

High rates of carbon oxidation through dissimilatory manganese reduction in sediment of Ulleung Basin in the East Sea

JUNG-HO HYUN¹, SUNG-HAN KIM¹, JIN-SOOK MOK¹,
HYE-YOUN CHO¹, VERONA VANDIEKEN²
AND BO THAMDRUP³

¹Hanyang University, Marine Sciences and Convergent
Technology, Korea; hyunjh@hanyang.ac.kr

²University of Oldenburg, Germany; verona.vandiek@uni-
oldenburg.de

³University of Southern Denmark; (bot@biology.sdu.dk).

Dissimilatory iron reduction plays an important role in the oxidation of organic carbon in continental sediments, whereas large contributions from dissimilatory manganese reduction are only known from a few locations characterized by a very high Mn content. There are very few experimental studies of these processes in deep sea sediments. As a contribution to filling this gap and obtaining a more detailed understanding of the regulation of the processes in marine sediments, we investigated experimentally the rates and relative importance of terminal electron acceptors in sediment from the slope and floor of the >2000 m deep Ulleung Basin in the East Sea. Our experiments also tested the assumptions behind the methods.

The contributions of Fe and Mn reduction were determined in anoxic incubations both indirectly by comparing total carbon oxidation rates from DIC production to the part of DIC production contributed by sulfate reduction, and directly from the accumulation of Fe(II) and Mn²⁺ over time, with corrections for reduction coupled to reoxidation of reduced sulfur species and for the adsorption of Mn²⁺. Rates obtained by the two methods agreed closely, which indicates that the stoichiometric assumptions behind the incubation approach are correct.

Dissimilatory Mn reduction accounted for ~50% of anaerobic carbon oxidation at the deep basin site, which contained more than 2.5 wt% Mn, while the process was insignificant at the slope site, which was not enriched in Mn. Here, sulfate reduction dominated with ~80% of anaerobic carbon oxidation. Both the diffusive O₂ uptake in intact cores and the depth-integrated DIC production from anoxic incubations demonstrated very high rates of carbon oxidation in these deep sediments.

Our results add the Ulleung Basin to the very small set of locations where dissimilatory Mn oxidation is important, and demonstrate that this deep basin is a hotspot of benthic mineralization, which can be related to the oceanographic characteristics of the East Sea.

Impact of Fe speciation in the aquifer sediments on ferric (hydr)oxide precipitation at the Changwon research site, Korea

S. P. HYUN*, H. S. MOON, P. YOON, K. HA
AND B.-G. CHAE

Korea Institute of Geoscience and Mineral Resources
(KIGAM), Daejeon 305-350, Korea (*Correspondence:
sphyun@kigam.re.kr)

Ferric (hydr)oxide precipitation can control the mobility of contaminants and redox conditions in an aquifer. The impact of Fe speciation on the kinetics of ferric (hydr)oxide precipitation at the sediment-groundwater interfaces was studied using the sediment samples collected from the KIGAM research site in Changwon, Korea. The research site is on unconsolidated, Quaternary floodplain deposits by the Nakdong River. Sets of sediment samples were collected at varying depths and locations within the research site. The sediment samples were wet-sieved to the sand, silt, and clay fraction, and further used for the Fe speciation characterization. Different pools of Fe present in the sediment samples were selectively extracted using ferrozine, ammonium oxalate, dithionite-citrate-bicarbonate, and hydrochloric acid. Chemical and mineralogical characterization of the sediment samples were performed using X-ray fluorescence, X-ray diffraction, and electron microscopy. Also, Fe distribution between the sediment and groundwater was modeled using the field measured groundwater chemistry data and Fe speciation results.

The results indicate alternating redox conditions along the depth of the aquifer. The alternating redox pattern suggests heterogeneities in the organic matter content and mineral composition within the aquifer, and seasonal and spatial variations in the groundwater table affected by the river water level changes. The different extraction methods resulted in independently varying or even apparently conflicting trends as functions of depth, suggesting the different quantities of Fe in the different pools. The field measured dissolved Fe(II) concentration in groundwater was up to a hundred mg/L with dissolved oxygen between 0.1 to 4 mg/L, depending on the depth and spatial location. This study suggests the potential of ferric (hydr)oxide precipitation upon the infiltration of surface water high in dissolved oxygen, to act as a sink and source of contaminants such as heavy metals and radionuclides, depending on the prevailing geochemical conditions within the aquifer. The results of this study will be used as background information in studying the kinetics of ferric (hydr)oxide precipitation.