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The fourth Antarctic Bottom Water: Cape Darnley Bottom Water

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Antarctic Bottom Water (AABW) is the cold, dense water that occupies the abyssal layer of the global ocean, accounting for 30-40 % of its mass (Johnson, 2008). The production of AABW is a key process in the global overturning circulation, representing a significant sink for heat and CO_2. It is currently recognized that AABW is formed in the Weddell Sea, the Ross Sea and off the Adelie Coast (Orsi et al., 1999). A fourth variety of AABW has been identified in the eastern sector of the Weddell-Enderby Basin (Meredith et al., 2000). However, its production has never been observed, nor its exact dense shelf water (DSW) source located. Recently, satellite-derived estimates of sea ice production suggest that the Cape Darnley Polynya (65-69E), located northwest of the Amery Ice Shelf, has the second highest ice production after the Ross Sea Polynya (Tamura et al., 2008). As such, this polynya is promoted as a strong candidate for DSW source of the AABW identified in the Weddell-Enderby Basin.

As part of the Japanese International Polar Year program, we conducted mooring observations in 2008-2009 offshore from the Cape Darnley Polynya, and revealed that the enhanced sea-ice production in this polynya is the missing source of the AABW (Ohshima et al., 2013). Moored instruments observed overflows of newly formed AABW, about 300 m thick and bottom-intensified, cascading down the canyons north of Cape Darnley. We propose to name this AABW Cape Darnley Bottom Water (CDBW). This result is novel because this AABW is produced purely from sea-ice production without the assistance of an ice shelf and/or large storage volume on the continental shelf, in contrast to the traditional paradigm. We therefore speculate that there could be further AABW-formation discoveries in similar polynyas, particularly those in East Antarctica.

We estimate that 0.3-0.7 Sv of DSW is transformed into CDBW, accounting for 6-13 % of the circumpolar total. The CDBW migrate westward, and increase its volume by gradual mixing with Circumpolar Deep Water, to ultimately constitute part of the AABW in the Weddell Sea (Atlantic sector) referred to as Weddell Sea Deep Water (WSDW). Production of WSDW originating from CDBW is estimated to be 0.65-1.5 Sv, which is about 13-30 % of the Atlantic AABW production. The WSDW is a major component of the AABW driving the lower limb of the meridional overturning circulation (MOC) of the Atlantic Sector. It has been reported that WSDW has been warming since the 1980s, with its volume possibly contracting (Purkey and Johnson, 2012), and that this could result in a weakening of the MOC. Additionally, sediment-core records taken around the CDP indirectly suggest that there has been millennium-scale variability in the local AABW production. It is vital that CDBW be incorporated into the global assessment of the MOC, a key element of the climate system. This will improve numerical simulations predicting its response to long-term climate change.

Keywords: Antarctic Bottom Water, coastal polynya, sea-ice production, dense shelf water, mooring, Cape Darnley