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Alkalinity as a control on the precipitation of Mg-carbonate minerals in alkaline lakes on the Cariboo Plateau and Atlin playa, British Columbia, Canada

MAIJA RAUDSEPP[1], SASHA WILSON[1], NINA ZEYEN[2], MARIA L. ARIZALETA[1] AND IAN M. POWER[3]

[1]University of Alberta
[2]University of Geneva
[3]Trent University
Presenting Author: raudsepp@ualberta.ca

Alkaline lakes and playas can be used a geochemical model for the influence of alkalinity on the precipitation of Mg-carbonate minerals after chemical weathering of mafic and ultramafic rocks. Alkaline lakes in the Cariboo Plateau of central British Columbia, Canada contain sediment with a primary carbonate mineralogy of either hydromagnesite [$Mg_5(CO_3)_4(OH)_2 \cdot 4H_2O$], magnesite ($MgCO_3$) or very high magnesium calcite (VHMC; $Ca_{0.5}Mg_{0.5}CO_3$). Evapoconcentration of groundwater results in elevated alkalinities and high pH values (9.2−10.5) in lakes and playas. The two sampled lakes with alkalinities below 20 mEq/kg do not have detectable carbonate minerals in the sediment. Hydromagnesite (± magnesite) occurs in larger lakes with alkalinities between 30 and 110 mEq/kg and magnesite (± VHMC) occurs in lakes with alkalinities between 70 and 800 mEq/kg. In the four sampled lakes with alkalinities >1000 mEq/kg, VHMC and Na-carbonates are the only carbonate minerals present. Aqueous Ca (<0.3 mM) and Mg (<12 mM) are limited in all of these alkaline lakes.

In contrast, waters from Atlin playa in northern British Columbia have both relatively high alkalinities (88−171 mEq/kg) and Mg (43−85 mM) concentrations but lower pH values (7.6−8.6) due to high amounts of dissolved CO_2 in the groundwater. The precipitation of hydromagnesite and magnesite is controlled, in part, by this CO_2 degassing [1]. An activity plot of [Mg^{2+}] vs [CO_3^{2-}] suggests that alkaline lakes in central BC and waters in the Atlin playa are both effected by a similar equilibrium geochemical process. One hypothesis is that Mg-carbonates are precipitating via non-classical pathways. In non-classical crystallization, carbonate minerals may nucleate and grow from solute carbonate prenucleation clusters [2]. Non-classical crystallization may explain the relatively high rates of magnesite precipitation in alkaline lakes compared to published experimentally-derived rates.

[1] Power et al. (2019), *GCA*, 255, 1-24.

[2] Gebauer et al. (2014), *Chem. Soc. Rev.*, 43, 2348