer, and the first and second confined aquifer. The samples 201011LBP-C5, -C6, -C7 and -C8 were collected from the exploitation wells with a depth interval of 6.00–100.00 m covering the phreatic aquifer and all three confined aquifers. ^{14}C dates of the four brine samples ranged from 8.13 ka to 9.46 ka, which likely represent the age of the main-body potassium-rich brine of this depth interval. ^{14}C dates of brine in Well ZK1200 are 1.989 ka and 3.417 ka at depths of 10.00 m and 17.00 m, respectively. All brine dates obtained in this study are younger or much younger than the strata age at corresponding stratigraphic depths (Wang and Liu, 2001). These lines of evidence show that brine dates, despite the mixed brine ages of different aquifers, are much younger than those of corresponding strata in both the Luobei Sag and Big Ear Lake in the Lop Nor Salt Lake. This suggests that constant recycling and supplying of underground water have been in existence in the salt lake since the hosting glauberite rocks formed. The brine dates still keep an aging trend with increase of depth,

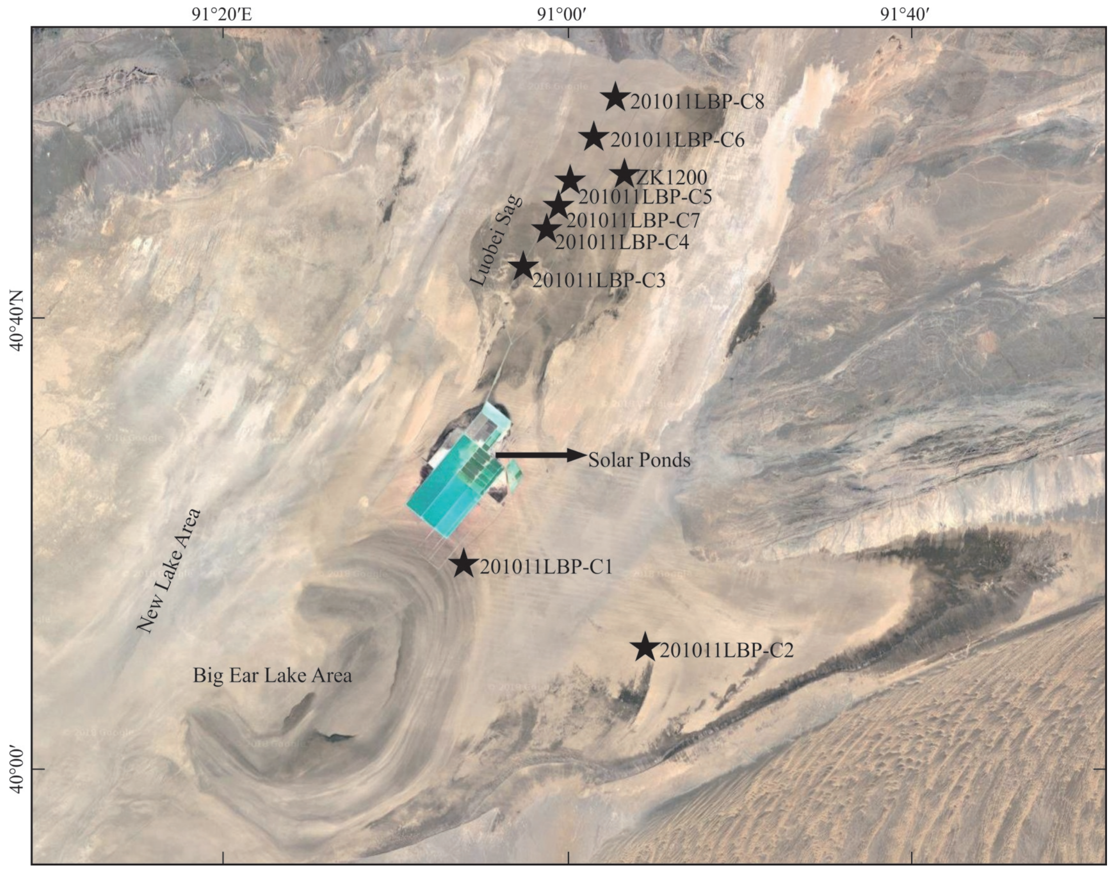

Fig. 1. Sampling sites of brine for ^{14}C dating in the Lop Nur playa, Xinjiang.

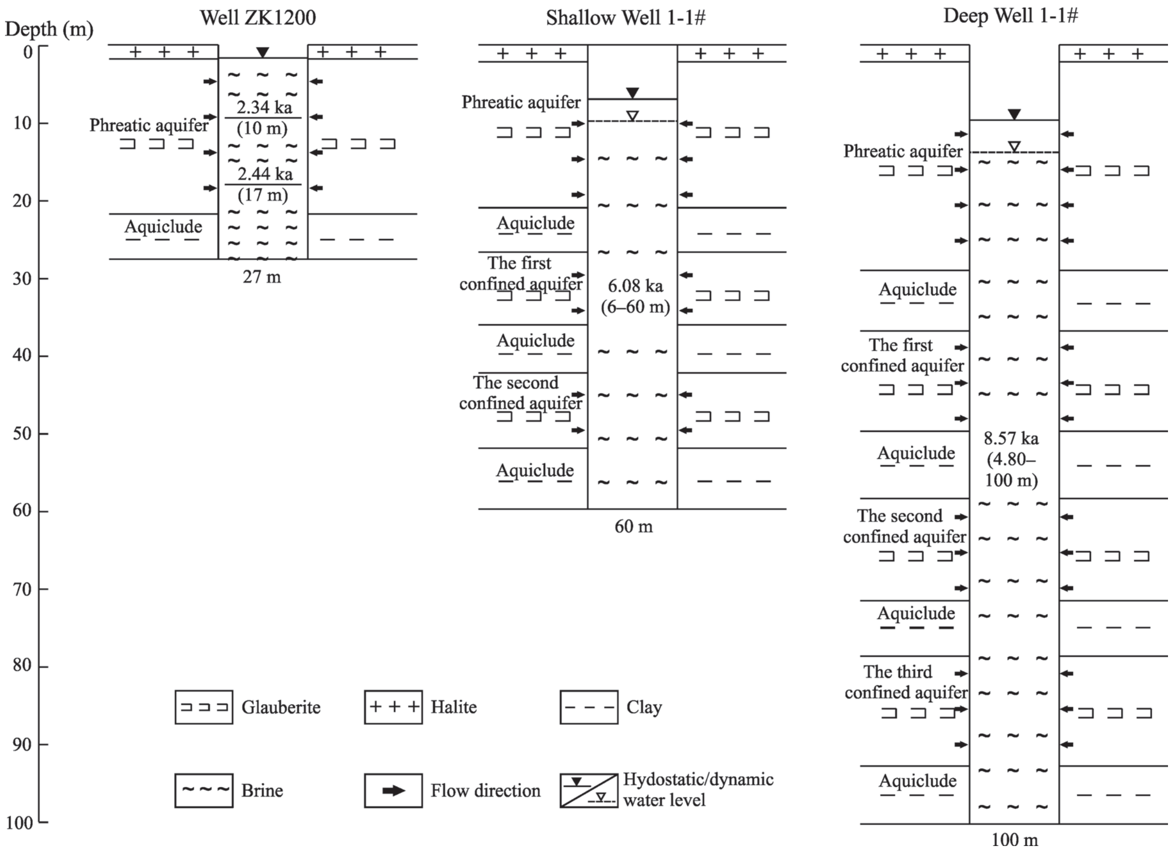

Fig. 2. Aquifer structure and flow direction of sampling wells in the Luobei Sag.

despite the going-down infiltration influence of meteoric water likely via extension fractures (Liu et al., 2006).

Conclusions

The obtained results provide new evidence of chronology illustrating the relationship of potassium-rich brine with the host glauberite rock and improve our understanding of the formation mechanism of the potassium-rich brine in Lop Nur playa.

The ^{14}C dates of the new brine samples and brines of Well ZK1200, at depths of 10.00 m, and 17.00 m, respectively, hosted in the glauberite rock from Luobei Sag show a range of 6–9 ka. Confined brines of Big Ear Lake hosted in gypsum-clastic sediments yield ^{14}C dates of 4.48–19.62 ka. All the ages of the brines are younger than those of the corresponding host strata. ^{14}C dates of brines in Luobei Sag are younger than 10 ka, suggesting that continuous recycling of water occurred after the glauberite deposition via meteoric water infiltration and/or related exchange with previous brine. This type of recycling did not reduce the KCl contents of the brines, and thus the obvious fresh water or diluted inflow supplying the aquifers can be excluded in the salt lake. Therefore, the modern sampled brines in the glauberite intercrystalline pores are likely a mixture of older brines formed when glauberite was deposited and younger brine impacted by atmospheric water experienced the strong evaporation and infiltration into the aquafers through fractures in the strata.

Acknowledgments

This research is supported by the National Natural Science Foundation of China (Grant No. 40830420, 41702097, 41972092). We thank the staff of SDIC Xinjiang Luobupo Potash Co. Ltd for sampling assistance and anonymous reviewers for constructive comments and suggestions.

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Table 1 ^{14}C dating results of brine in Lop Nur playa

Sample	Area	Well	Depth (m)	Results	
				Modern carbon (wt%)	Age (ka)
201011LBP-C1	Big Ear Lake	ZK1103	0.40–50.00	58.15 ± 1.10	4.48 ± 0.16
201011LBP-C2	Big Ear Lake	ZK0404	2.50–150.00	9.31 ± 1.28	19.62 ± 1.14
201011LBP-C3	Luobei Sag	1-1#	4.80–100.00	35.48 ± 1.12	8.57- ± 0.27
201011LBP-C4	Luobei Sag	1-5#	6.00–60.00	47.96 ± 3.62	6.08 ± 0.63
201011LBP-C7	Luobei Sag	1-6#	6.00–100.00	31.83 ± 0.90	9.46 ± 0.24
201011LBP-C5	Luobei Sag	1-9#	6.00–100.00	37.39 ± 1.98	8.13 ± 0.44
201011LBP-C6	Luobei Sag	1-13#	6.00–100.00	35.75 ± 1.17	8.50 ± 0.27
201011LBP-C8	Luobei Sag	1-17#	6.00–100.00	35.52 ± 0.87	8.56 ± 0.20