Cooling of deep Southern Ocean in the late Miocene

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Mg/Ca ratios of foraminifera have the potential to determine the temperature of the seawater in which they calcified and, in combination with foraminiferal $\delta^{18}O$, provide an estimation of seawater $\delta^{18}O$. Mg/Ca in infaunal benthic foraminifera might be a more reliable proxy for bottom water temperature (BWT) compared to epifaunal benthic foraminifera because the influence of carbonate ion saturation (ΔCO_3^{2-}) may be minor in pore waters. Indeed, Mg/Ca temperature record from *Uvigerina* spp. (ODP Site 1123, 3.3 km water depth on Chatham Rise, east of New Zealand) provides Pleistocene changes in seawater $\delta^{18}O$ that agree well with independent sea level records. This result confirms the validity of *Uvigerina* Mg/Ca ratio as BWT proxy [1]. Here, we use *Uvigerina* spp. Mg/Ca ratio from ODP Site 1123, and extend the BWT record back to the late Miocene (~7 Ma).

Mg/Ca ratios of *Uvigerina* spp. from ODP Site 1123 exhibit the range from 0.9 to 1.7 mmol mol^{-1} for the past 7 Myr. The Pleistocene record of *Uvigerina* spp. from our study was consistent with the record reported in the previous study [1]. The long-term variation in the Mg/Ca ratios shows significant decrease from 1.7 to 1.0 mmol mol^{-1} during the period of 7 Ma to 5.5 Ma, followed by gradual decrease for the past 5.5 Ma. If we apply the sensitivity to temperature of Mg/Ca ratios in *Uvigerina* spp. of 0.1 mmol/mol/ºC to our record as the previous study [1], the BWT in the Southern Ocean during the late Miocene can be estimated to be at least ~7ºC. If we correct *Uvigerina* spp. Mg/Ca ratios by considering the changes in Mg/Ca ratios in seawater, the BWT should increase up to ~10ºC. Compared to the *O. umbonatus* Mg/Ca record from ODP Site 806 in the western equatorial Pacific [2], our BWT record shows that the deep Southern Ocean (Site 1123) experienced earlier cooling in the late Miocene.

[1] Elderfield *et al*. (2012) Science **337**, 704–709. [2] Lear *et al*. (2015) Paleoceanography, doi: 10.1002/2015PA002833.