Accepted Manuscript

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PII: S0883-2927(18)30052-0

DOI: 10.1016/j.apgeochem.2018.03.001

Reference: AG 4049

To appear in: *Applied Geochemistry*

Received Date: 18 October 2017

Revised Date: 26 February 2018

Accepted Date: 2 March 2018

Please cite this article as: Seibert, S.L., Holt, T., Reckhardt, A., Ahrens, J., Pollmann, T., Giani, L., Waska, H., Böttcher, M.E., Greskowiak, J., Massmann, G., Hydrochemical evolution of a freshwater lens below a barrier island (Spiekeroog, Germany): The role of carbonate mineral reactions, cation exchange and redox processes, *Applied Geochemistry* (2018), doi: 10.1016/j.apgeochem.2018.03.001.

Hydrochemical evolution of a freshwater lens below a barrier island (Spiekeroog, Germany): The role of carbonate mineral reactions, cation exchange and redox processes

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Keywords: coastal aquifer, apparent groundwater age, decalcification, aquifer freshening, carbon isotopes, southern North Sea

Abstract: Freshwater lenses below barrier islands are a precious resource for the local water supply and important for coastal ecosystems. The aim of this study was to investigate the hydrochemical evolution of a freshwater lens, using the barrier island Spiekeroog, Germany, as an example. For this purpose, groundwater samples were obtained during several campaigns, and hydrochemical data and $^{13}C/^{12}C$ isotope ratios of dissolved inorganic carbon were linked to apparent groundwater ages. Results show that apparent groundwater ages increase with depth and range between 4 to 51 years. All groundwater samples were close to equilibrium with respect to calcite and considerably enriched in calcium and bicarbonate, suggesting calcite dissolution in the unsaturated zone of the dune sediments. The estimated average rate of decalcification was ~ 13 mm/a, resulting in a decalcification depth of ~ 4.6 m for the oldest sediments of an approximate age of 350 years. Moreover, $^{13}C/^{12}C$ isotope