Hydrology of Subsaline Lakes in Southern Mongolia: A Terrestrial Analog Study for Lacustrine Environments and Chloride Depositions on Early Mars.

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Chloride deposits on Mars are found on mid-Noachian to early Hesperian (3.9-3.5 Gyr old) crust, and generally on local topographic lows. Despite the importance of the formation process(es) of the widespread chloride deposits for understanding hydrology and climate on early Mars, the fact that the chloride deposits are often small and degraded leads to their formation process(es) being unclear.

In this regard, terrestrial analogs can provide unique insights into the formation process(es) of chloride deposits on Mars. In the present study, we performed a geological survey for three subsaline lakes and their surrounding areas in the Gobi Desert-Altai mountains transition zone of Mongolia. This area is a promising terrestrial analog environment that harbors ponding and lake evaporating under arid-to-semi-arid conditions [8,9]. We measured groundwater levels and analyzed chemical compositions of the surface/subsurface water in the region.

Two lakes, the Böön Tsagaan lake and the Orog lake, are the possible remains of a larger lake that previously existed under a more humid condition [9]. While the lakes each have their inflow rivers, they do not, at least currently, possess any outflow rivers, thus creating a closed-basin system. Water samples were taken from the lakes, wells, rivers, and springs in the region. The dissolved species of the water were measured using ICP-OES and ion chromatograph, and the results are displayed using stiff diagrams. We then used Visual MINTEQ, a chemical equilibrium model, to calculate the saturation index of minerals.

The lake pHs are all basic (pH 9–9.5); meanwhile, those of rivers, springs, and wells are circumneutral (pH = 6.4–8.1). Lake water has high concentrations of dissolved species which is most likely a result of surface/groundwater input and subsequent evaporation, leading to precipitation of calcite ($CaCO_3$) within the lakes. Rivers, springs, and well groundwater generally have low ion concentrations. Figure 1 shows that even the groundwater adjacent to the Böön Tsagaan lake has a distinctive chemical composition than that of the lake water. This fact suggests that the lakes have no effective groundwater outflow, despite high salinity and, thus, high density of the lake water.

Our results of chemical equilibrium calculations show that evaporation of river water, groundwater, or a mixture of them cannot reproduce the current pH and chemical composition of the lake water. A possible explanation for this is that the current chemical composition of the lake water is also affected by evaporation of a large paleolake [9]. The large lake captures surface/subsurface water from both catchment areas of the Böön Tsagaan and Orog lakes; whereas, each lake currently has an individual catchment area. We suggest that the lake composition would be determined not only by current hydrology but also by a long-term change of hydrology and climate of the area.

It is likely that paleolakes on early Mars underwent similar evaporation processes as the lakes in this study.

The paleolakes with chloride deposits on Mars may have had active groundwater supply, as well as possible supply from the surface water. Our results suggests that a similar chemical contrast between the surface and subsurface water may have occurred on early Mars. They also suggest a need to consider a long-term evolution of climate for evaluation of hydrology responsible for chloride formation on early Mars.

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