Mineralogical and mineral composition analysis of lacustrine sediments from Lake Toson, NE Qinghai-Tibet Plateau, China

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Abstract: Mineralogy is very important in the study of lake, especially in the study of regional and past global change using lake sediments. In the final analysis, mineralogy could be involved in the study of the in-depth mechanism of lake sediments. In this paper, analysis the minerals by XRD in the sediments of Toson lake in the northeast of Qinghai-Tibet Plateau, the results showed that the main minerals in Toson lake were aragonite, calcite, quartz, halite, albite, muscovite, clinochlore and dolomite. And the main categories were detrital minerals and carbonate minerals with obvious reverse correlation. It suggested that Toson lake was mainly situated carbonate sedimentary stage, and the input of carbonate was lacustrine authigenic carbonate.

1. Introduction

Due to the advantages of wide coverage, high resolution and rapid response to regional environment, lake sediments have become one of the most important information carriers in the study of terrestrial environmental change [1-2]. Meanwhile, the assemblage of mineral in lake sediments is one of the sensitive indicators of paleoenvironment research, which contains abundant information of past global change [3-5]. So it plays an important role in the study of paleoenvironment. Moreover the minerals in the sediments record the information of material source, paleoclimate and sedimentary environment, which can provide qualitative and quantitative basis for modern geological process, surface process and climate evolution. In recent decades, sedimentary mineralogy has been widely used and made great progress in provenance tracing and monsoon evolution [6-9]. For example, Chamley (1989) reviewed the paleoclimate and environmental changes revealed by the change of clay mineral content in sediments.

In addition, for lake sediments, carbonate mineral content is a good climatic indicator, which can reflect the sedimentary environment and evolution process of the lake, such as temperature, precipitation, dynamic conditions and so on [6, 10-12]. In the semi-arid closed lakes, the carbonate deposits represented by calcite and aragonite in the sediments are the early stage of salt deposition. The carbonate content in the sediments indicates the salinization or desalination of the lake water, and indirectly reflects the dry and wet changes of the lake [13]. On the other hand, the method of XRD (X-ray Diffraction) is widely used in sedimentology research, especially in the study of lacustrine sedimentation, the mineral composition of carbonate given semi-quantitatively. Great progress has
been made in the study of carbonate in lake sediments by XRD [14-16].

2. Materials and methods

2.1. Study area

Lake Toson(37°04′~37°13′ N, 96°50′~97°03′E) is located in the lowlands of the Delingha, a closed-drainage basin in the northeastern Qaidam Basin (QB). The QB has an area of 120,000 km², and is thus the largest inland basin on the Qinghai-Tibet Plateau (Fig.1). The surface area of Toson lake is ~145 km², and the lake has a maximum water depth of 25 m. It is fed mainly by the Bayin River and Water from Hurleg lake drains into Toson lake through about 3 km long river northwest of the lake.

2.2. Sample collection and analytical methods

Core Ts4 was extracted using a gravity corer consisting of an acrylic pipe and a length of 69 cm. The core was kept upright and then cut open. The core was subsampled at 1-centimeter intervals. Full XRD analysis of the sample was performed for the sediment core Ts4, where samples were taken over the entire core length. And then, dried sediment samples were crushed in an agate mortar and pestle, and analyzed for the determination of mineralogical composition of the sediment by X-Ray Powder Diffraction (XRD) using powdered. Mineralogical analysis of sedimentary material was carried according to the standard methods of XRD. The methods described were applied to identify minerals and determine their quantitative proportions.

3. Results and Discussion

The XRD analysis results of Ts4 in Toson lake showed that the main minerals in the sediments were aragonite, calcite, quartz, halite, albite, muscovite, clinohlore and dolomite (Table1). Aragonite and quartz had the highest content, with averages of 28.10% and 25.99% respectively, followed by albite and calcite, and dolomite with the lowest average content of 2.43%. And there was no obvious correlation between these minerals.
Table 1. The composition and content of minerals in Toson lake

|                | Aragonite | Calcite | Quartz | Halite | Albite | Muscovite | Clinochlore | Dolomite |
|----------------|-----------|---------|--------|--------|--------|-----------|-------------|----------|
| Average%       | 28.10     | 13.75   | 25.99  | 4.17   | 15.06  | 7.60      | 3.81        | 2.43     |
| Maximum%       | 45        | 37      | 44     | 0      | 24     | 12        | 6           | 5        |
| Minimum%       | 15        | 4       | 15     | 9      | 8      | 5         | 2           | 1        |
| Standard Deviation | 5.99   | 5.41    | 8.53   | 1.72   | 3.11   | 1.81      | 1.28        | 0.76     |

Furthermore, according to the mineral composition, it could be divided into three categories. Detrital minerals: quartz, albite, muscovite and clinochlore; carbonate minerals: calcite, aragonite and dolomite; Chloride: halite. The core was dominated by detrital minerals, followed by carbonate minerals (Fig. 2). Because of with no sulfate minerals, it could be suggested that the lake was mainly in the carbonate deposition stage at this stage.

Fig. 2 The categories of minerals from core Ts4 in Toson Lake

The topsoil, fluvial sediments, lake surface sediments [17] and core samples were analyzed by XRD from Toson lake (Table 2). The results showed that the river sediments and the topsoil along the lake the content of calcite and dolomite was very low, and no aragonite; the calcite content in lake surface sediments and core sediments increased significantly and the aragonite content was very high. This illustrated that the aragonite and calcite in Toson lake sediments come from carbonate precipitation. The source of dolomite was difficult to determine, but its content was extremely low. Therefore, XRD analysis revealed that the carbonate in core sediments mainly came from lacustrine authigenic carbonate in Toson lake.

Table 2. XRD analysis of modern and core sample from Toson lake

| Sample          | Quartz% | Albite% | Calcite% | Aragonite % | Dolomite % |
|-----------------|---------|---------|----------|-------------|------------|
| Topsil1^        | 68      | 27      | 4        | 0           | 1          |
| Topsil 2^       | 40      | 48      | 7        | 0           | 4          |
| Fluvial         | 83      | 9       | 5        | 0           | 3          |
The variation of carbonate mineral composition in Toson lake was shown in Fig.3 and the aragonite and calcite were the main minerals, with an average content of 28.10% and 13.75% respectively. The content of dolomite was low in the whole section, even sporadic in some sections.

![Graph](image)

Fig.3 Components of detrital minerals and carbonate minerals from core Ts4 in Toson Lake

In order to better summarize the variation of mineral content in the profile, the detrital minerals and carbonate minerals with most common and high content were selected for analysis. And it could be seen from the figure that the content of detrital minerals and carbonate minerals in the profile varies greatly. In the arid area of Northwest China and the high cold area of Qinghai-Tibet Plateau, the minerals in lacustrine sediment suggested that the carbonate minerals showed obvious low values in the layers where the content of detrital minerals increased [13,16]. This phenomenon also existed in the sediments of Toson lake. Moreover, the correlation between detrital minerals and carbonate minerals in this section, it was found that the correlation coefficient was as high as -0.77. Therefore, this was further illustrated the input of carbonate minerals from the sediments of Toson lake was mainly authigenic. It suggested the fluctuation of lake water and indirectly indicated the variation of dry and wet climate in Toson lake area.

4. Conclusion

Through the study of mineralogy in Toson lake sediments, it showed that they mainly include detrital minerals and carbonate minerals. The lake was mainly dominated by detrital minerals with the stage of carbonate deposition. And the carbonate mainly including aragonite and calcite was mainly lacustrine authigenic carbonate in Toson lake. It experienced the fluctuation of lake water area and the change of dry and wet.

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