Chronological Study of West Taijinar Salt Lake Sediments, Qaidam Basin (Postprint)

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Date: 2019-08-02T00:00:00+00:00

Abstract

The genesis and chronological framework of Xitaijinaier Salt Lake in the central Qaidam Basin remain controversial. By applying optically stimulated luminescence (OSL) dating and accelerator mass spectrometry radiocarbon (AMS 14C) dating to two cores from the central and eastern marginal areas of the salt lake, four OSL and five AMS 14C age dates were obtained. The results indicate that: (1) Radiocarbon dating exhibits significant age underestimation for samples older than 30 ka, while a reservoir effect of approximately 4.0 ka is observed for younger samples; comparatively, the OSL dating method demonstrates greater reliability. (2) The upper silty clay layer of the two cores formed at approximately 0.3 ka, the middle silty-clay-bearing salt layer formed at approximately 4.0 ka, and the basal silty clay layer formed at least prior to 70 ka.

Full Text

Formation and Evolution of the Xitaijinair Salt Lake in the Qaidam Basin Revealed by Chronology

DOI: 10.12118/j.issn.1000-6060.2019.04.19

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Abstract:
The Xitaijinair Salt Lake, located in the middle of the Qaidam Basin, Qinghai Province, China, is rich in lithium, potassium, boron, and magnesium resources. Due to its tremendous economic value, previous studies have mainly focused on the hydrology and hydrochemical characteristics of the brine. However, the formation and evolution of the salt lake remain controversial, and the chronology of the Xitaijinair Salt Lake is absent. In this paper, two cores from the middle and eastern edge of the salt lake were dated using Optically Stimulated Luminescence (OSL) and radiocarbon dating (AMS ^{1}C). The experimental conditions of OSL dating were conducted, and the feasibility of the two methods was also discussed. The sedimentary sequence of the two cores showed that the sediments in both the top and bottom are dominated by silty clay, while the middle of the cores are dominated by halite with several layers of silty clay. The sedimentary facies also revealed that the Xitaijinair Salt Lake has been desalted at least twice. Based on five AMS ^{1}C and four OSL chronologies, the chronological framework of the Xitaijinair Salt Lake was preliminarily discussed. In the middle of the cores, the OSL dating materials are scarce, and only AMS ^{1}C chronologies were obtained. Thus, we calculated the reservoir effect offset by comparing the OSL chronologies with AMS ^{1}C chronologies from the same layer. The ages of silty clay layers from the middle of the cores were obtained by deducting reservoir effect offset from the measured AMS ^{1}C ages. The results showed as follows: (1) In AMS ^{1}C dating method, samples older than 30 ka were obviously underestimated. While for the younger samples, a ~4.0 ka reservoir effect offset was calculated by comparing with the OSL ages. Relatively, the OSL dating results are more reasonable. (2) In both of the two cores, the top silty clay layer was formed about 0.3 ka BP; the silty clay layer in the middle, about 4.0 ka BP, and the bottom silty clay layer, at least 70 ka BP. (3) It seems the Baga Yawu anticline in the northeast of the salt lake controlled the formation of the basin, and the blind fault between the anticline and basin controlled the depth of the basin. However, more details are needed to reveal the specific process between the lake evolution and tectonic activity.

Keywords: Qaidam Basin; Xitaijinair Salt Lake; chronology; OSL; radiocarbon dating

1 Introduction

The Xitaijinair Salt Lake is located in the central Qaidam Basin (93°13 -93°34 E, 37°33 -37°53 N) at an elevation of 2680 m, covering an area of approximately 560 km^2. It represents one of the most important salt lakes in the region [3-5, 8]. The lake has a maximum water depth of about 20 m and a salinity of 380 g/L, classifying it as a typical chloride-type salt lake [15]. The lake basin measures approximately 17 km in length and 15 km in width, with a surface area of about 150 km^2.

Two sediment cores were collected for this study: Core XT1 from the central part of the lake and Core XT2 from the eastern margin. Core XT1 has a length of 5.5 m, while Core XT2 extends to 4.0 m. The sampling intervals varied by depth: 10 cm intervals for the upper sections, 5 cm for middle sections, and 5-10 cm for lower sections, with bulk samples collected for OSL and AMS ^{1} C dating.

2 Methods

2.1 Sampling and Laboratory Procedures

The sediment cores were split longitudinally in the laboratory. One half was archived while the other half was photographed and described lithologically. Samples for OSL dating were collected from quartz-rich layers under subdued red light conditions. For AMS ^{1} C dating, organic material was extracted from silty clay layers.

The OSL dating procedure followed standard protocols [20]. The equivalent dose was measured using the single-aliquot regenerative-dose (SAR) protocol [24]. Environmental dose rates were determined by neutron activation analysis (NAA) of U, Th, and K concentrations in the surrounding sediment [17]. The water content was estimated at 20% ± 5% based on measured values. Cosmic ray contribution to the dose rate was calculated following Aitken (1985) [20].

For AMS ^{1} C dating, organic carbon was extracted and purified using standard acid-alkali-acid treatments. The samples were then converted to graphite and measured using an accelerator mass spectrometer. The results were calibrated using the IntCal13 calibration curve [9, 19].

2.2 Dating Methods

OSL Dating: Quartz grains of 38-63 m and 90-125 m fractions were extracted for OSL measurements. The purity of the quartz extracts was verified using infrared stimulation. The dose rate was calculated from U, Th, and K concentrations, with an alpha efficiency factor of 0.035 ± 0.003 [17].

AMS ^{1} C Dating: Organic material from silty clay layers was dated using accelerator mass spectrometry. The conventional radiocarbon ages were calibrated to calendar years using the CALIB 7.1 program.

Table 1 presents the chronologies obtained from both dating methods for the two cores.

3 Results

3.1 OSL Dating Results

Four OSL ages were obtained from the two cores. The top silty clay layer yielded ages of 0.3-0.4 ka. The middle silty clay layer provided ages around 4.0 ka. The bottom silty clay layer gave ages exceeding 70 ka, though these should be considered minimum ages due to signal saturation.

3.2 AMS ^{1} C Dating Results

Five AMS ^{1} C ages were obtained from organic material in the cores. The top layer gave modern ages (<0.3 ka). The middle layer yielded ages of 2.9-4.2 cal ka BP, while deeper samples provided ages of 27-35 cal ka BP. However, comparison with OSL ages revealed significant discrepancies.

The AMS ^{1} C ages for samples older than 30 ka appear underestimated, likely due to contamination and instrument background. For younger samples, a reservoir effect offset of approximately 4.0 ka was calculated by comparing AMS ^{1} C ages with OSL ages from the same stratigraphic horizon.

4 Discussion

4.1 Comparison of OSL and AMS ^{1} C Chronologies

The OSL and AMS ^{1} C dating results show systematic differences. For the middle silty clay layer, AMS ^{1} C ages are consistently younger than OSL ages by about 4.0 ka, which we interpret as the reservoir effect offset. This offset is attributed to the presence of old carbon in the lake system, either from bedrock dissolution or recycling of older organic matter.

For samples older than 30 ka, AMS ^{1} C ages are severely underestimated and cannot be considered reliable. In contrast, OSL ages appear more consistent with the stratigraphic sequence and are considered more reliable for this study.

4.2 Geological Implications

The chronological framework established by this study indicates that the Xitaijinair Salt Lake has experienced at least two major desalination events. The bottom silty clay layer formed at least 70 ka ago, representing an early lacustrine phase. The middle silty clay layer, dated to ~4.0 ka BP, indicates a period of freshwater influx and lake expansion. The top silty clay layer, formed ~0.3 ka BP, suggests recent hydrological changes.

The Baga Yawu anticline to the northeast appears to have controlled the basin' s formation, while a blind fault between the anticline and the basin may have influenced the basin’ s depth and sedimentation patterns. However, the specific relationship between tectonic activity and lake evolution requires further investigation with higher-resolution data.

The sedimentary sequence, dominated by halite in the middle section with silty clay layers above and below, suggests that the lake evolved from a freshwater environment to a hyper-saline state, with intermittent freshening events. This pattern is consistent with regional climate changes and tectonic evolution of the Qaidam Basin during the Late Quaternary.

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Note: Figure translations are in progress. See original paper for figures.