ELSEVIER

Earth and Planetary Science Letters 175 (2000) 297–308

EPSL

www.elsevier.com/locate/epsl

Paradox lost: silicon 32 and the global ocean silica cycle

H. Craig [a,*], B.L.K. Somayajulu [b], K.K. Turekian [c]

[a] *Isotope Laboratory, Scripps Institution of Oceanography, UCSD, La Jolla, CA, USA*
[b] *Physical Research Laboratory, Ahmedabad, India*
[c] *Department of Geology and Geophysics, Yale University, New Haven, CT, USA*

Received 14 June 1999; accepted 17 November 1999

Abstract

The ^{32}Si Paradox is that the GEOSECS measurements of ^{32}Si specific activity in silica collected on ferric hydroxide-coated fibers are essentially uniform throughout the deep water of the global oceans [Somayajulu et al., Earth Planet. Sci. Lett. 85 (1987) 329–342; 107 (1991) 197–216]. Peng, Maier-Reimer, and Broecker have argued that ^{32}Si specific activities in Indian and Pacific deep water should be 3–5 times lower than in the deep Atlantic, because the dissolved SiO_2 concentrations are higher than in the Atlantic by this factor, and because cosmogenic ^{32}Si should be essentially confined to the ocean basins in which it falls due to its short half-life relative to mixing times for water interchange between the oceans. Thus these authors proposed that the entire GEOSECS ^{32}Si data set "may be flawed". The resolution of the ^{32}Si Paradox is straightforward. Silica collected on the acrilan fibers is a two-phase mixture of biogenic particulate SiO_2 (opaline tests of diatoms and radiolaria) and silica scavenged chemically from dissolved SiO_2 in ocean water. Particulate silica is the high-activity component in this mixture, and dissolved SiO_2 is the low-activity end-member. Thus the mixing trajectories on 'Cornucopia plots' of specific activity vs. reciprocal SiO_2 recovered weights overlap in specific-activity range, regardless of the different concentrations and specific activities of dissolved silica in the deep waters. The specific activities of dissolved SiO_2 in the Pacific, Indian, and Atlantic oceans, as deciphered from the two-component total activity data, are $\sim$0, 2.6, and 4.5 dpm/kg SiO_2. The atmospheric production rate of ^{32}Si has been calculated and is found to be 0.72 atoms/m^2 s. This value is much lower than in previous calculations, which were based on the Lal and Peters plots of stratospheric fallout that incorrectly use geomagnetic latitude for scaling the fallout patterns. Correcting these curves to scale by geographic latitude, which controls the stratospheric 'dumping' pattern, we show that the ^{32}Si concentrations in Indian rains represent the total fallout from both stratosphere and troposphere, rather than only tropospheric fallout as was previously assumed. The new value of the atmospheric production rate is consistent with the low activities of the dissolved silica in the three oceans, which are modulated to some extent by radioactive decay of ^{32}Si during the sequestering of particulate silica in sediments before regeneration in bottom waters.

Keywords: silicon; isotopes; geochemical cycle; Atlantic Ocean; Pacific Ocean

1. Introduction

Measurements of the cosmogenic nuclide ^{32}Si (mean life $\approx$ 202 years [2]) were made in seawater profiles during the GEOSECS program, in

* Corresponding author. Fax: +1-619-534-0784; E-mail: passim@helium.ucsd.edu

0012-821X/00/$ – see front matter
PII: S0012-821X(99)00300-3