Argon-39 Measurements in the Atlantic and Pacific Oceans

Bill Smethie, Lamont-Doherty Earth Observatory of Columbia University

During the 1980s and early 1990s about 125 seawater samples were collected for Ar-39 and measured by Hugo Loosli at the University of Bern. Twelve-hundred liter samples were collected using 5 Gerard Barrels hung over a 50m interval and the water was vacuum degassed on board ship. Samples were collected in the Arctic Ocean, the Atlantic Ocean, the Weddell Sea and the Pacific Ocean. Deep water in the Atlantic Ocean had Ar-39 concentrations ranging from about 85 % modern near its source regions at high latitudes to about 45% modern in the South Atlantic and the eastern basin. Deep and abyssal waters in the Atlantic Ocean are essentially a two component mixture of water from high latitudes in the North Atlantic and Southern oceans. C-14 measurements reveal the average age of the deep water to range from about 40 years in the western North Atlantic to 240 years in the eastern Atlantic. Combining Ar-39 concentrations with C-14 concentrations allows the age of the individual northern and southern source waters to be calculated. The northern source water has an age range of about 40 - 200 years with age increasing as the fraction of northern component water decreases and the southern source water has a range of about 60 – 600 years with age increasing as the fraction of southern component water decreases. Three vertical profiles of Ar-39 have been measured in the Pacific Ocean. Concentrations range from 100% modern at the surface to 6% modern at 3500 m depth north of Hawaii, which is equivalent to a 1500 year isolation time from the surface. There is an increase in concentration at the bottom, which is greater in the South Pacific than the North Pacific reflecting the entry of ventilated bottom water from the Southern Ocean and aging as the water flows into the North Pacific and upwells to mid-depths. Simulations of Ar-39 and C-14 distributions with ocean circulation models demonstrate that the relationship between Ar-39 and C-14 reveals information on the relative importance of advection and mixing in the deep ocean. The straight forward boundary condition for entry of Ar-39 into the ocean, its conservative behavior and its 270 year half-life result in this noble gas isotope being ideally suited for investigations of circulation and mixing on time scales of about 40 to about 1500 years. This covers the deep thermocline and deep and abyssal waters of the ocean, where anthropogenic tracers such as CFCs have not yet penetrated. Opportunities for future measurements of Ar-39 include a suite of about 1000 samples from the Atlantic Ocean collected in the 1980s and future cruises on the GOETRACES project, which will be mapping the global ocean distributions of various trace elements and isotopes over the next decade, and CLIVAR repeat hydrography cruises, which repeats oceanographic sections on a 10 – 15 year time scale to document uptake of anthropogenic CO2 by the oceans and changes in ocean properties.