Tracking extreme events of droughts and floods in the past 1500 years: high-resolution XRF core scanning record from Tuosu Lake, Qaidam Basin*

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Climate change in the past 2000 years is intimately associated with the changing environment of the globe. Quality proxy from lakes with sufficient key-site information on this aspect is required in order to improve our understanding on the climate history in the last bimillennium, which is indispensable for the study and prediction of future changes. Tuosu Lake, a brackish and closed lake with proper configuration, is an ideal site for the investigation because variations in lake level and water chemistry are a function of precipitation-dominated runoff of Bayin River from the montane catchment of the Delingha Basin. Five cores were recovered for the first time from selected sites of Tuosu Lake with water depths of up to 40 m, using advanced coring device. The method of XRF core scanning was applied to measure the variables of 26 elements and associated ratios with mm-resolutions for the sediment cores. Seasonal/annual signals have been traced by the proxy records. Such high resolutions made it possible to correlate the lacustrine proxies with the annual hydroclimate parameters of the Bayin River catchment with good reliability. Chronology of the proxy records is based on AMS 14C, 137Cs and 210Pb dating of the sediments. The established proxy record of Tuosu Lake is basically coherent in precipitation with the tree-ring records from the Delingha area. Extreme events of floods and droughts in the past 1500 years are also indicated by the proxy record, which provides valuable references for the study of their future trend, frequency and magnitude of occurrence. This information is therefore useful for protecting the farming and livestock agriculture from the natural disasters in the lower catchment, which appear to be more frequently occurred in recent years. The data from this investigation will serve as a key-site record for regional correlations and for the study of mechanism and simulations of the climate change in the last 2000 years, as well as
for helping calibrate simulation models.

Tuosu Lake is the terminal lake of the closed-drainage basin of Delingha (Figure 1). Bayin River is the main river system collecting runoff from the large montane catchment. It flows across the lower catchment, forming large wetland areas and a freshwater lake (Keluke) and terminates in the brackish waterbody of the Tuosu Lake. Because a number of villages distribute on the large wetland areas as the base of farming and livestock agricultures, abnormal runoff of Bayin River can be disastrous, resulting in either floods or droughts. Such abnormal events in the past 2000 years may be documented in the sediments of Tuosu Lake, simply because the closed lake level and chemical composition of the brackish lake fluctuate sensitively in response to changes in catchment inflow. A key point in deciphering the environmental signals is to use high-resolution measure so that annual/seasonal signals become detectable from the sediment archive. In this study we apply the technique of XRF core scanning with mm-scale measurements for high quality cores recovered from the profundal site of the lake.

Figure 1 Tuosu Lake is a closed lake with brackish water, the terminal lake of the Bayin River, which is the main river of the closed-drainage basin of Delingha, collecting precipitation-dominated runoff from the montane catchment. It flows across the large wetland areas and enters first into the Keluke Lake (freshwater) and then out through Dalian River, terminates in Tuosu Lake.

XRF core scanning for core TS-3 provides 1-mm resolution measurements of 26 elements and related element ratios. Chronology of the proxy records of the past 1500 years is based on five AMS $^{14}$C dates with reservoir effect calibration. Results suggest
that (1) Elements of Si, Al, K, Ti in the sediments of Tuosu Lake originate predominantly from catchment detritus. (2) Biogenic silica may have a partial contribution to the total silica of the sediments. (3) The curve of the catchment erosion factor, extracted based on statistical analysis of single element, coincides well with the Si/Ti curve and with average effective moisture record of the past 50 years at the Delingha Weather Station.

Figure 2 Down-core variations in Ti, K, Si, and Al. Prominent lows are marked by strips, representing extreme events of draughts occurred before 1360 AD.

The elements of Si, Al, K, and Ti show highly correlated covariance (Figure 2), which may reflect variations in catchment erosion determined by magnitudes of surface runoff. The proxy records suggest that from 1360 AD to the present, the Bayin River runoff shows more frequent variations with smaller changes in magnitude if compared with the time period of 1500 to 1360 AD. Three extreme events of droughts were detected by the proxy records as marked in Figure 2. The magnitude of such extreme droughts therefore should exceed any of the disastrous draught events recorded in historical archives.

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