Supporting Information

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Two End-Member Mixing Equations

The isotopic composition ($\delta^{56}DFe_M$) resulting from the mixing between two end members (A and B) is calculated following the equation:

$$\delta^{56}DFe_M = \frac{x\delta^{56}DFe_A[DFe]_A + (1-x)\delta^{56}DFe_B[DFe]_B}{x[DFe]_A + (1-x)[DFe]_B},$$

where x and $(1-x)$ are the fractions of A and B involved in the mixing, respectively.

For salinity (S), potential temperature (θ), and [O_2], the equations are as follows:

$$S_M = xS_A + (1-x)S_B,$$

$$\theta_M = x\theta_A + (1-x)\theta_B,$$

$$[O_2]_M = x[O_2]_A + (1-x)[O_2]_B.$$

Methods

The samples were collected with acid-cleaned Go-Flo bottles attached on a Kevlar line. Profiles were sampled down to a maximum depth of 4,068 m (the length of the Kevlar line), with 9–10 depths per profile. Although the sampling vertical resolution is limited below 1,000 m, samples were taken in the core of all major water masses at each station. They were tripped with Teflon messengers. Depths of closures and the absence of leak were carefully checked with (*i*) a pressure sensor to measure the inclination of the cable and (*ii*) measurements of salinities and nitrate and silicate concentrations. Samples were filtered with 0.4-μm-pore size, 90-mm-diameter Nuclepore membranes and acidified on board, just after collection, within a trace metal clean container (46).

A ^{57}Fe–^{58}Fe double spike was added to the filtered seawater with a spike-to-sample ratio ranging from 1 to 3. Iron in these samples was then preconcentrated using a NTA superflow resin (46). Five percent of the solution was taken for multielemental analysis with an Element XR inductively coupled plasma-mass spectrometer (ICP-MS) (Observatoire Midi Pyrénées, Toulouse, France). The accuracy of DFe concentrations was determined with the geostandard SLRS-5 with certified values of [Fe] = 91.2 ± 5.8 ppb, whereas our measurements were [Fe] = 90.5 ± 2.9 ppb

($n = 12$, 2SD). Iron was subsequently purified using an AG MP-1 anionic resin (46). Average recovery for the overall DFe treatments was 104 ± 8% (2SD, $n = 49$), and the blank of DFe was 1.3 ± 3.2 ng (2SD, $n = 8$). DFe concentrations repeatability has been measured from replicate samples (all of the chemical procedure being replicated) to be on average 3.3% (average value of 2SD of individual replicates, $n = 13$), with a maximum of 9.7%. These replicate sample repeatabilities are used to quantify the [DFe] uncertainties at the 95% confidence level. The average value of 3.3% is used for the nonreplicated samples (Dataset S1).

The iron isotopic composition ($\delta^{56}Fe$) is defined as follows:

$$\delta^{56}Fe \ (\permil) = \left[\frac{(^{56}Fe/^{54}Fe)_{sample}}{(^{56}Fe/^{54}Fe)_{IRMM\text{-}14}} - 1 \right] \times 10^3, \qquad \textbf{[S1]}$$

where $\delta^{56}Fe$ is reported relative to the IRMM-014 reference material. Iron isotopic compositions were measured with a Neptune MC-ICP-MS at the Observatoire Midi Pyrénées (Toulouse, France), following a previously published method (46). This protocol has been validated by the GEOTRACES intercalibration exercise (47) and an intercomparison study (48). The external precision of our instrument measured from repeated analysis of hematite standard (ETH-STD) was found to be of 0.07‰ (2SD, $n = 107$), whereas the internal precision for individual samples varied between 0.03 and 0.12‰. Several seawater replicates were measured and they reproduced to within ±0.06‰ (2SD) on average. The precision limiting factor is therefore the external precision (0.07‰, 2SD), except when the internal precision is larger than this value. Therefore, $\delta^{56}Fe$ uncertainty at the 95% confidence level is characterized by the external precision (2SD = 0.07‰) or the internal precision (2SE), whichever is greater (Dataset S1). Sampled volume ranged from 2 to 20 L. The mass of Fe used for Fe isotope measurements ranged from 37 to 145 ng, with a mean value of 75 ng. The total procedural blank reported above, 1.3 ± 3.2 ng (2SD, $n = 8$), was established for 20-L samples. Its mean value represents 3.5% of the most depleted sample. Its contribution to the sample isotopic composition is corrected for assuming a crustal isotopic composition for the blank. Even when assuming a large deviation of the blank $\delta^{56}Fe$ from the crustal value, of ±3‰, the effect on the corrected value for the most depleted sample would only vary within ±0.1‰ (0.05‰ on average).

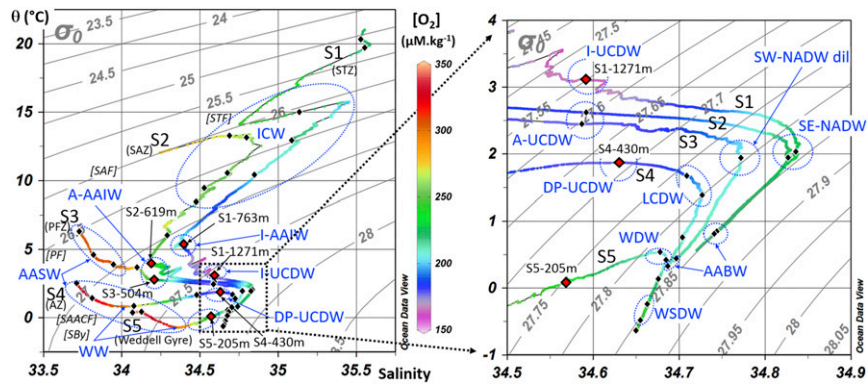**Fig. S1.** Potential temperature salinity diagram. Potential density (σ_θ in kilograms per cubic meter) and dissolved oxygen concentrations (in micromoles per kilogram) are shown. The right figure is a detail of the left graph. Black (and red) diamonds indicate iron isotope samples. At each station, intermediate-depth δ^{56}DFe minimum samples are indicated by red diamonds. Water masses are identified in blue. Fronts and zones are indicated in brackets and parentheses, respectively. See Fig. 2 for acronyms.
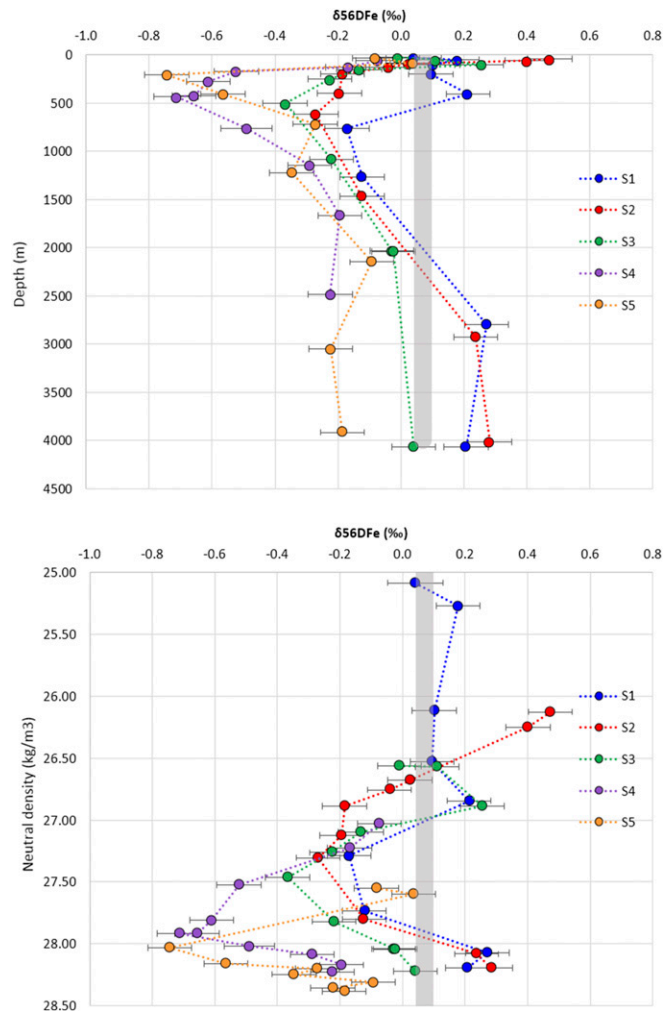

Fig. S2. Vertical profiles of δ^{56}DFe relative to IRMM-14 in per mill, as a function of depth (in meters) and neutral density (in kilograms per cubic meter). Bonus/GoodHope cruise.

Other Supporting Information Files

[Dataset S1 (XLSX)](#)