Paper Number: 5484

Climatic controls on the formation of evaporitic sequences and associated brine deposits in the Qaidam Basin, northern Tibet-Qinghai Plateau, China*

Yu, J.Q.[1], Gao, C.L.[1], Cheng, A.Y.[1], Zhang, L.S.[1] and Hong, R.C.[1,2]

[1]Qinghai Institute for Salt Lakes, Chinese Academy of Sciences, Xining 810008, China. junqyu@isl.ac.cn

[2]Unversity of Chinese Academy of Sciences, Beijing 100049, China

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Qaidam Basin is the largest inland drainage basin of the Tibet-Qinghai Plateau with an area of 120,000 km^2, one quarter of which is covered by a number of playas and saline lakes under hyperarid conditions. Deposition of evaporitic sediments of the Qarhan salt lake, the largest potash deposit of China, was previously attributed to evaporative concentration of a large freshwater lake due to climate change from wet to arid in the Late Pleistocene. Results from our recent investigations, however, provide new insight into the role of climate in controlling the formation of evaporitic sequences and associated brine deposits.

We found that seasonal changes in inflow/evaporation balance of the saline lakes are the key processes today controlling rapid shifts in saline lake size, concentration of ions, and evaporitic deposition. The inflow peaks twice a year in April and August from the large mountain catchment into the salt lakes, which are followed consistently by intense evaporative concentration of the brines. Long-term repeating of the annual processes has resulted in the formation of evaporitic sequences and associated potassium brine deposits. A calculation based on river-transported lithium influx and the sum total of Li reserves in the salt lake brines suggest that the commencement of evaporitic deposition occurred not before the last deglaciation. Importantly, the hydroclimatic regime affecting the depositional system is characterized by the topographically-induced differential effects of dry westerlies, which cause contrasting hydroclimatic conditions of the watershed between the wetter high-altitude mountains with annual precipitation 150-280 mm and hyperarid basins where the precipitation is less than 30 mm/year, but evaporation exceeds 2800 mm/year as a result of rain shadow effect.

Our work found that the differential effects of dry westerlies become amplified in warmer climate, such as during the early to middle Holocene. The amplification results in enhanced summer precipitation and glacier melting in the high mountain catchment, thus the terminal lakes receive more inflow from the increased river runoff. In the meantime, it also heightens evaporation in the Qaidam Basin, facilitating the enrichment of lake waters and salt precipitation in the salt lakes. In contrast, cold climate, such as during the LGM, minimizes summer precipitation and glacier melting in the mountain catchment, resulting in much decreased river runoff. The salinity of lake waters then in the Qaidam Basin was yet much lower than today, because evaporation decreased substantially as ice cover on the lakes persisted for a much longer period of the year than today. Therefore, we propose that warmer climate favors the formation of evaporitic sequence and associated brine deposits in the Qaidam Basin. The deposition pattern of evaporitic strata at the Qarhan salt lakes shows evidence for the proposed conceptual model, though a reevaluation of the chronological framework of the evaporitic sequences is yet required. Supporting evidence has also been found from AMS ^{14}C dated lithostratigraphy from the DaQaidam salt lake, northern Qaidam Basin, based on the study of a 100-m core drilled at the depo-center of the lake.

*This work was supported by NSFC grants U1407206; 41471013; 41171171.