

*[Global Biogeochemical Cycles]*

Supporting Information for

**Sediment release in the Benguela Upwelling System dominates trace metal input to the shelf and the eastern South Atlantic**

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Table S1. Values of dissolved trace metals (TMs) for SAFe S, SAFe D2, GSP and GSC Certified Reference Materials (CRMs).

|  |  |  |  |
| --- | --- | --- | --- |
| CRMs | TMs | Consensus/Reported value (nM) | Measured value (nM) |
| SAFe Sa | Mn | 0.79 ± 0.06 | 0.860 ± 0.099 (n=2) |
| Fe | 0.093 ± 0.008 | 0.106 ± 0.013 (n=2) |
| Co | 0.0048 ± 0.0012 | 0.005 ± 0.002 (n=2) |
| Ni | 2.28 ± 0.09 |  |
| Cu | 0.52 ± 0.05 |  |
| Cd | 0.0011 ± 0.0003 |  |
| SAFe D2a | Mn | 0.35 ± 0.05 | 0.303 ± 0.002 (n=2) |
| Fe | 0.933 ± 0.023 | 1.068 ± 0.275 (n=2) |
| Co | 0.0457 ± 0.0029 | 0.054 ± 0.004 (n=2) |
| Ni | 8.63 ± 0.25 |  |
| Cu | 2.28 ± 0.15 |  |
| Cd | 0.986 ± 0.023 |  |
| GSCb | Mn | 2.180 ± 0.075 | 1.848 ± 0.340 (n =9) |
| Fe | 1.535 ± 0.115 | 1.600 ± 0.156 (n =9) |
| Coc | 0.084 ± 0.004 | 0.117 ± 0.007 (n =9) |
| Ni | 4.393 ± 0.205 | 4.270 ± 0.304 (n =9) |
| Cu | 1.099 ± 0.149 | 1.293 ± 0.119 (n =9) |
| Cd | 0.364 ± 0.022d | 0.435 ± 0.037 (n =9)d |

*Note. a Bruland K.W., 2009. GEOTRACES and SAFe Intercalibrations, Consensus Values for the GEOTRACES 2008 and SAFe Reference Samples. In:* [*https://websites.pmc.ucsc.edu/~kbruland/GeotracesSaFe/kwbGeotracesSaFe.html*](https://websites.pmc.ucsc.edu/~kbruland/GeotracesSaFe/kwbGeotracesSaFe.html)

*b In:* [*https://www.geotraces.org/standards-and-reference-materials/*](https://www.geotraces.org/standards-and-reference-materials/)

*c Dissolved cobalt (Co) values reported by Wuttig et al., (2019) were obtained without UV digestion, representing only the labile fraction.*

*d We suspect our measured Cd concentrations of GSC were slightly higher probably because of mass spectrometry interferences from polyatomic ions (e.g. 95Mo16O+, 94Mo16OH+, 98Mo16O+*

*, 96Mo18O+ and 97Mo16O+)****.***

Table S2. Values for manifold blanks (±1 standard deviation of repeated measurements (n)) as well as combined blank with resulting detection limits (three times the standard deviation of the blanks: 3 × SD) *(Rapp et al., 2017).*

|  |  |  |  |
| --- | --- | --- | --- |
| TMs | Procedural blank ± 1sd(pM) | n | Detection limit (3sd)(pM) |
| Mn | 8.8 ± 3.5 | 360 | 10.6 |
| Fe | 60.6 ± 23.8 | 255 | 71.4 |
| Co | 1.9 ± 1.0 | 375 | 3.0 |
| Ni | 412.4 ± 262.9 | 210 | 788.7 |
| Cu | 17.0 ± 13.6 | 210 | 40.7 |
| Cd | 4.8 ± 2.6 | 135 | 7.7 |

*Note. The procedural blank represents manifold blanks plus buffer blanks.*

**Table S3. The variance and coefficients of the principal components.**

|  |
| --- |
| Eigen-analysis of the Correlation Matrix |
|  | Eigenvalue | Variance Percent | Cumulative |
| Dim.1 | 6.210 | 51.7% | 51.7% |
| Dim.2 | 3.490 | 29% | 80.8% |
| Dim.3 | 0.982 | 8.18% | 88.9% |
| Eigenvectors |
|  | PC1 | PC2 | PC3 |
| Depth | 0.220 | -0.394 | 0.277 |
| Cd | 0.365 | -0.085 | -0.035 |
| Mn | 0.050 | 0.354 | 0.685 |
| Fe | 0.175 | 0.373 | 0.233 |
| Co | 0.198 | 0.426 | 0.214 |
| Ni | 0.357 | -0.177 | 0.031 |
| Cu | 0.257 | -0.325 | 0.285 |
| NOx | 0.367 | -0.009 | -0.247 |
| Si | 0.336 | -0.227 | 0.166 |
| phosphate | 0.380 | 0.048 | -0.169 |
| Oxygen | -0.213 | -0.390 | 0.295 |
| AOU | 0.339 | 0.221 | -0.259 |

Table S4. Pearson correlations of dissolved trace metal concentrations, macronutrients, Apparent Oxygen Utilization (AOU) and depth for our study area.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | AOU | Oxygen | Phosphate | Si | NOx | Cu | Ni | Co | Fe | Mn | Cd |
| Depth | 0.13 | 0.27 | 0.37 | 0.85 | 0.39 | 0.82 | 0.67 | -0.27 | -0.16 | -0.26 | 0.54 |
| Cd | 0.67 | -0.31 | 0.83 | 0.80 | 0.87 | 0.57 | 0.89 | 0.31 | 0.30 | 0.025 | 1 |
| Mn | 0.18 | -0.31 | 0.095 | -0.10 | -0.0040 | -0.14 | -0.051 | 0.72 | 0.53 | 1 |  |
| Fe | 0.59 | -0.66 | 0.40 | 0.20 | 0.28 | -0.080 | 0.14 | 0.72 | 1 |  |  |
| Co | 0.68 | -0.77 | 0.51 | 0.080 | 0.44 | -0.057 | 0.21 | 1 |  |  |  |
| Ni | 0.56 | -0.16 | 0.82 | 0.85 | 0.83 | 0.69 | 1 |  |  |  |  |
| Cu | 0.24 | 0.091 | 0.47 | 0.84 | 0.48 | 1 |  |  |  |  |  |
| NOx | 0.81 | -0.52 | 0.96 | 0.67 | 1 |  |  |  |  |  |  |
| Si | 0.50 | -0.12 | 0.69 | 1 |  |  |  |  |  |  |  |
| Phosphate | 0.85 | -0.58 | 1 |  |  |  |  |  |  |  |  |
| Oxygen | -0.89 | 1 |  |  |  |  |  |  |  |  |  |

Table S5. Water masses present at our study site, and their characteristic neutral density, depth (m), salinity (psu), potential temperature (℃), dissolved Cd and Ni concentrations (nM).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Water Mass | Neutral Density | Depth | Salinity | Potential Temperature | Cd | Ni |
| South Atlantic Central Water (SACW) | 26.5-26.93 |  | 34.9-35.4 | 9.44-13.6 |  |  |
| Antarctic Intermediate Water (AAIW) | 26.95-27.4 | <1500 | 34.3 | 3.8 | 0.53 | 5.59 |
| North Atlantic Deep Water (NADW) | 27.85-28.05 | <3500 | 34.97 | 2.4 | 0.22 | 3.78 |
| Antarctic Bottom Water (AABW) | 28-28.3 | >3500 | 34.66 | -0.1 | 0.78 | 7.72 |

Note. Data is from literature (Baars et al., 2014; Boye et al., 2012; Kenneth W. Bruland & Franks, 1983; Liu & Tanhua, 2021; Middag et al., 2018, 2020; Xie et al., 2014, 2019).

Table S6. Vertical fluxes at each station across the 26.5 kg m-3 isopycnal on the Namibian shelf including diffusive and upwelling fluxes (in unit of μmol m-2 d-1)­.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Station No. | Fe | Co | Mn | Location |
| 4 | 1.1 ± 0.44 | 0.048 ± 0.020 | 0.66 ± 0.27 | Shelf |
| 3 | 2.5 ± 1.1 | 0.059 ± 0.026 | 1.2 ± 0.51 | Shelf |
| 2 | 1.8 ± 0.82 | 0.061 ± 0.027 | -0.41 ± 0.18 | Shelf |
| 52 | 2.8 ± 1.2 | 0.013 ± 0.006 | -0.42 ± 0.18 | Shelf |
| 51 | 2.5 ± 1.1 | 0.083 ± 0.037 | 0.48 ± 0.22 | Shelf |
| 50 | 2.9 ± 1.2 | 0.049 ± 0.021 | 0.71 ± 0.31 | Shelf |
| 49 | 0.64 ± 0.28 | 0.078 ± 0.035 | -0.32 ± 0.14 | Shelf |
| 47 | 4.1 ± 1.9 | 0.063 ± 0.029 | 0.11 ± 0.048 | shelf |
| 45 | 4.7 ± 1.4 | 0.095 ± 0.028 | 3.7 ± 1.1 | shelf |
| 44 | 0.74 ± 0.26 | 0.022 ± 0.008 | -0.044 ± 0.015 | shelf |
| 43 | 0.24 ± 0.096 | 0.002 ± 0.001 | -0.15 ± 0.060 | shelf edge |
| 42 | 0.053 ± 0.044 | 0.002 ± 0.002 | -0.11 ± 0.091 | shelf edge |

Figure S1. Plots of daily and monthly precipitation rate (upper and lower panel, respectively) during the GA08 cruise period and during the year of 2015. Data and plots were retrieved from the NASA Goddard Earth Sciences Data and Information Services Center (GES DISC): <https://disc.gsfc.nasa.gov/datacollection/TRMM_3B42_Daily_7.html> (Goddard Earth Sciences Data and Information Services Center (2016).



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