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Ten thousand overflows in the abyssal ocean

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On average about 20Sv of Antarctic Bottom Water are produced. In order to balance this production of high-density water, upwelling and buoyancy gain are required in the abyssal ocean. This seems hard to reconcile with microstructure observations from the abyssal South Atlantic, which show a general downward increase in the diapycnal buoyancy fluxes and thus imply density gain and, if a point-wise vertical advective-diffusive balance is assumed, downwelling rather than upwelling. A recent analysis of hydrographic and microstructure data from the South Atlantic shows that the energy dissipation as well as the hydrographic effects of mixing are largely confined within the deep canyons on the flank of the Mid-Atlantic Ridge (MAR), where horizontal advection of buoyancy cannot be ignored. The observations are consistent with flow toward the MAR crest in many of the ridge-flank canyons, implying upwelling as a kinematic consequence. Hydrographic evidence suggests that the diapycnal buoyancy fluxes in one particular canyon, where persistent transport of order 0.1Sv toward the MAR crest was observed directly, are primarily associated with overflows across sills.

Cross-flank canyons are the off-axis traces of the segmentation of slow-spreading mid-ocean ridges, which make up 2/3 of the global ridge system. The average along-flank spacing of the canyons ($\approx$50km) implies that there are approximately 1,000 such cross-flank canyons in the abyssal ocean. The ubiquitous abyssal hills that are inherently associated with seafloor spreading appear as sills rising above the canyon floors. Extrapolating from the South Atlantic observations, where the along-axial spacing between sills that are at least 250m high is 30–40km, yields an estimate of order 10,000 sills in the abyssal ocean. Flows along ridge-flank canyons and mixing associated with cross-sill flows may account for most of the abyssal mass and buoyancy budget below the crest depth of the mid-ocean ridge.