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^{137}Cs in the western South Pacific Ocean

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Abstract

The ^{137}Cs activities were determined for seawater samples from the East Caroline, Coral Sea, New Hebrides, South Fiji and Tasman Sea (two stations) Basins of the western South Pacific Ocean by γ spectrometry using a low background Ge detector. The ^{137}Cs activities ranged from 1.4 to 2.3 Bq m^{-3} over the depth interval 0–250 m and decreased exponentially from the subsurface to 1000 m depth. The distribution profiles of ^{137}Cs activity at these six western South Pacific Ocean stations did not differ from each other significantly. There was a remarkable difference for the vertical profiles of ^{137}Cs activity between the East Caroline Basin station in this study and the GEOSECS (Geochemical Ocean Sections Study) station at the same latitude in the Equatorial Pacific Ocean; the ^{137}Cs inventory over the depth interval 100–1000 m increased from 400±30 Bq m^{-2} to 560±30 Bq m^{-2} during the period from 1973 to 1992. The total ^{137}Cs inventories in the western South Pacific Ocean ranged from 850±70 Bq m^{-2} in the Coral Sea Basin to 1270±90 Bq m^{-2} in the South Fiji Basin. Higher ^{137}Cs inventories were observed at middle latitude stations in the subtropical gyre than at low latitude stations. The ^{137}Cs inventories were 1.9–4.5 times (2.9±0.7 on average) and 1.7–4.3 times (3.1±0.7 on average) higher than that of the expected deposition density of atmospheric global fallout at the same latitude and that of the estimated ^{137}Cs deposition density in 10° latitude by 10° longitude grid data obtained by Aoyama et al. [Aoyama M, Hirose K, Igarashi Y. Re-construction and updating our understanding on the global weapons tests ^{137}Cs fallout. J Environ Monit 2006;8:431–438], respectively. The possible processes for higher ^{137}Cs inventories in the western South Pacific Ocean than that of the expected deposition density of atmospheric global fallout may be attributable to the inter-hemisphere dispersion of the atmospheric nuclear weapons testing ^{137}Cs from the northern stratosphere to the southern one and its subsequent deposition, and water-bearing transport of ^{137}Cs from the North Pacific Ocean to the western South Pacific.

Keywords: ^{137}Cs activity; γ spectrometry; Vertical profile; Latitudinal distribution; Water column inventory; Western South Pacific Ocean

1. Introduction

The main introduction routes of the artificial radionuclide ^{137}Cs (half life of 30.07 yr) into the Pacific Ocean are worldwide global fallout from atmospheric nuclear weapons testing and close-in fallout from U. S. tests conducted on the Bikini and Enewetak Atolls in the

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northern Marshall Islands (UNSCEAR, 2000; Aarkrog, 2003; Hamilton, 2004). Hamilton (2004) has estimated that the globally dispersed ^{137}Cs deposited in the Pacific Ocean was 182 PBq (decay-corrected to January 1, 2000), which included an estimated 58 PBq of ^{137}Cs in local and regional fallout. In the South Pacific Ocean there is another source of artificial radionuclides from the French nuclear testing at the Mururoa and Fangataufa Atolls from 1966 to 1974 (Bourlat et al., 1995; Hamilton et al., 1996; Chiappini et al., 1999). The activities of artificial radionuclides are generally lower in southern hemisphere waters because they received less fallout from atmospheric nuclear weapons testing; it was estimated that approximately 3/4 of test fallout affected the northern hemisphere and 1/4, the southern hemisphere (UNSCEAR, 2000; Aarkrog, 2003).

In the western South Pacific Ocean, oceanic ridges and island arcs separate the ocean into many semi-isolated basins. This area includes the East Caroline Basin, Coral Sea Basin, New Hebrides Basin, South Fiji Basin and Tasman Sea Basin; all of these are deeper than 4000 m. The ^{137}Cs activities and inventories in the water columns have been well investigated in the North Pacific Ocean (e.g., Bowen et al., 1980; Nagaya and Nakamura, 1981, 1984, 1987; Aoyama and Hirose, 1995; Aoyama et al., 2000; Povinec et al., 2003a), however, investigations on vertical profiles of ^{137}Cs activities and inventories have been limited in the South Pacific Ocean, especially in the present study area of the western South Pacific (Fig. 1). Bowen et al. (1980) reported the ^{137}Cs and $^{239+240}$Pu activities at stations in the open ocean east of Fiji and New Zealand (GEOSECS-246, 251 and 263; Fig. 1) during the GEOSECS (Geochemical Ocean Sections Study) Expedition. A few measurements of ^{137}Cs activities were carried out at the Mururoa and Fangataufa Atolls in the French Polynesia (Bourlat and Martin, 1992; Bourlat et al., 1996; Hamilton et al., 1996).

The Sagittarius Expedition of the R/V Hakuho-Maru aimed at collecting a geochemical dataset in the western South Pacific Ocean (Kudo et al., 1996; Zhang and Nozaki, 1996). The objectives of the present study are to measure the ^{137}Cs activities in water columns collected during the Sagittarius Expedition in the East Caroline, Coral Sea, New Hebrides, South Fiji and Tasman Sea Basins of the western South Pacific Ocean, to trace temporal changes by comparing with measurements reported by the GEOSECS Expedition, to compare the ^{137}Cs inventories with the integrated deposition density of atmospheric global fallout and to discuss the processes controlling the ^{137}Cs inventory in the western South Pacific Ocean.

2. Materials and methods

Water samples for ^{137}Cs determinations were obtained during the Sagittarius Expedition (KH-92-4

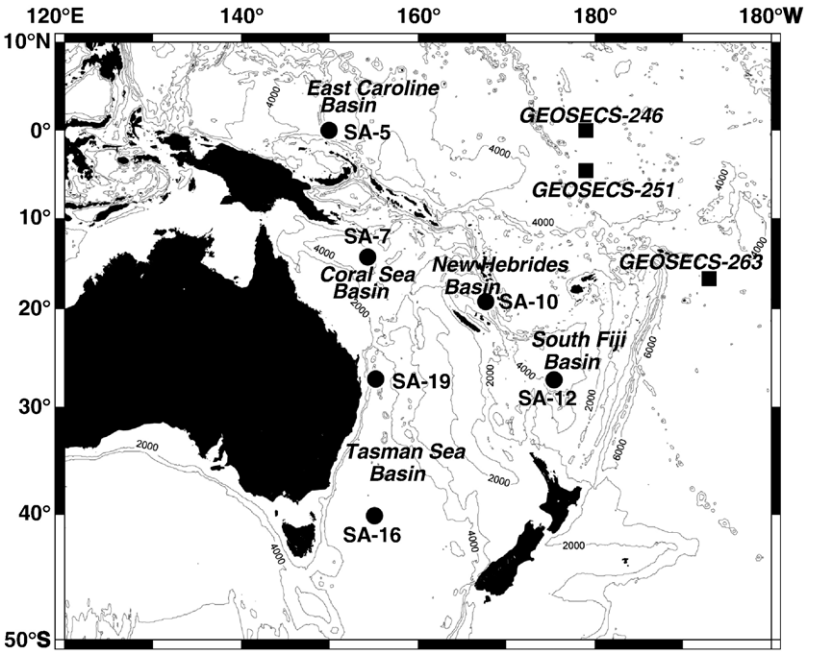

Fig. 1. Map showing the sampling locations. Black circles represent sampling locations for this study and black squares represent sites from Bowen et al. (1980).