

## FINAL REPORT PROGRAM LEFE

<b>Program LEFE / CYBER</b>	<b>Project Title: AbAc Abyssal mixing and biogeochemical fluxes traced with <sup>227</sup>Ac</b>	<b>Years 2021 – 2022</b>
PI: Roy-Barman, Matthieu Participating Laboratories : LSCE, UMR821		Contribution to <i>GEOTRACES</i>  Other funding sources : UVSQ, EUR IPSL
<p><i>Context:</i> Vertical mixing in the deep ocean is an important process for the functioning of the thermohaline circulation and also for the global climate system. Actinium-227 (<sup>227</sup>Ac, T<sub>1/2</sub> = 22.8 years) is a natural radioactive isotope product of the decay of protactinium-231 (<sup>231</sup>Pa) in deep marine sediments. The half-life of this isotope makes it a suitable tracer of vertical mixing in the deep ocean. The large volumes of water, from 50 to several hundred litres, required for <sup>227</sup>Ac analysis by nuclear counting have limited the use of <sup>227</sup>Ac in oceanography.</p> <p><i>Objectives / scientific questions :</i> Taking advantage of the recent development of <sup>227</sup>Ac analysis by isotope dilution and MC-ICPMS, the AbAc project aims to measure samples collected during the BONUS GOODHOPE cruise, which sampled stations with strategic locations (ocean margin, ridge) and processes (benthic nepheloid layers), both to understand the fate of <sup>227</sup>Ac in the lower water column and to quantify mixing in the deep ocean.</p> <p><i>Main results</i>  <sup>227</sup>Ac concentrations were analysed by isotope dilution and MC-ICPMS in particulate and dissolved phases of samples from the BONUS GoodHope (BGH) IPY GEOTRACES cruise in the SE Atlantic sector of the Southern Ocean (36°S-13°E to 57°S-0°, Feb.-Mar. 2008). The excess of <sup>227</sup>Ac relative to its radioactive parent, <sup>231</sup>Pa, is produced by <sup>227</sup>Ac diffusion from deep sediments and allows estimation of the mean vertical eddy diffusion coefficient (Kz). Along the transect from 34°S 19°E to 51°S 0°W and along the Greenwich meridian from 51°S to 58°S (Figure 1), dissolved <sup>227</sup>Ac concentrations in seawater ranged from about 0.27 ± 0.34 ag/kg in shallow waters of station S1 to 9.55 ± 1.42 ag/kg in bottom water of the station S5 (Figure 2). The <sup>227</sup>Ac profiles generally show a decrease of the concentration from the bottom waters to shallow waters.</p> <p>The calculated vertical eddy diffusion coefficients (Kz) ranged from about 1 cm<sup>2</sup>/s over the mid-ocean ridge to 14 cm<sup>2</sup>/s at stations constrained by the topographic effect of the African margin. Mixing along the isopycnal surface between the Weddell Gyre and the ACC is mainly constrained by isopycnal diffusion due to a strong gradient between the actinium-rich waters of the Weddell Sea and the Ac-poor waters of the intermediate waters.</p>		

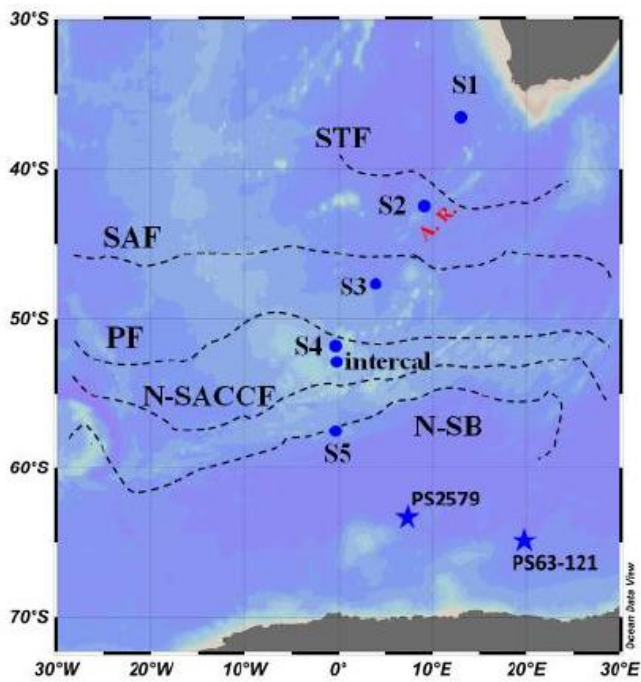


Figure 1 : Map of the stations from the Bonus Goodhope cruise, with the location of the hydrological fronts. Stations sampled to determine  $^{227}\text{Ac}$  are indicated by a blue dot. Figure from Levier (2022)

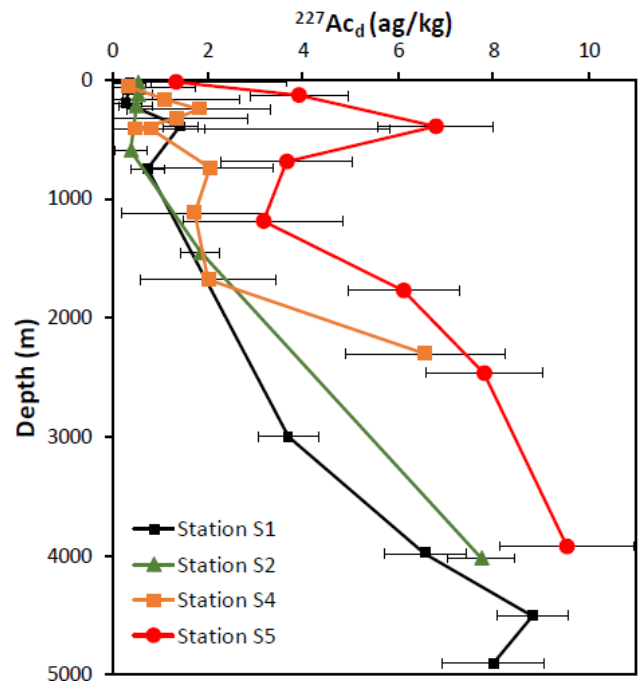


Figure 2: Profiles of dissolved  $^{227}\text{Ac}$  at stations S1, S2, S4 and S5. Figure from Levier (2022)

*Future of the project :*

The project has demonstrated the pertinence of the  $^{227}\text{Ac}$  analysis by isotope dilution and MC-ICPMS, and should promote the use of this tracer by the GEOTRACES community

*Number of publications, communications and theses*

Martin Levier (2022) Développement et utilisation de l'Actinium 227 comme traceur du mélange de l'océan profond. Doctorat de l'Université Paris-Saclay. PhD Thesis, 191 p.

M. Levier, M. Roy-Barman, C. Colin, A. Dapigny (2021) Determination of low level of actinium 227 in seawater and freshwater by isotope dilution and mass spectrometry. Marine Chemistry 233, doi.org/10.1016/j.marchem.2021.103986

*Data availability*

