Faithful transfer of radiolarian silicon isotope signatures from water column to sediments in the South China Sea

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Abstract. Radiolarian silicon isotopes ($\delta^{30}Si_{rad}$) hold significant potential as a proxy for constraining past silicon cycling in seawater. However, the extent to which $\delta^{30}Si_{rad}$ signatures in sediments accurately represent the isotopic signals of the overlying water column remains unclear, particularly under the influence of radiolarian shell dissolution during sinking and burial in the sediment record. This study presents the first comparative analysis of $\delta^{30}Si_{rad}$ compositions and the radiolarian

5 assemblage community using water column and surface sediment samples collected from the South China Sea (SCS). The results indicate that $\delta^{30}Si_{rad}$ values range from 1.56-1.83‰ (mean = 1.74‰) in the water column, and from 1.61-1.85‰ (mean = 1.73‰) in surface sediments. No significant discrepancies in $\delta^{30}Si_{rad}$ values were observed between plankton and sediment samples at each sampling station as evidenced by the paired t-test ($p = 0.75$), implying that dissolution has a minimal impact on $\delta^{30}Si_{rad}$ during the transfer of radiolarian shells to the sediment record. This finding may be enhanced by the

10 dominance of more dissolution-resistant Spumellaria and Nassellaria taxa (>99% relative abundance) within the radiolarian community, coupled with the scarcity or absence of the readily dissolvable radiolarian taxa in the analysed samples. This study demonstrates the faithful preservation of the $\delta^{30}Si_{rad}$ signature and its potential for studying past changes in the marine silicon cycle.

1   Introduction

15   Silicon (Si) is a crucial nutrient in marine ecosystems, playing a significant role in both the global carbon cycle and climate change. For example, during glacial periods the Southern Ocean exhibits reduced rates of primary productivity and silicon utilization efficiency due to the alleviation of iron (Fe) limitation by enhanced aeolian deposition, resulting in an excess of silicic acid ($Si(OH)_4$) in the water column (Matsumoto et al., 2002; Brzezinski et al., 2002). Based on this the "silica acid leakage hypothesis" (SALH) was proposed, in which excess $Si(OH)_4$ within glacial Antarctic intermediate water was transported to

20   lower latitudes, leading to enhanced diatom productivity at the expense of carbonate export (Brzezinski et al., 2002). This shift to diatom growth over carbonate export was expected to result in higher seawater alkalinity, and lower atmospheric pCO_2 (Matsumoto et al., 2002; Matsumoto and Sarmiento, 2008; Ellwood et al., 2010) and is supported by significant increases in glacial siliceous productivity in lower latitude regions of the equatorial Atlantic and low-latitude Pacific Oceans (e.g., Kienast

et al., 2006; Bradtmiller et al., 2007; Arellano-Torres et al., 2011; Hendry et al., 2021). However, other findings have challenged
25 this hypothesis by suggesting that siliceous productivity and surface water $Si(OH)_4$ concentrations were actually higher during
interglacials (e.g., Bradtmiller et al., 2006; Dubois et al., 2010). To gain a deeper insight into the mechanisms, and impact, of
marine silicon cycling in both glacials, and other temporal/spatial scales across the geological record, it is essential to have a
more comprehensive understanding of the relationships between marine $Si(OH)_4$ concentrations, primary productivity and the
wider climate system.

30   The silicon isotope ($\delta^{30}Si$) composition of biogenic silica (BSi), primarily comprising radiolarians, diatoms, and sponge
spicules, serves as a key indicator for quantifying marine silicon cycling and its response to changing oceanographic and
climate processes. Whereas the $\delta^{30}Si$ of diatoms, inhabiting the photic zone of the water column, primarily reflects changes in
silicic acid utilization/supply in the surface ocean (De La Rocha et al., 1998; Reynolds et al., 2006; Egan et al., 2012; Abelmann
et al., 2015; Swann et al., 2016, 2017; Hendry et al., 2021; Worne et al., 2022), the $\delta^{30}Si$ of sponge spicules, inhabiting bottom
35 waters, are closely related to deep ocean $Si(OH)_4$ concentrations (De La Rocha, 2003; Wille et al., 2010; Hendry et al., 2010;
Hendry and Robinson, 2012; Hendry et al., 2014; Fontorbe et al., 2016). More recently, attempts have been made to use the
$\delta^{30}Si$ of radiolaria shells ($\delta^{30}Si_{rad}$), which typically occupy intermediate water depths in high latitudes (Boltovskoy, 2017),
to fill in the gaps between surface (diatom) and bottom (sponge) measurements of $\delta^{30}Si$ and so allow whole water column
reconstructions of silicon cycling (e.g., Abelmann et al., 2015).

40   Numerous studies have demonstrated that c. 97% of biogenic silica, specifically for diatoms in surface waters, is dissolved
during sinking through the water column and/or early diagenesis (Tréguer et al., 1995; Ragueneau et al., 2000; Tréguer and
De La Rocha, 2013). The potential for this dissolution to fractionate and so alter BSi $\delta^{30}Si$ is under debate. Cardinal et
al. (2007) reported a positive relationship between the silicon isotopic fractionation factor and net diatom production in the
Southern Ocean, implying a dissolution-driven isotope effect. Demarest et al. (2009) then conducted dissolution experiments on
45 natural diatom frustules, observing a silicon isotope fractionation factor of -0.55 ± 0.05‰ with lighter isotopes preferentially
released. However, others have showed that diatom dissolution is not associated with significant silicon isotope fractionation
in both laboratory experiments (Wetzel et al., 2014) and in studies monitoring the sinking and burial of diatom in the natural
environment (Egan et al., 2012; Panizzo et al., 2016). These inconsistent findings make it unclear to what extent silicon isotopic
fractionation might impact the $\delta^{30}Si$ records of also other forms of biogenic silica preserved in the sediments.

50   Polycystine radiolarians, a primary component of biogenic silica in tropical ocean surface sediments (Lisitzin, 1972; Zhang
et al., 2015), typically exhibit a greater resistance to dissolution (Suzuki and Aita, 2011) than the more fragile and soluble
diatoms. However, existing investigations of $\delta^{30}Si_{rad}$ have been limited by difficulties in successfully culturing radiolarians
and/or purifying their tests from the natural environment. Whilst a few studies have explored $\delta^{30}Si_{rad}$ compositions in surface
sediments and their correlations with $Si(OH)_4$ concentrations in the overlying water column (Ding et al., 1996; Egan et al.,
55 2012; Abelmann et al., 2015; Doering et al., 2021), as well as their response to changing climatic conditions (Hendry et al.,
2014; Fontorbe et al., 2016), the impact of dissolution on $\delta^{30}Si_{rad}$ during the sinking and burial of radiolarian shells into
sediments remains unknown. Using a new method for extracting and purifying radiolarian tests from sediments (Zhang and

Swann, 2023), this study documents the $\delta^{30}\mathrm{Si}_{\mathrm{rad}}$ in water column and surface sediments in the South China Sea (SCS) and assesses whether there is evidence of a dissolution impact on values of $\delta^{30}\mathrm{Si}_{\mathrm{rad}}$.

60 ## 2 Material and methods

2.1 Sample material
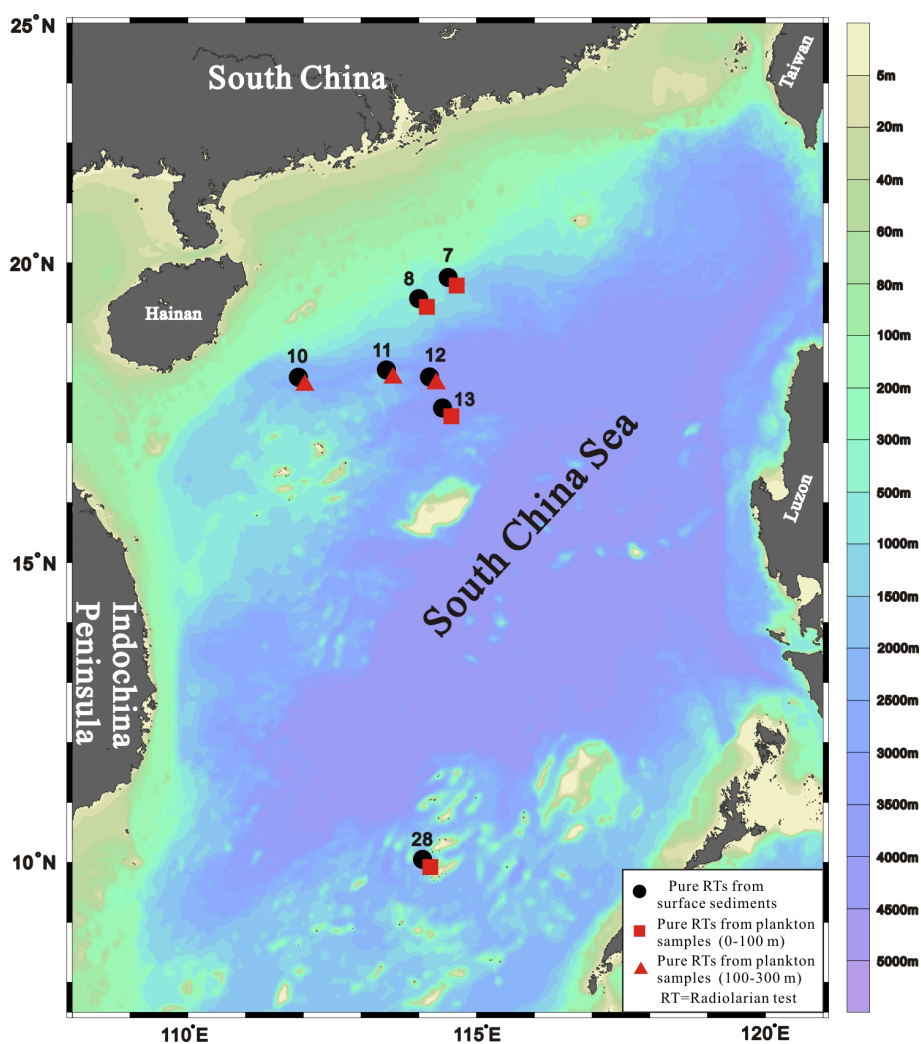
Figure 1. Locations of sampling stations in the South China Sea (base map created using Ocean Data View software, version 5.3.0).

A total of 21 samples, comprising 14 plankton samples and 7 surface sediment samples, were collected at seven stations spanning the upper continental slope to the deep basin in the northwestern and southern SCS (Figure 1). All samples were collected during SCS cruises by R/V Shiyan 3 and Shiyan 1 of the South China Sea Institute of Oceanology, Chinese Academy

65   of Sciences, in September 2016, November 2020 and August 2021 (Table S1 in the Supplementary Material). Plankton samples
were collected from the 0-100 m and 100-300 m water layers at each station using a Hydro-Bios MultiNet with a 63 μm mesh
size and were preserved in 5% buffered formalin. Each plankton sample was then divided into two or four aliquots, washed
through a 63 μm sieve with deionized water, reacted with 30% H_2O_2 in a water bath at 75°C for 24 hours, and freeze-dried. Due
to insufficient radiolarian tests, only one plankton sample from either the 0-100 m or 100-300 m layer was used for isotopic
70   analysis at each station. Surface sediments were sampled from the top 1 cm of the seabed using a box corer, and stored in cold
storage at 5°C.

2.2   Radiolarian composition analysis

To determine the species composition of radiolarians, in both plankton samples and surface sediments, all samples were wet-
sieved through a 63 μm sieve and prepared into radiolarian slides following the method described by Zhang et al. (2014).
75   Radiolarian species were then identified and counted under a Nikon optical microscope at x100 or x200 magnification, with
more than 500 specimens identified on slides using the publications of Chen and Tan (1996) and Tan and Chen (1999). Relative
abundances of various species were then calculated based on individual count of each species and the total number of radiolarian
specimens observed under the microscope.

2.3   Silicon isotope analysis

80   For isotope analysis, sufficient radiolarian tests were extracted and purified from 7 plankton samples and 7 surface sediment
samples following the method of Zhang and Swann (2023). The purity of extracted radiolarian tests in each sample was
visually assessed under a Zeiss inverted light microscope at x100 magnification, with selected samples further examined using
a scanning electron microscopy (SEM) (JEOL JSM-IT200) equipped with an energy dispersive X-ray spectroscopy (EDS)
detector at the Nanoscale and Microscale Research Centre, University of Nottingham.

85   Pure radiolarian samples were digested using the NaOH fusion method, with 1-3 mg radiolarian tests fused with a 200 mg
NaOH pellet. Subsequent purification was achieved via ion exchange chromatography at a pH of between 2-8 (Georg et al.,
2006; van den Boorn et al., 2006). Prior to analysis, each sample was filtered through a Millipore PTFE 0.2 nm filter to remove
any particulate matter. The samples were then acidified using hydrochloric acid (HCl, to a concentration of 0.05 M, using
twice quartz-distilled acid) and sulfuric acid (H_2SO_4, to a concentration of 0.001 M using Romil UPA). Swamping the natural
90   abundance of chloride (Cl^-) and sulfate (SO_4^{2-}) ions, in both samples and reference materials alike, will induce a similar mass
bias response in each (Hughes et al., 2011). Finally, all samples are spiked with approximately 300 ppb magnesium (Mg, Alfa
Aesar SpectraPure, $^{24}Mg/^{25}Mg = 0.126633$) to enable correction of the data for instrument-induced mass bias.

Silicon isotope analysis was performed in dry plasma mode using the high mass-resolution capability of a Thermo Fisher
Scientific Neptune Plus MC-ICP-MS (multi collector inductively coupled plasma mass spectrometer) at the Geochronology
95   and Tracers Facility, British Geological Survey. Analytical replicates were conducted where sample volume allowed, with
repeated sampling of the standard (diatomite) to validate the data and sample bracketing with standard NBS28 to correct for
any instrumental drift (Panizzo et al., 2016). The silicon isotope results are present in δ-notation in per mille (‰) deviations

relative to NBS28, using within-run aliquots of NBS28. All uncertainties are reported at 2σ absolute, and are propagated to incorporate an excess variance derived from the diatomite validation material, which was quadratically added to the analytical
100 uncertainty of each measurement. The reproducibility and instrument accuracy were assessed by analyzing the secondary reference material (Diatomite). Repeated measurements of diatomite yielded average δ^{30}Si values of 1.26 ± 0.14‰ (2 SD, n = 16), which agree well with the published values (consensus value of 1.26‰ ± 0.2‰, 2 SD) (Reynolds et al., 2006). δ^{29}Si and δ^{30}Si values of radiolarian tests fall on the expected mass-dependent fractionation line δ^{29}Si = 0.51 × δ^{30}Si (Reynolds et al., 2006) (Figure S1 in the Supplementary Material), indicating the effective removal of all polyatomic interferences during
105 measurement.

2.4 Paired t-tests and Wilcoxon signed-rank tests

To assess for potential differences in radiolarian species composition and δ^{30}Si$_{rad}$ values between water and surface sediment samples at each sampling station, paired t-tests and Wilcoxon signed-rank tests were employed. These statistical analyses were conducted using IBM SPSS Statistics Version 28, with the selection of the appropriate test determined by whether the data for
110 relative abundances of prominent radiolarian species and δ^{30}Si$_{rad}$ values conformed to a normal distribution.

3 Results

More than 400 radiolarian species have been reported in the SCS (Chen and Tan, 1996; Chen et al., 2008a), with 67-134 radiolarian species (mean = 114) identified in individual samples in this current study. The radiolarian diversity and the number of their shells in the plankton samples collected from the 0-100 m water layer, ranged from 67 to 116 species and from 28,025
115 to 102,443 individuals, respectively (Figure 2). These values represent 70-93% (mean = 83%) and 52-86% (mean = 72%) of the total observed in the upper 300 m of the water column (Figure 2). To characterize the radiolarian composition of each sample, species with a relative abundance exceeding 2% were defined as prominent species. Based on this, 29 prominent species belonging to Polycystine radiolarians were identified (Figure 3), most of which are typical tropical-subtropical species dwelling in warm surface to subsurface waters at low latitudes (Chen and Tan, 1996; Boltovskoy et al., 2010). The total abundance of
120 prominent radiolarian species constitutes 62-80% (mean=68%) of the radiolarian community in the studied samples (Figure 3). Wilcoxon test analysis for relative abundances indicated no statistically significant differences in the radiolarian community between plankton and sediment samples at each sampling station (p = 0.19-0.98) (Table S2 in supplementary material).
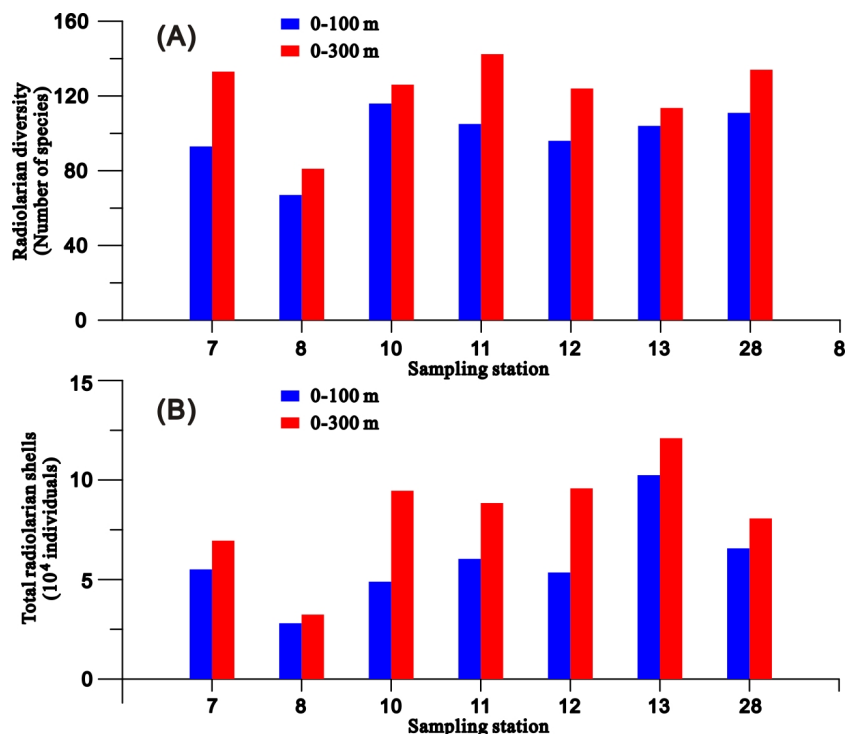
Figure 2. Radiolarian diversity (A) and shell numbers (B) in the upper 0-100 m and 0-300 m water columns at each sampling station.
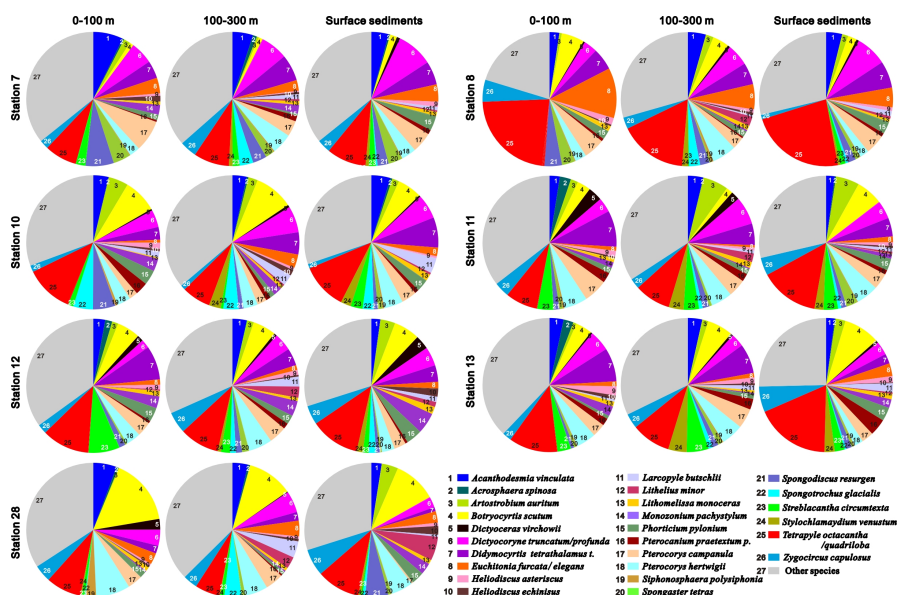
Figure 3. The prominent species and their relative abundances in plankton samples and surface sediments at each sampling station.

Visual inspection, by light microscopy and SEM, indicated a high degree of purity (>99%) and cleanliness in the radiolarian tests that were free from clay minerals or fine detrital particles on their shells (Figure 4). EDS analysis further showed that Si

125 and O were the primary constitutes of pure radiolarian test samples, with their combined concentration exceeding 99%. The concentrations of other elements (Fe, Al, Mg, Sr, Na, K and Cl) were all below the minimum detectable limit for the EDS detector (Figure 4).
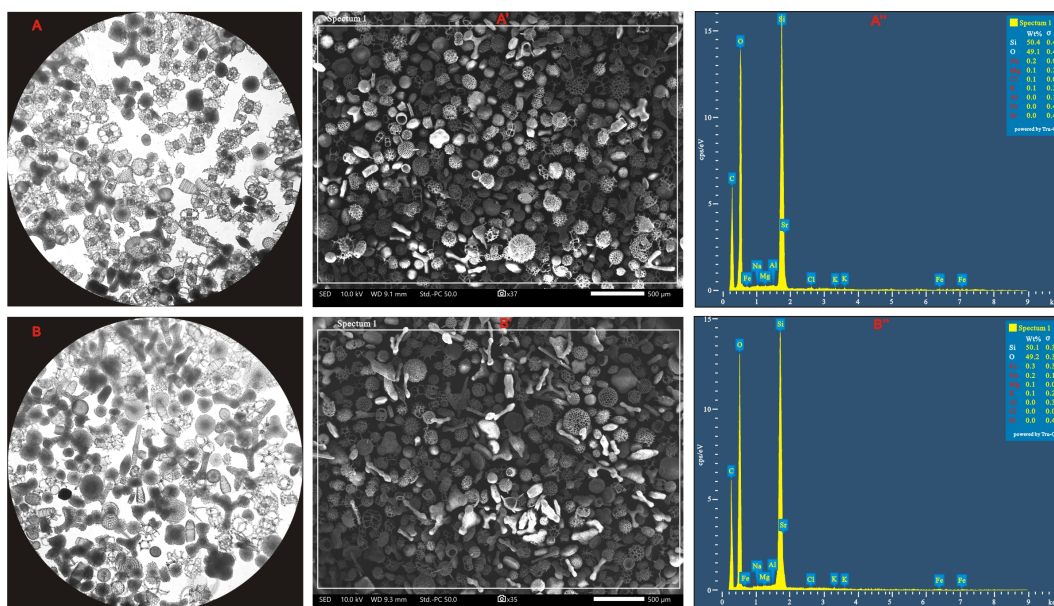
Figure 4. Pure radiolarian tests extracted from the plankton sample at station 8 (A) and the surface sediment at station 28 (B) under an inverted microscope at x100 magnification, as well as their SEM (A' and B') and EDS (A" and B") spectrum images.

$\delta^{30}\text{Si}_{\text{rad}}$ values ranged from 1.68‰ ± 0.20 to 1.81‰ ± 0.20 (mean = 1.76 ± 0.20‰) between 0-100 m of the water column, from 1.56‰ ± 0.20 to 1.83‰ ± 0.20 (mean = 1.72 ± 0.20‰) between 100-300 m, and from 1.61‰ ± 0.10 to 1.85‰ ± 0.21

130 (mean = 1.73 ± 0.17‰) in surface sediments (Figure 5A and Table S1 in the Supplementary Material). A paired t-test indicates no significant difference between the plankton and surface sediment $\delta^{30}\text{Si}_{\text{rad}}$ values at each station (p = 0.75) (Figure 5B).
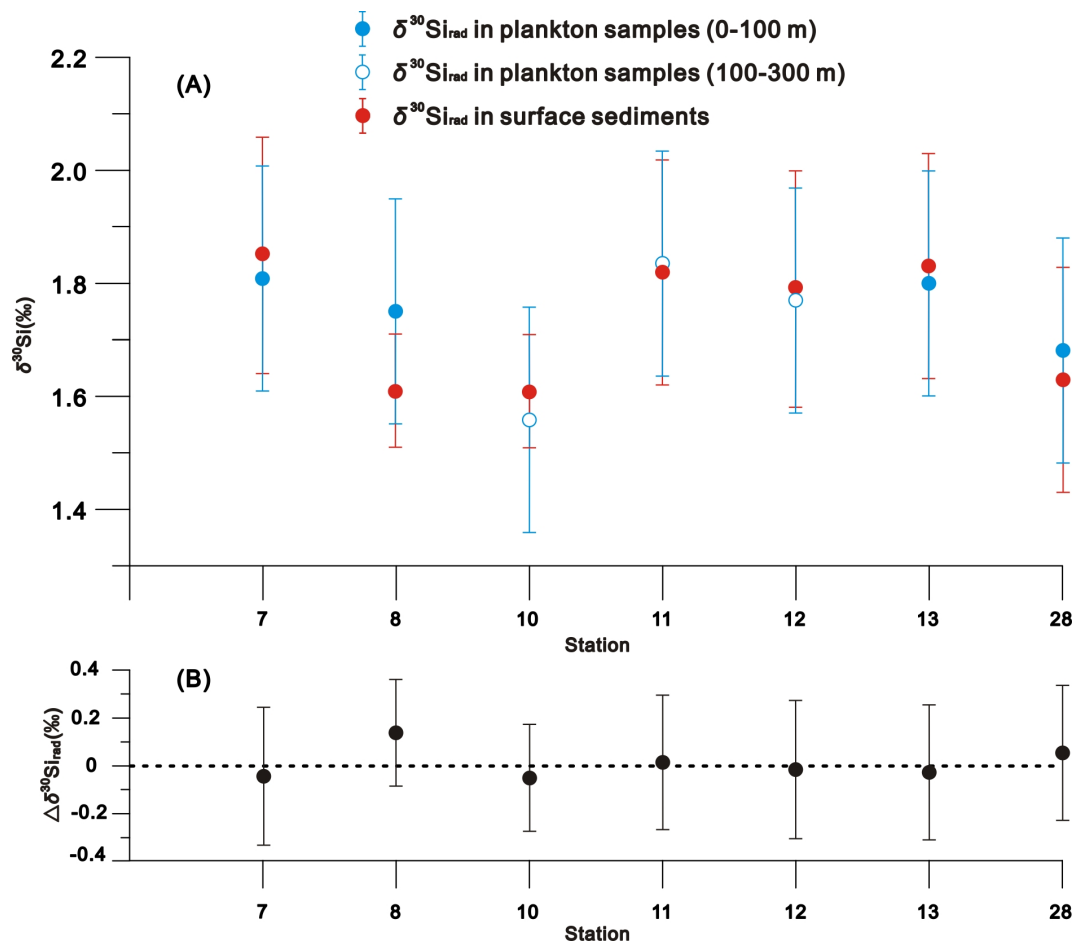
Figure 5. Comparison (A) and differences ($\triangle \delta^{30}\mathrm{Si_{rad}}$) (B) of $\delta^{30}\mathrm{Si_{rad}}$ values between plankton samples and surface sediments at each sampling station. The vertical bar denotes the analytical uncertainty (2σ) of $\delta^{30}\mathrm{Si_{rad}}$ compositions in (A), and the combined uncertainty (2σ) of $\triangle \delta^{30}\mathrm{Si_{rad}}$ in (B). The horizontal dashed line in (B) represents the zero line, indicating no differences in $\delta^{30}\mathrm{Si_{rad}}$ compositions between plankton samples and surface sediments.

4   Discussions

4.1   Radiolarian δ^{30}Si signatures in water column plankton and surface sediment samples

δ^{30}Si$_\mathrm{rad}$ values (1.56 to 1.85‰) of water column and surface sediment samples in this study fall within the range of pub-
135   lished data for sediment cores across the globe (-1.87 to 2.00 ‰; Hendry et al., 2014; Abelmann et al., 2015; Fontorbe et
al., 2016, 2017, 2020), and are approximately consistent with δ^{30}Si$_\mathrm{rad}$ values of *Dictyocoryne profunda/truncatum* (1.42 to
1.74 ‰; Doering et al., 2021), a species of Spumellaria radiolarians dwelling between 50–100 m along the Peruvian coast
(eastern East Pacific). However, they are higher than reported δ^{30}Si compositions of mixed radiolarians in surface sediments
from the mid-Pacific (-0.2 to 0.3 ‰, Ding et al., 1996), the Southern Ocean (-0.74 to 1.33‰; Abelmann et al., 2015), and off
140   the Peruvian coast (0.86 to 1.22‰, Doering et al., 2021).

In the oceans, radiolarians are distributed throughout the water column from surface to bottom waters (e.g., Kling, 1979;
Abelmann and Gowing, 1996; Zhang et al., 2009; Boltovskoy et al., 2010; Hu et al., 2015). In this study from the SCS, the
radiolarians extracted from plankton samples and surface sediments for isotopic analysis comprise a mix of species from the
bulk community, theoretically representing the average δ^{30}Si$_\mathrm{rad}$ signature across different water layers. Indeed, radiolarians in
145   the SCS inhabit water depths from the surface to c. 2000 m (Hu et al., 2015). However, we suggest that the δ^{30}Si$_\mathrm{rad}$ signal
in our samples primarily originates from radiolarians dwelling in surface to subsurface water (0-100 m). Firstly, the diversity
and abundance of radiolarians in the SCS generally peak between 25 and 75 m water depth, declining significantly below
100 m (Zhang et al., 2009; Hu et al., 2015). This is consistent with global observations, which show that standing stock and
species richness of polycystine radiolarians typically reach their highest values at 0-100 m in tropical and subtropical oceans
150   (Boltovskoy, 2017). Secondly, radiolarians living above 100 m in the SCS account for a mean of 72% of the radiolarian shells
in the plankton δ^{30}Si$_\mathrm{rad}$ samples analyzed in this current study (Figure 2), aligning with the observation that living radiolarians
above 150 m contribute c. 77% of the all radiolarian shells from the surface to a depth of 2000 m (Hu et al., 2015).

Whilst δ^{30}Si$_\mathrm{rad}$ values from plankton samples at 100-300 m water depth were expected to potentially differ from those at
0-100 m, no significant difference was detected (p = 0.52). We suggest that the similarity of δ^{30}Si$_\mathrm{rad}$ values from samples
155   at 0-100 m and 100-300 m water depth may be attributed to the fact that radiolarians at 100-300 m water depth primarily
consist of dead individuals settling from the upper 100 m of the water column. This is supported by the observation that: 1)
the radiolarian species present in this study at 100-300 m water depth are normally found within the 0-100 m layer; and 2)
no statistically significant differences were found between the prominent radiolarian species in these two water layers at each
station (Wilcoxon signed-rank tests: p = 0.32 to 0.98) (Table S2 in supplementary material).
160   Wilcoxon signed-rank tests also show no statistical difference between the relative abundances of prominent radiolarian
species in plankton water column samples and surface sediment samples at each station (p = 0.19 to 0.98, Table S2 in sup-
plementary material). This is in agreement with previous studies demonstrating that the radiolarian thanatocoenose in surface
sediments generally reflect the major species of living radiolarian assemblage in the overlying water column in the SCS (Hu et
al., 2014) and other oceans (Takahashi, 1982; Itaki, 2003; Itaki et al., 2003). Although minor differences in the relative abun-
165   dances of radiolarian species are observed, these likely result from the varying temporal coverage of each sample. The SCS,

influenced by the East Asian Monsoon, exhibits seasonal and interannual variability in its hydrological environment (Ning et al., 2009; Palacz et al., 2011) and radiolarian community (Wang et al., 2000; Zhang et al., 2020). Plankton samples were collected during a single snapshot in time, capturing radiolarians in a particular season, whereas radiolarians in the sediment samples represent an average record accumulated over multiple seasons and years. Although variations in the δ^{30}Si compo-

170   sition (vital effects) have been documented among different radiolarian taxa (Doering et al., 2021), the relative abundance differences between plankton and surface sediment samples do not result in significant δ^{30}Si$_{rad}$ disparities in our study in the SCS. This may be attributed to two factors: 1) the minor differences in the relative abundance of prominent taxa between water column and sediment samples (Wilcoxon signed-rank tests: p = 0.19 to 0.98, Table S2 in supplementary material); and 2) the high diversity of radiolarians in each sample averaging out the δ^{30}Si$_{rad}$ signal across different taxa, mitigating the risk of vital

175   effects in some taxa distorting the measured isotopic value.

Overall, we conclude that δ^{30}Si$_{rad}$ signatures in the water column, and subsequently incorporated in surface sediments, are primarily influenced by radiolarians from the 0-100 m water depth layer (surface to subsurface water), due to the substantial contribution of radiolarians in this depth range to the bulk radiolarian community in the SCS water column and sediment record.

180   ## 4.2   Transfer of radiolarian δ^{30}Si signatures into the sediment record

At each sampling station, δ^{30}Si$_{rad}$ compositions (mean = 1.73‰) in the surface sediment closely resembles those (mean = 1.74‰) in the overlying water column evidenced by the paired t-test (p=0.75), indicating a faithful transfer of the δ^{30}Si signal incorporated into radiolarian skeletons from the water column to sediments. This suggests that dissolution and other processes have minimal impacts on the δ^{30}Si$_{rad}$ signatures of radiolarians as shells sink through the water column and become

185   incorporated into the sediment record.

It is generally accepted that radiolaria comprise three classes: Polycystinea, Acantharea, and Taxopodida (Adl et al., 2019), despite debate concerning radiolarian classification schemes (Chen and Tan, 1996; Suzuki et al., 2015; Adl et al., 2019; Biard, 2022). Acantharians are composed of celestite $SrSO_4$, and their skeletons are highly susceptible to dissolution due to the significant undersaturation of seawater with respect to this mineral (Bernstein et al., 1992; De Deckker, 2004; Shimmen et al.,

190   2009). However, their absence of a silicon based skeletons renders their dissolution inconsequential for δ^{30}Si$_{rad}$ measurements in the water column and sediment. Taxopodida, though composed of silica, are generally rare in the water column, and no fossil records of this Class have been discovered in surface sediments of the world ocean to date (Biard, 2022). In our studied samples from the SCS, both Acantharea and Taxopodida taxa are trace components (<0.1%) in plankton samples and absent in surface sediments.

195   In the oceans, particularly in the SCS, polycystine radiolarians are the predominant group of the radiolarian community in both the water column and in sediments (Chen and Tan, 1996; Chen et al., 2008a, b; Suzuki and Aita, 2011) and are comprised of three Orders: Spumellaria, Nassellaria, and Collodaria. Collodaria radiolaria, with skeletons composed of both opal and Celestine (Afanasieva et al., 2005; Afanasieva and Amon, 2014), are generally susceptible to dissolution in seawater and poorly preserved in sediment samples. However, Collodaria radiolaria are less common in the oceans (Probert et al., 2014;

200 Zhang et al., 2018) and generally represent a low abundance in both the water column and sediments (Suzuki et al., 2015; Biard, 2022). In the SCS the abundance of Collodaria radiolarians in the water column ranges from 2-270 $\text{individuals}/\text{m}^3$ (mean = 30 $\text{individuals}/\text{m}^3$) (Zhang et al., 2020; Cheng et al., 2023), while the mean abundance of Spumellaria and Nassellaria in the upper water exceeds 3000 $\text{individuals}/\text{m}^3$ (Zhang et al., 2009; Hu et al., 2015). Spumellaria and Nassellaria taxa, which have been widely used as proxies for paleoenvironmental reconstruction (e.g., Itaki et al., 2004; Abelmann and Nimmergut,

205 2005; Zhang et al., 2014; Cortese and Prebble, 2015), are characterized by a greater resistance to dissolution and are generally well preserved in sediments (Takahashi, 1982; Morley et al., 2014). In this current study Collodaria taxa have very low relative abundance in the analysed samples (mean < 1%), which are instead dominated by the more dissolution-resistant Spumellaria and Nassellaria taxa (Figure 2). Since Spumellaria and Nassellaria radiolarians, the primary constituent of the radiolarian community in the SCS, are characterized by a great resistance to dissolution, dissolution is expected have limited impacts on

210 these radiolarian shells, and thus on $\delta^{30}\text{Si}_{\text{rad}}$ compositions during sinking and burial.

As discussed above, we suggest that the effect of dissolution on the $\delta^{30}\text{Si}_{\text{rad}}$ composition in the SCS is negligible during the transfer from the water column to the surface sediment, based on the comparable $\delta^{30}\text{Si}_{\text{rad}}$ compositions observed in plankton samples and surface sediment at each sampling station. This is likely attributed to the dominance of Spumellaria and Nassellaria taxa in the radiolarian community, which generally exhibit a high resistance to dissolution, as well as the scarcity or absence

215 of the readily dissolvable Taxopodida, Acantharea, and Collodaria taxa.

5 Conclusions

To investigate the potential effects of dissolution on $\delta^{30}\text{Si}_{\text{rad}}$ signatures during the sinking and burial processes from the water column to sediments, we conducted a comparative analysis of radiolarian community and $\delta^{30}\text{Si}_{\text{rad}}$ compositions between plankton samples and surface sediments from seven stations in the SCS. The key findings are summarized as follows:

220 1. $\delta^{30}\text{Si}_{\text{rad}}$ compositions ranged from 1.56-1.83‰ (mean = 1.74‰) in the plankton samples and from 1.61-1.85‰ (mean = 1.73‰) in surface sediments. No statistically significant differences in $\delta^{30}\text{Si}_{\text{rad}}$ values were observed between the water column and surface sediment samples at each sampling station.

2. Minor differences in the relative abundance of prominent taxa between the water column and sediments are not statistically significant. As most radiolarians in the water column originate from depths above 100 m in this study, we suggest

225 that the $\delta^{30}\text{Si}_{\text{rad}}$ signature preserved in surface sediments is primarily contributed from radiolarians within this depth range in the SCS.

3. The similar $\delta^{30}\text{Si}_{\text{rad}}$ compositions in plankton samples and surface sediment at each station suggest a faithful transfer of $\delta^{30}\text{Si}_{\text{rad}}$ signatures from the water column to the surface sediment in the SCS. This is aided by the dominance of the more dissolution-resistant Spumellaria and Nassellaria taxa (>99%) within the radiolarian community, coupled with the

230 scarcity or absence of the readily dissolvable taxa (Taxopodida, Acantharea, and Collodaria).

Data availability. Data from this paper can be found in Table S1 of the Supplement

Author contributions. QZ and GEAS conceived and designed the study. QZ analysed the radiolarian assemblages and prepared the samples for isotope analysis, supported by GEAS. Isotope samples were prepared and analysed by VP and QZ with additional support from MSAH. All authors contributed to the writing of the paper and commented on drafts.

235   *Competing interests.* The authors declare that they have no conflict of interest.

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