Geological Structure Exploration of the Blocked Dam in Xinjiang Tianchi and Its Lithological-Structural Water-Blocking Effect

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Abstract: Tianchi Lake in the Tianshan Mountains exhibits complex geological processes, including moraine formation, collapses, and landslides. Although previous studies have identified general causes, the locations and formation mechanisms of older collapses and landslides controlled by the accumulation dam and regional faults remain unclear. This study integrates field surveys, drilling data, high-density electrical resistivity tomography (ERT), optical luminescence dating, hydrochemical analysis, and remote sensing to investigate the structural framework, hydrogeology, and stability of the Tianchi accumulation dam. Results reveal the dam's internal stratigraphy, groundwater pathways, and fault-controlled hydrodynamics, providing insights into Holocene landslide development and guiding dam stability and protection strategies.

Keywords: ***Xinjiang, Tianchi, Moraine, Landslide, Blocked dam, Fault, Hydrogeology.***

Introduction

Tianchi Lake, located in the Tianshan Mountains, is characterized by moraines, collapses, and landslides shaped by both natural processes and the accumulation dam structure. While the general causes of these events are understood, the spatial extent, formation process, and structural control of old collapses and landslides remain insufficiently documented. This study aims to clarify these aspects and assess the hydrogeological features influencing dam stability.

Materials and Methods

Field Survey and Drilling

Geological surveys and drilling data were used to delineate the structural framework of the Tianchi Lake dam.

Geophysical Investigation

High-density electrical resistivity tomography (ERT) lines were established parallel and perpendicular to the dam axis to detect subsurface electrical structures.

Remote Sensing Analysis

Multi-temporal satellite imagery was analyzed to trace the development of old collapses and landslides during the Holocene.

Hydrogeological Assessment

Optical luminescence dating and hydrochemical analysis were conducted to determine the age of dam material and examine groundwater characteristics.

Results

Structural Features

Fault F2 at the north edge of the old landslide acts as a control boundary, with its exposed fault plane providing critical insight into landslide movement. Post-glacial collapse and landslide accumulation filled the ancient river channel of Tianchi Lake, shifting the spillway eastward and forming the present dam shape.

Figure 1, Landform Map of Giant Old Collapse and Old Landslide Relics in Tianchi Lake.

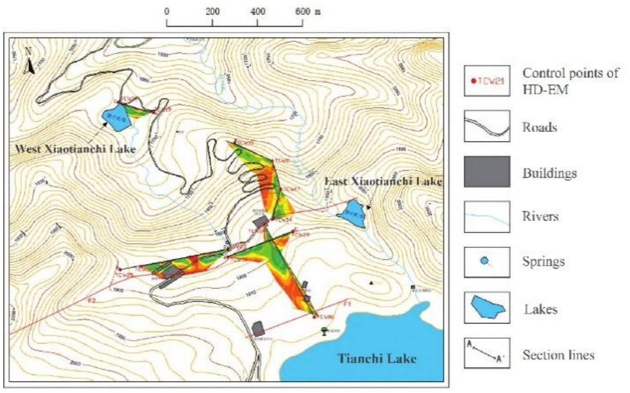

Figure 2, Layout of geophysical prospecting line and profile projection of electrical structure.

Hydrogeology

Low-resistivity zones and concentrated spring discharge areas identified on the electrical profiles correspond to the source of the West Xiaotianchi Pond. Fault F1 near the lake bank acts as a water barrier, maintaining the lake level at 1910 m a.s.l. (Figure 3).

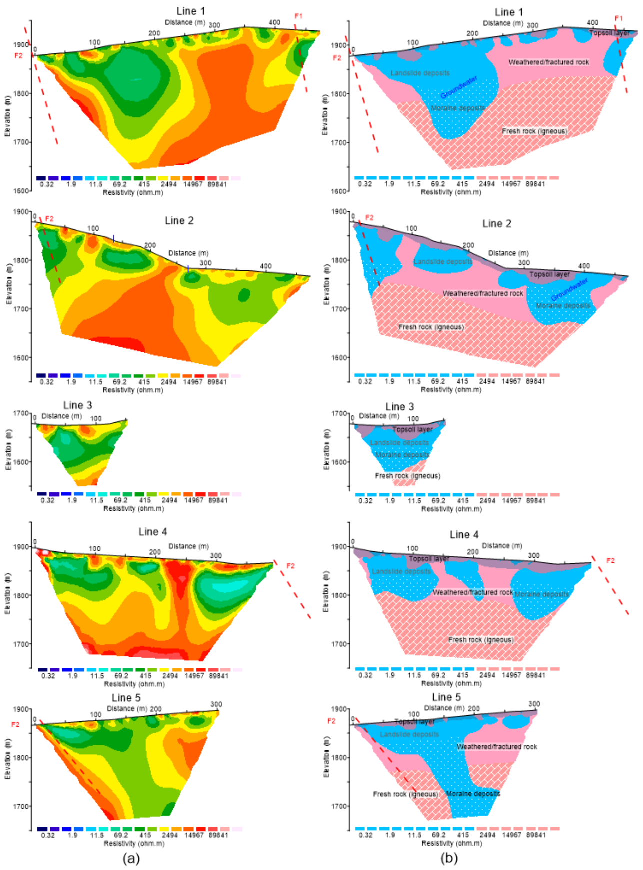

Figure 3, Profile map of 5 high-density electrical inversion and geological interpretation on Tianchi Dam (a) Electrical structural section diagram; (b) Geological interpretation profile map.

Dam Stratigraphy and discharge

The Tianchi accumulation dam exceeds 100 m in thickness. The upper shallow massive boulder layer is 30–40 m thick, and the lower aquifer is 30–50 m thick, underlain by igneous rocks of the C2l Liushugou Formation (andesite, tuff, etc.). Middle-dam groundwater infiltrates intensively, replenishing West Xiaotianchi Pond. Overflow points and discharge channels along the left bank of the Feilong River control seasonal shallow spring occurrence. An EW-striking fault F1 beneath the highland forms an aquitard, raising the phreatic water level. Calculated groundwater discharge is ~1,200 m^3/d, with total seasonal discharge from 5.2×10^4 to 1.13×10^5 m^3/d.

Discussion

The dam's structural and hydrogeological characteristics are controlled by its origin and evolution. Faults and stratigraphy significantly influence groundwater flow, seepage, and overall stability. Understanding bedrock burial depth and water diversion structures is critical for assessing long-term dam stability.

Conclusion

This study provides a comprehensive model of the Tianchi Lake accumulation dam, integrating structural, hydrogeological, and stratigraphic data. The findings contribute to understanding the formation and evolution of Tianchi Lake and offer guidance for stability analysis and protective measures.