High Sulfate Reduction and Its Controls in the Ulleung Basin, off the Southeast Korean Upwelling System in the East Sea

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Despite its significance in carbon mineralization pathways, relatively little is known about the sulfate reduction along the continental slope and rise [1]. We investigated the temporal and spatial variations and controls of sulfate reduction rates (SRRs) in the continental margin sediment of the Ulleung basin (UB), off the southeast Korean upwelling system. The depth integrated SRRs ranged from 1.22 to 8.07 mmol m^{-2} d^{-1} at the slope sites and from 0.69 to 3.18 mmol m^{-2} d^{-1} at the basin sites (Table 1), which were exceptionally higher than those observed within other marginal seas [2-6], and were comparable to the SRR values at the same depth range in the Peruvian and Chilean upwelling systems [7, 8]. The high sulfate reduction in the UB was attributable to enhanced primary production in the water column associated with coastal upwelling and a high export flux of large organic particles into the UB via the Ulleung warm eddy [9].

The SRR was approximately 4 times higher in the highly productive spring (4.91 ± 2.55 mmol m^{-2} d^{-1}) than during summer, which exhibited a highly stratified water column (1.28 ± 0.48 mmol m^{-2} d^{-1}). In the meantime, despite the high organic carbon content (> 2.5% dry wt.) in the UB, the SRR was consistently suppressed in the Mn oxide-enriched (174 μmol cm^{-3}) surface sediments of the continental rise. Overall, these results indicate that the production of organic carbon in the water column and its subsequent deposition on the seafloor is the primary source controlling the temporal variability of sulfate reduction [9], whereas the Mn oxides that were enriched in the basin are responsible for the spatial variability of the SRR in the UB [10, 11]. By assuming that the sulfate reduction in the ocean margin accounts for 25 – 50% of total carbon oxidation [12], carbon oxidation in the UB accounted for approximately 30% of primary production and approximately 60% of the export flux, indicating that the continental slope and rise of the UB is a region of rapid organic carbon turnover and nutrient regeneration.

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Table 1. Depth integrated sulfate reduction rates (SRR) in various continental slope and rise

Site	Location.	Water Depth (m)	Integrated SRR (mmol m^{-2} d^{-1})	References
Slope	Ulleung basin, East Sea (off Korean upwelling)	1051 − 1452 1042 − 1453	1.22 − 2.07 (Aug) 5.85 (April) − 8.07 (May)	This study
	Chilean upwelling	1000	4.9	8
	Peruvian upwelling	502	25.5	7
	Benguela upwelling	850 − 1488	0.18 − 1.39	3, 4
	Black Sea	396 − 1176	0.42 − 0.56	5
	East China Sea	637 − 1498	0.095 − 4.81	6
	Washington State	465 − 630	0.65 − 1.30	2
Basin (rise)	Ulleung basin, East Sea (off Korean Upwelling)	2144 − 2155 2050 − 2155	0.69 − 1.22 (Aug) 2.52 (April) − 3.18 (May)	This study
	Chilean upwelling	2000	2.4	8
	Peruvian upwelling	2650	5.2	7
	Benguela upwelling	2060 − 3013	0.14 − 0.37	3, 4
	Black Sea	2045	0.22	5