Lyle, M., Koizumi, I., Richter, C., and Moore, T.C., Jr. (Eds.), 2000
*Proceedings of the Ocean Drilling Program, Scientific Results,* Vol. 167

# 13. *DATA REPORT:* PHOSPHORUS CONCENTRATIONS AND GEOCHEMISTRY IN CALIFORNIA MARGIN SEDIMENTS[1]

Margaret L. Delaney[2] and Linda D. Anderson[3]

## INTRODUCTION

The ocean history of reactive phosphorus (P) (i.e., dissolved P available to fuel oceanic primary productivity) is of interest because of the role of P as a biolimiting nutrient, and knowledge of P burial in marine sediments is key to testing hypotheses about temporal changes in P input or output fluxes. Our understanding of the history of the P cycle over the Cenozoic has increased substantially with temporal records of reactive P mass accumulation rates from open-ocean Pacific and Atlantic equatorial sites. However, questions about the relative importance of nutrient burial in ocean-margin sediments relative to burial in open-ocean sediments and about the extent of P remobilization in organic-rich, reducing environments characteristic of margin sediments remain unresolved.

Nutrient burial in oceanic boundary current systems has been suggested to have a controlling role in oceanic nutrient budgets in certain time intervals (Vincent and Berger, 1985), with higher sediment accumulation rates balancing the limited spatial extent of these sediments. Some investigators suggest that remobilization of P from reducing sediments in margin settings is a significant positive feedback to primary productivity (e.g., Van Cappellan and Ingall, 1994), whereas other results indicate that both P uptake and P release may occur in these settings depending on the balance of organic carbon and iron supply to the sediments and on the oxygenation of bottom waters (McManus et al., 1997). It is important to quantitatively understand the geochemistry of reactive P in margin sediments, where productivity and delivery of organic-rich material to the sediments in relatively shallow-water settings is often sufficient to promote anoxia in interstitial waters.

To address these questions, we determined the P concentrations and geochemistry in sediment samples from eight sites drilled during Ocean Drilling Program (ODP) Leg 167, California margin (Sites 1010–1012, 1014, 1016–1017, and 1021–1022). These results are the first records of reactive P concentrations on long time scales—required for the calculation of P accumulation rates—for sediments from a highly productive eastern boundary current setting. In addition, we determined calcium carbonate contents and biogenic silica concentrations to define the environments of sedimentary production, burial, and diagenesis.

## METHODS

We measured P concentrations in sediment samples using a sequential extraction technique as modified from Ruttenberg (1992) and as described in Delaney and Anderson (1997). The original sequential extraction technique isolates five sedimentary P components: adsorbed, oxide associated (sorbed to oxides or oxide coatings), authigenic (carbonate-fluorapatite), detrital (terrestrial silicates and apatite), and organic P. We applied this method to some of the samples, with results listed for all five fractions. For most of the samples reported, we modified this to a four-step procedure by eliminating an initial exchange step and instead beginning with a reduction step, assuming that most of the adsorbed fraction is associated with oxides. This has the effect of combining the adsorbed and oxide-associated fractions of the five-step procedure into a single fraction, with results listed as the oxide-associated component.

Splits of 10-cm$^3$ samples were freeze dried and lightly ground. Weighed samples (typically 0.1 g each) were processed in replicate through the P sequential extraction procedure. P concentrations in known volumes of extractants (and thus in the solid samples) were determined using an automated spectrophotometric flow injection analysis system (Lachat *QuickChem* 8000). Results are reported as the means ± 1s (sample standard deviation) for each component. Total reactive P and total P are calculated as the sums of the relevant components, with the errors calculated from the propagation of absolute errors of the individual components. Analytical detection limits in typical size samples, assessed as three times the standard deviation of replicate measures of a low concentration solution standard, were typically 0.06 µmol P/g sediment for adsorbed P, 0.3 µmol/g for oxide-associated P, 0.1 µmol/g for detrital P, and 0.1 µmol/g for organic P. With the exception of oxide-associated P concentrations in some samples, P concentrations were generally well above these detection limits. We assessed long-term analytical variability by analyzing three composite samples here termed "consistency standards" (the first, a high calcium carbonate, low detrital P, and low organic carbon composite; the other two, homogenized from splits from a number of Leg 167 samples, with one composite higher in detrital P). The relative errors (1s) on the long-term means of these consistency standards from the four-step procedure were relatively high for the components that constitute small fractions of total P, ranging from 20% to 80% for oxide associated, 2% to 10% for higher detrital P consistency standards to as high as 74% for the low detrital P standard, and from 20% to 44% for organic P. The relative errors on the long-term means for authigenic P (the dominant sedimentary component) were 8%–17%, and for total P the errors were 6%–10%.

Using subsamples of the freeze-dried splits, we measured the weight percent calcium carbonate using a UIC, Inc., Coulometrics Model 5012 $CO_2$ coulometer and the weight percent biogenic opal using the technique of Mortlock and Froelich (1989). Relative standard deviations on the means for (1) multiple determinations of a pure calcium carbonate standard, (2) samples run in duplicate within a given analytical run, and (3) replicate analyses of the consistency standards were always <1%. The effective detection limit for weight percent $CaCO_3$ depended on the sample size; for typical sample sizes of 5–10 mg, the detection limit is 0.5–1.0 wt%. We adjusted sample sizes as needed to increase the detection limit, which decreases proportionally to the increase in sample size. The detection limit for biogenic opal, defined from three times the standard deviation of replicate measurements of a blank, was equivalent to 0.9 wt% in a typical size sample. The relative errors on long-term means of the two Leg

[1]Lyle, M., Koizumi, I., Richter, C., and Moore, T.C., Jr. (Eds.), 2000. *Proc. ODP, Sci. Results,* 167: College Station TX (Ocean Drilling Program).
[2]Ocean Sciences/Institute of Marine Sciences, 1156 High Street, University of California, Santa Cruz CA 95064, USA. delaney@cats.ucsc.edu
[3]Institute of Marine Sciences, 1156 High Street, University of California, Santa Cruz CA 95064, USA.

167 consistency standards were 6%–10%, with higher relative errors for the consistency standard with lower biogenic opal content. Analytical reproducibility for replicate samples had relative errors typically <5%, and up to 10% or greater for samples with low biogenic opal contents.

## RESULTS

The P concentrations in each geochemical component, the total reactive P concentration, and the total P concentration for each sediment sample, along with the calcium carbonate and biogenic silica concentrations when determined, are listed in Tables 1–8 for the samples from the respective sites. Total reactive P dominates the sedimentary budget of P at all sites, representing an average of 46% of total P at Site 1022 to as much as 98% of total P at Site 1017.

The more labile forms of reactive P generally constitute a minor portion of total reactive P with increasing sediment depth. Oxide-associated P represents on average no more than 15% of total reactive P, and organic P is on average no more than 16% of total reactive P. Authigenic P constitutes the majority of total reactive P at all sites on average (70%–87% of total reactive P). These site averages are influenced by the depth ranges sampled at each site because, at all sites, the fractions of reactive P represented by the more labile forms (oxide-associated and organic P) decrease with increasing sediment depth. These decreases are mirrored by increases in the fraction of authigenic P relative to total reactive P to values over 80% and as high as 96%–97%, depending on site and sediment depth. These observations—about the significance of reactive P burial in the sediment budget of total P, the dominance of authigenic P fraction in total reactive P budgets, and the geochemical transformations of more labile forms of reactive P to authigenic P with sediment depth—are similar to those in open-ocean sediments (e.g., Delaney and Anderson, 1997).

## ACKNOWLEDGMENTS

Samples were provided through the ODP. M.L.D. is grateful to the ODP and to the co-chief scientists and other shipboard scientists for her shipboard participation during Leg 167. We thank M. Lyle, R. Murray, and D. Rea for their reviews. This research was supported by postcruise science support from JOI/USSAC to M.L.D. and by NSF OCE-9416593 to M.L.D. We thank Rob Franks and the UCSC Institute of Marine Sciences Marine Analytical Laboratories for the high-quality research support provided. We thank Henry Lao and Kathy Motte for laboratory assistance.

### REFERENCES

Delaney, M.L., and Anderson, L.D., 1997. Phosphorus geochemistry in Ceara Rise sediments. *In* Shackleton, N.J., Curry, W.B., Richter, C., and Bralower, T.J. (Eds.), *Proc. ODP, Sci. Results,* 154: College Station, TX (Ocean Drilling Program), 475–482.

McManus, J., Berelson, W.M., Coale, K.H., Johnson, K.S., and Kilgore, T.E., 1997. Phosphorus regeneration in continental margin sediments. *Geochim. Cosmochim. Acta,* 61:2891–2907.

Mortlock, R.A., and Froelich, P.N., 1989. A simple method for the rapid determination of biogenic opal in pelagic marine sediments. *Deep-Sea Res. Part A,* 36:1415–1426.

Ruttenberg, K.C., 1992. Development of a sequential extraction method for different forms of phosphorus in marine sediments. *Limnol. Oceanogr.,* 37:1460–1482.

Van Cappellen, P., and Ingall, E.D., 1994. Benthic phosphorus regeneration, net primary production, and ocean anoxia: a model of the coupled marine biogeochemical cycles of carbon and phosphorus. *Paleoceanography,* 9:677–692.

Vincent, E., and Berger, W.H., 1985. Carbon dioxide and polar cooling in the Miocene: the Monterey Hypothesis. *In* Sundquist, E.T., and Broecker, W.S. (Eds.), *The Carbon Cycle and Atmospheric $CO_2$: Natural Variations Archean to Present.* Geophys. Monogr., Am. Geophys. Union, 32:455–468.

**Date of initial receipt: 15 October 1998**
**Date of acceptance: 19 April 1999**
**Ms 167SR-227**

**Table 1. Sedimentary geochemical results for Site 1010.**

| Core, section, interval (cm) | Depth (mbsf) | P concentration (µmol/g sediment) | | | | | | | | | | | | | | $CaCO_3$ (wt%) | Biogenic opal (wt%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Adsorbed | | Oxide associated | | Authigenic | | Detrital | | Organic | | Total reactive | | Total | | | |
| | | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | | |
| 167-1010B- | | | | | | | | | | | | | | | | | |
| 1H-2, 85-87 | 2.35 | 1.91 | 0.40 | 4.86 | 0.86 | 7.78 | 0.17 | 7.94 | 0.21 | 1.03 | 0.08 | 15.59 | 0.97 | 23.53 | 0.99 | | 1.47 |
| 2H-2, 85-87 | 6.55 | 2.02 | 0.50 | 8.14 | 1.07 | 11.37 | 0.19 | 7.36 | 0.16 | 1.02 | 0.12 | 22.55 | 1.21 | 29.91 | 1.22 | 0.9 | 1.28 |
| 2H-5, 85-87 | 11.05 | 2.16 | 0.40 | 10.16 | 2.88 | 12.26 | 0.20 | 9.23 | 0.17 | 1.06 | 0.06 | 25.64 | 2.91 | 34.87 | 2.92 | 0.9 | 1.98 |
| 3H-2, 85-87 | 16.05 | 2.05 | 0.55 | 7.80 | 1.20 | 12.77 | 0.44 | 7.62 | 0.17 | 2.21 | 0.08 | 24.83 | 1.40 | 32.45 | 1.41 | 1.4 | 1.06 |
| 3H-2, 111-113 | 17.61 | 1.99 | 0.29 | 2.03 | 1.21 | 10.64 | 0.60 | 7.07 | 0.28 | 1.98 | 0.92 | 16.64 | 1.65 | 23.72 | 1.68 | | 1.20 |
| 3H-5, 84-86 | 20.54 | 1.85 | 0.24 | 0.26 | | 14.25 | 0.39 | 6.06 | 0.27 | 1.90 | 0.49 | 18.26 | 0.67 | 24.32 | 0.72 | 18.7 | 1.14 |
| 167-1010C- | | | | | | | | | | | | | | | | | |
| 3H-5, 107-109 | 22.07 | 2.01 | 0.19 | 0.75 | 0.52 | 8.50 | 0.25 | 5.41 | 0.20 | 1.28 | 0.22 | 12.55 | 0.65 | 17.96 | 0.68 | 46.4 | 2.05 |
| 4H-2, 108-110 | 27.08 | 1.72 | 0.43 | 0.79 | 0.23 | 11.69 | 0.47 | 7.00 | 0.25 | 0.94 | 0.11 | 15.14 | 0.68 | 22.13 | 0.72 | 14.3 | 1.15 |
| 5H-2, 107-109 | 36.57 | 2.13 | 0.41 | 0.87 | 0.31 | 9.64 | 0.45 | 6.45 | 0.23 | 1.07 | 0.13 | 13.71 | 0.69 | 20.16 | 0.73 | 26.8 | 0.68 |
| 5H-5, 108-110 | 41.08 | | | | | 12.85 | 0.40 | 9.14 | 0.03 | 0.99 | 0.08 | 13.84 | 0.41 | 22.98 | 0.41 | 15.5 | 1.06 |
| 6H-2, 108-110 | 46.11 | 2.49 | 0.38 | 1.13 | 0.69 | 9.98 | 0.34 | 7.43 | 0.18 | 1.13 | 0.03 | 14.74 | 0.86 | 22.17 | 0.88 | 0.9 | 1.42 |
| 6H-5, 105-107 | 50.58 | 1.90 | 0.17 | 1.69 | 0.58 | 11.38 | 0.24 | 7.00 | 0.17 | 1.62 | 0.75 | 16.59 | 1.00 | 23.58 | 1.01 | BDL | 2.95 |
| 6H-5, 105-107 | 50.58 | | | 1.57 | 0.59 | 12.02 | 0.30 | 7.28 | 0.02 | 1.04 | 0.06 | 14.64 | 0.66 | 21.92 | 0.66 | | 2.13 |
| 7H-2, 108-110 | 55.58 | 1.75 | 0.37 | | | 12.89 | 0.44 | 6.12 | 0.16 | 1.41 | 0.18 | 16.05 | 0.60 | 22.16 | 0.62 | 8.9 | |
| 7H-2, 108-110 | 55.58 | | | 0.44 | 0.04 | 13.13 | 0.22 | 6.35 | 0.04 | 1.31 | 0.03 | 14.87 | 0.23 | 21.22 | 0.23 | | 4.94 |
| 7H-2, 108-110 | 60.08 | 1.70 | 0.65 | 1.89 | 1.58 | 12.17 | 0.43 | 6.06 | 0.25 | 0.95 | 0.16 | 16.71 | 1.77 | 22.77 | 1.79 | 9.0 | |
| 7H-2, 108-110 | 60.08 | | | 1.85 | 1.34 | 12.43 | 0.20 | 6.04 | 0.01 | 0.99 | 0.06 | 15.26 | 1.36 | 21.30 | 1.36 | | 3.54 |
| 8H-2, 107-109 | 65.07 | | | 0.45 | | 13.15 | 0.15 | 5.70 | 0.17 | 0.80 | 0.06 | 14.39 | 0.17 | 20.09 | 0.24 | 27.4 | |
| 8H-5, 107-109 | 69.57 | | | 0.48 | | 15.53 | 0.11 | 5.71 | 0.12 | 0.72 | 0.03 | 16.74 | 0.12 | 22.45 | 0.17 | 28.8 | 4.42 |
| 8H-2, 107-109 | 74.57 | | | 0.42 | | 11.09 | 0.15 | 4.06 | 0.06 | 0.47 | 0.01 | 11.98 | 0.15 | 16.04 | 0.16 | 51.9 | 3.44 |
| 9H-5, 107-109 | 79.07 | | | 0.49 | 0.10 | 22.88 | 0.52 | 6.38 | 1.05 | 1.22 | 0.94 | 24.60 | 1.08 | 30.98 | 1.50 | 15.6 | 2.77 |
| 10H-2, 109-111 | 84.09 | | | 0.31 | | 23.39 | 0.52 | 5.24 | 0.38 | 0.65 | 0.09 | 24.35 | 0.53 | 29.59 | 0.65 | 18.6 | 4.47 |
| 11H-5, 109-111 | 88.59 | | | 0.27 | 0.12 | 12.57 | 0.13 | 4.64 | 0.22 | 0.58 | 0.10 | 13.42 | 0.21 | 18.06 | 0.30 | 10.7 | 10.46 |
| 11H-2, 108-110 | 93.58 | | | 0.16 | 0.01 | 19.16 | 0.31 | 4.53 | 0.10 | 0.57 | 0.05 | 19.88 | 0.32 | 24.41 | 0.33 | 23.3 | 14.13 |
| 11H-5, 108-110 | 98.08 | | | 0.46 | | 16.97 | 0.11 | 3.26 | 0.07 | 0.40 | 0.02 | 17.83 | 0.11 | 21.09 | 0.13 | 51.1 | 9.02 |
| 12H-2, 32-34 | 102.32 | | | 0.16 | 0.08 | 22.61 | 0.11 | 4.40 | 0.20 | 0.63 | 0.03 | 23.40 | 0.14 | 27.80 | 0.25 | 12.6 | |
| 12H-2, 108-110 | 103.08 | | | 1.04 | 0.14 | 19.74 | 0.41 | 4.55 | 0.19 | 0.66 | 0.15 | 21.44 | 0.46 | 26.00 | 0.50 | BDL | |
| 12H-5, 32-34 | 106.82 | | | 0.59 | | 10.89 | 0.12 | 3.86 | 0.35 | 0.55 | 0.09 | 12.03 | 0.15 | 15.89 | 0.38 | 1.0 | |
| 12H-5, 108-110 | 107.58 | | | 0.63 | 0.03 | 10.35 | 0.19 | 2.41 | 0.09 | 0.41 | 0.26 | 11.39 | 0.32 | 13.80 | 0.34 | 58.6 | |
| 13H-2, 108-110 | 112.58 | | | 0.63 | | 19.25 | 0.08 | 4.13 | 0.14 | 0.54 | 0.06 | 20.42 | 0.10 | 24.55 | 0.17 | 25.7 | |
| 13H-5, 108-110 | 117.08 | | | 0.74 | 0.23 | 15.19 | 0.49 | 2.81 | 0.08 | 0.36 | 0.03 | 16.28 | 0.54 | 19.10 | 0.55 | 51.0 | 9.53 |
| 14H-2, 106-108 | 122.06 | | | 1.23 | 0.50 | 26.89 | 0.35 | 5.69 | 0.32 | 0.73 | 0.07 | 28.86 | 0.62 | 34.55 | 0.70 | BDL | 3.69 |
| 14H-5, 107-109 | 126.57 | | | 1.13 | 0.09 | 19.04 | 0.20 | 3.48 | 0.26 | 0.50 | 0.09 | 20.67 | 0.24 | 24.15 | 0.35 | BDL | 4.97 |
| 15H-2, 108-110 | 131.58 | | | 0.52 | | 7.70 | 0.16 | 1.84 | 0.09 | 0.34 | 0.04 | 8.56 | 0.16 | 10.40 | 0.18 | 4.0 | 9.51 |
| 15H-5, 108-110 | 136.08 | | | 0.39 | 0.04 | 9.84 | 0.19 | 3.32 | 0.12 | 0.61 | 0.06 | 10.84 | 0.20 | 14.16 | 0.23 | 3.9 | 20.30 |
| 16H-2, 106-108 | 141.06 | | | 0.48 | 0.07 | 29.41 | 0.13 | 2.80 | 0.07 | 0.38 | 0.03 | 30.27 | 0.15 | 33.07 | 0.17 | 34.2 | 15.49 |
| 16H-5, 106-108 | 145.56 | | | 0.83 | 0.29 | 15.74 | 0.10 | 1.45 | 0.08 | 0.23 | 0.02 | 16.80 | 0.31 | 18.25 | 0.32 | 57.8 | 10.65 |
| 16H-5, 106-108 | 145.56 | | | 0.35 | 0.20 | 15.68 | 0.13 | 1.77 | 0.11 | 0.22 | 0.03 | 16.25 | 0.24 | 18.02 | 0.27 | | 11.23 |
| 17H-2, 106-108 | 150.56 | | | 0.35 | 0.23 | 22.74 | 0.69 | 2.55 | 0.03 | 0.27 | 0.00 | 23.36 | 0.73 | 25.91 | 0.73 | 27.5 | |
| 17H-5, 106-108 | 155.06 | | | 0.39 | 0.12 | 15.26 | 0.05 | 1.50 | 0.07 | 0.19 | 0.03 | 15.84 | 0.14 | 17.34 | 0.15 | 50.6 | 17.41 |
| 18X-2, 104-106 | 160.04 | | | 0.53 | 0.12 | 10.29 | 0.20 | 1.13 | 0.04 | 0.20 | 0.04 | 11.02 | 0.24 | 12.16 | 0.24 | 41.9 | 13.64 |
| 18X-5, 105-107 | 164.55 | | | 0.38 | 0.26 | 19.12 | 0.07 | 2.74 | 0.08 | 0.34 | 0.03 | 19.83 | 0.27 | 22.57 | 0.29 | 49.2 | 13.13 |
| 19X-2, 105-107 | 167.75 | | | 0.33 | 0.09 | 16.70 | 0.06 | 1.38 | 0.20 | 0.24 | 0.01 | 17.28 | 0.11 | 18.66 | 0.23 | 34.3 | 14.23 |
| 19X-5, 105-107 | 172.25 | | | 0.44 | 0.34 | 11.35 | 0.14 | 1.71 | 0.14 | 0.36 | 0.03 | 12.15 | 0.37 | 13.86 | 0.39 | 12.3 | 15.88 |
| 20X-2, 106-108 | 177.46 | | | BDL | | 21.40 | 1.16 | 3.84 | 0.08 | 1.02 | 0.12 | 22.42 | 1.17 | 26.26 | 1.17 | 32.3 | 17.12 |
| 20X-4, 106-108 | 180.46 | | | 0.41 | | 2.70 | 0.69 | 1.17 | 0.04 | 0.15 | 0.08 | 3.26 | 0.69 | 4.43 | 0.70 | 4.0 | 7.50 |
| 22X-1, 87-89 | | | | 0.80 | 2.73 | 28.80 | 0.79 | 2.43 | 0.29 | 1.18 | 0.08 | 30.78 | 2.84 | 33.21 | 2.86 | 9.9 | 1.27 |

Note: SD = standard deviation, BDL = below detection limit, blank = quantity not determined for that sample.

**Table 2. Sedimentary geochemical results for Site 1011.**

| Core, section, interval (cm) | Depth (mbsf) | P concentrations (µmol/g sediment) | | | | | | | | | | | | $CaCO_3$ (wt%) | Biogenic opal (wt%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Oxide associated | | Authigenic | | Detrital | | Organic | | Total reactive | | Total | | | |
| | | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | | |
| 167-1011B- | | | | | | | | | | | | | | | |
| 1H-3, 140-145 | 4.45 | 1.17 | 0.20 | 6.41 | 0.07 | 7.75 | 0.33 | 4.10 | 0.11 | 11.68 | 0.24 | 19.43 | 0.41 | 1.3 | |
| 2H- 3, 145-150 | 12.85 | 1.23 | 0.21 | 6.95 | 0.22 | 7.68 | 0.23 | 2.47 | 0.09 | 10.65 | 0.32 | 18.32 | 0.39 | 3.1 | |
| 3H- 3, 145-150 | 22.35 | 1.49 | 0.36 | 8.82 | 0.25 | 7.34 | 0.36 | 1.81 | 0.06 | 12.11 | 0.44 | 19.44 | 0.57 | 8.4 | 1.39 |
| 4H- 3, 145-150 | 31.85 | 1.38 | 0.38 | 7.52 | 0.05 | 5.84 | 0.38 | 1.59 | 0.12 | 10.49 | 0.41 | 16.33 | 0.55 | 15.1 | 1.27 |
| 5H- 3, 145-150 | 41.35 | 0.95 | 0.34 | 8.66 | 0.13 | 7.20 | 0.46 | 1.82 | 0.22 | 11.43 | 0.43 | 18.63 | 0.63 | 4.9 | 1.65 |
| 6H- 3, 145-150 | 50.85 | 1.06 | 0.26 | 9.99 | 0.12 | 8.54 | 0.42 | 1.50 | 0.10 | 12.55 | 0.30 | 21.09 | 0.52 | 9.1 | 1.63 |
| 9H- 3, 145-150 | 79.35 | 0.86 | 0.25 | 7.99 | 0.12 | 7.07 | 0.34 | 1.39 | 0.21 | 10.24 | 0.35 | 17.31 | 0.48 | 7.5 | 1.70 |
| 12H-3, 145-150 | 107.85 | 1.31 | 0.24 | 10.97 | 0.11 | 5.68 | 0.35 | 0.99 | 0.04 | 13.26 | 0.27 | 18.94 | 0.44 | 22.9 | 1.36 |
| 15H-3, 145-150 | 136.35 | 1.27 | 0.06 | 10.19 | 0.40 | 6.40 | 0.18 | 1.00 | 0.04 | 12.46 | 0.40 | 18.86 | 0.44 | 35.9 | 1.07 |

Note: SD = standard deviation, blank = quantity not determined for that sample.

**Table 3. Sedimentary geochemical results for Site 1012.**

| Core, section, interval (cm) | Depth (mbsf) | P concentrations (µmol/g sediment) | | | | | | | | | | | | | | Biogenic opal (wt%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Adsorbed | | Oxide associated | | Authigenic | | Detrital | | Organic | | Total reactive | | Total | | |
| | | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | |
| 167-1012A- | | | | | | | | | | | | | | | | |
| 1H-3, 145-150 | 2.95 | 1.39 | 0.09 | 0.68 | 0.65 | 16.60 | 1.68 | 6.80 | 0.71 | 5.33 | 1.62 | 24.00 | 2.42 | 30.81 | 2.52 | 0.98 |
| 2H-3, 145-150 | 9.15 | 1.97 | 0.30 | 3.45 | 3.09 | 12.57 | 0.04 | 6.96 | 0.08 | 4.13 | 1.39 | 22.11 | 3.41 | 29.07 | 3.41 | 1.23 |
| 3H-3, 145-150 | 18.65 | 1.50 | 0.10 | | | 11.61 | 0.17 | 7.00 | 0.12 | 3.14 | 1.03 | 16.26 | 1.05 | 23.26 | 1.06 | 1.26 |
| 4H-3, 145-150 | 28.15 | 1.32 | 0.24 | 0.49 | 0.26 | 14.44 | 0.08 | 7.88 | 0.06 | 2.63 | 0.57 | 18.88 | 0.67 | 26.77 | 0.67 | 1.28 |
| 5H-3, 145-150 | 37.65 | 2.91 | 0.44 | 0.71 | 0.16 | 11.13 | 0.00 | 5.45 | 0.03 | 1.95 | 0.27 | 16.71 | 0.54 | 22.16 | 0.54 | 0.90 |
| 6H-3, 145-150 | 47.22 | 2.89 | 0.23 | 1.12 | 0.42 | 12.29 | 0.00 | 5.56 | 0.20 | 1.73 | 0.23 | 18.03 | 0.53 | 23.59 | 0.56 | 1.25 |
| 9H-3, 145-150 | 75.65 | 3.88 | 0.15 | 2.24 | 1.13 | 13.35 | 0.16 | 2.76 | 0.19 | 0.18 | 0.02 | 19.63 | 1.15 | 22.40 | 1.17 | 0.79 |
| 12H-3, 145-150 | 104.32 | 2.25 | 0.26 | 0.72 | 0.61 | 21.52 | 0.19 | 6.31 | 0.07 | 1.95 | 0.40 | 26.44 | 0.80 | 32.74 | 0.80 | 1.20 |
| 15X-2, 145-150 | 131.35 | 2.56 | 0.22 | 1.54 | 0.78 | 13.33 | 0.04 | 2.67 | 0.18 | 1.15 | 0.14 | 18.58 | 0.83 | 21.25 | 0.85 | |
| 18X-3, 145-150 | 161.65 | 3.04 | 0.33 | 1.49 | 0.29 | 13.71 | 0.09 | 3.32 | 0.11 | 1.01 | 0.16 | 19.25 | 0.48 | 22.58 | 0.49 | |

Note: SD = standard deviation, blank = quantity not determined for that sample.

**Table 4. Sedimentary geochemical results for Site 1014.**

| Core, section, interval (cm) | Depth (mbsf) | P concentrations (µmol/g sediment) | | | | | | | | | | | | | | $CaCO_3$ (wt%) | Biogenic opal (wt%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Adsorbed | | Oxide associated | | Authigenic | | Detrital | | Organic | | Total reactive | | Total | | | |
| | | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | | |
| 167-1014A- | | | | | | | | | | | | | | | | | |
| 1H-2, 34-36* | 1.84 | 1.11 | 0.11 | 1.42 | 0.32 | 16.43 | 1.60 | 6.44 | 0.82 | 5.45 | 0.31 | 24.41 | 1.67 | 30.84 | 1.86 | | |
| 2H-5, 34-36* | 9.44 | 0.90 | 0.11 | 2.29 | 0.76 | 18.02 | 1.80 | 6.53 | 1.24 | 5.52 | 0.30 | 26.72 | 1.98 | 33.25 | 2.33 | | |
| 3H-5, 33-35* | 18.93 | 1.16 | 0.06 | 1.89 | 0.12 | 14.53 | 0.74 | 6.31 | 0.62 | 3.69 | 0.14 | 21.28 | 0.77 | 27.59 | 0.99 | | |
| 4H-5, 33-35* | 28.43 | 1.30 | 0.04 | 2.22 | 1.07 | 25.92 | 2.13 | 6.25 | 1.81 | 3.46 | 0.60 | 32.89 | 2.46 | 39.14 | 3.05 | | |
| 5H-5, 33-35* | 37.97 | 1.46 | 0.03 | 1.86 | 0.55 | 11.21 | 1.35 | 4.73 | 1.10 | 2.24 | 0.24 | 16.76 | 1.48 | 21.49 | 1.84 | | |
| 6H-5, 33-35* | 46.50 | 1.27 | 0.11 | 1.98 | 0.06 | 23.27 | 1.27 | 6.50 | 1.84 | 2.88 | 0.27 | 29.40 | 1.31 | 35.90 | 2.26 | | |
| 7X-3, 34-36* | 53.64 | 1.50 | 0.17 | 2.48 | 0.26 | 16.49 | 1.60 | 6.54 | 1.55 | 2.23 | 0.21 | 22.70 | 1.64 | 29.24 | 2.26 | | |
| 8X-5, 33-35* | 60.63 | 1.23 | 0.09 | 2.30 | 0.59 | 29.15 | 2.23 | 5.29 | 1.43 | 3.06 | 0.32 | 35.74 | 2.33 | 41.02 | 2.74 | | |
| 9X-5, 33-35* | 70.33 | 1.62 | 0.10 | 2.03 | 0.65 | 24.33 | 2.75 | 6.95 | 1.14 | 1.76 | 0.06 | 29.74 | 2.83 | 36.69 | 3.05 | | |
| 10X-5, 33-35* | 80.13 | 1.45 | 0.08 | 3.33 | 0.17 | 17.98 | 1.28 | 5.07 | 2.09 | 1.99 | 0.27 | 24.75 | 1.32 | 29.82 | 2.47 | | |
| 1H-2, 34-36 | 1.84 | | | 1.97 | 0.49 | 17.03 | 1.51 | 6.68 | 3.01 | 5.66 | 0.53 | 24.66 | 1.68 | 31.34 | 3.44 | 30.4 | 1.18 |
| 2H-5, 34-36 | 9.44 | | | 2.33 | 0.35 | 19.18 | 0.98 | 5.62 | 2.24 | 5.67 | 0.54 | 27.18 | 1.17 | 32.80 | 2.53 | 15.3 | 1.11 |
| 3H-5, 33-35 | 18.93 | | | 2.17 | 0.98 | 15.19 | 1.45 | 6.14 | 2.81 | 3.78 | 0.27 | 21.14 | 1.77 | 27.28 | 3.32 | 33.9 | 1.46 |
| 4H-5, 33-35 | 28.43 | | | 2.12 | 0.96 | 26.45 | 2.64 | 5.87 | 1.53 | 3.36 | 0.25 | 31.93 | 2.82 | 37.80 | 3.21 | 25.3 | 0.81 |
| 5H-5, 33-35 | 37.97 | | | 2.63 | 0.35 | 11.83 | 1.30 | 4.62 | 1.13 | 2.19 | 0.19 | 16.65 | 1.36 | 21.27 | 1.77 | 44.1 | 1.14 |
| 6H-5, 33-35 | 46.50 | | | 2.43 | 0.13 | 24.23 | 0.89 | 6.29 | 2.26 | 2.83 | 0.44 | 29.49 | 1.00 | 35.78 | 2.48 | 29.5 | 0.73 |
| 7X-3, 34-36 | 53.64 | | | 2.49 | 0.03 | 16.81 | 0.90 | 6.64 | 2.58 | 2.28 | 0.21 | 21.59 | 0.92 | 28.23 | 2.74 | 37.3 | 0.76 |
| 8X-5, 33-35 | 60.63 | | | 2.13 | 0.36 | 29.89 | 1.94 | 4.82 | 1.08 | 2.94 | 0.37 | 34.96 | 2.01 | 39.78 | 2.28 | 28.5 | 0.98 |
| 9X-5, 33-35 | 70.33 | | | 2.58 | 0.12 | 25.09 | 1.44 | 6.57 | 2.23 | 1.62 | 0.11 | 29.29 | 1.45 | 35.86 | 2.66 | 36.4 | 0.68 |
| 10X-5, 33-35 | 80.13 | | | 2.31 | 0.52 | 19.12 | 2.96 | 4.44 | 1.49 | 1.89 | 0.11 | 23.32 | 3.00 | 27.76 | 3.36 | 45.1 | 0.70 |
| 11X-5, 33-35 | 89.83 | | | 1.61 | 0.13 | 22.79 | 0.53 | 3.46 | 0.11 | 1.47 | 0.03 | 25.87 | 0.55 | 29.33 | 0.56 | 43.9 | 0.70 |
| 12X-5, 44-46 | 98.96 | | | 1.79 | 0.30 | 19.19 | 0.44 | 3.85 | 0.05 | 1.67 | 0.05 | 22.64 | 0.53 | 26.50 | 0.54 | 52.7 | 1.24 |
| 13X-5, 33-35 | 109.13 | | | 1.54 | 0.27 | 35.81 | 0.33 | 5.84 | 0.04 | 2.91 | 0.14 | 40.25 | 0.45 | 46.09 | 0.45 | 30.1 | 1.56 |
| 14X-5, 33-35 | 118.59 | | | 2.19 | 0.18 | 32.35 | 1.24 | 4.52 | 0.18 | 2.21 | 0.08 | 36.74 | 1.25 | 41.27 | 1.27 | 43.4 | 1.56 |
| 15X-5, 26-28 | 126.96 | | | 3.65 | 2.05 | 20.30 | 1.10 | 5.12 | 0.10 | 2.41 | 0.12 | 26.36 | 2.33 | 31.48 | 2.33 | 35.5 | 2.09 |
| 16X-5, 44-45 | 137.12 | | | 2.34 | 1.65 | 29.79 | 1.20 | 4.52 | 0.26 | 2.08 | 0.04 | 34.21 | 2.04 | 38.74 | 2.06 | 44.2 | 1.96 |
| 17X-5, 33-35 | 147.53 | | | 1.92 | 0.25 | 15.72 | 0.67 | 1.35 | 0.07 | 0.98 | 0.02 | 18.62 | 0.71 | 19.97 | 0.72 | 72.6 | 2.32 |
| 18X-5, 33-35 | 156.24 | | | 1.92 | 0.28 | 20.40 | 0.58 | 2.30 | 0.07 | 1.29 | 0.03 | 23.61 | 0.64 | 25.91 | 0.64 | 60.1 | 2.44 |
| 19X-5, 33-35 | 166.73 | | | 1.90 | 0.31 | 17.57 | 0.20 | 7.10 | 0.11 | 1.98 | 0.05 | 21.44 | 0.37 | 28.55 | 0.39 | 34.6 | 1.85 |
| 20X-5, 33-35 | 175.74 | | | 1.81 | 0.34 | 24.54 | 0.81 | 5.37 | 0.43 | 1.69 | 0.07 | 28.04 | 0.88 | 33.41 | 0.98 | 46.1 | 1.89 |
| 21X-5, 33-35 | 184.95 | | | 1.97 | 0.23 | 25.48 | 0.60 | 3.22 | 0.12 | 1.57 | 0.05 | 29.02 | 0.64 | 32.24 | 0.65 | 56.5 | 1.87 |
| 22X-5, 33-35 | 194.37 | | | 1.77 | 0.30 | 19.14 | 0.42 | 3.77 | 0.08 | 1.14 | 0.03 | 22.05 | 0.52 | 25.82 | 0.53 | 60.6 | 1.90 |
| 23X-4, 32-34 | 202.53 | | | 1.74 | 0.12 | 22.19 | 0.69 | 3.11 | 0.14 | 1.13 | 0.03 | 25.06 | 0.70 | 28.17 | 0.71 | 55.3 | 6.02 |
| 23X-5, 33-35 | 203.81 | | | 1.59 | 0.12 | 29.11 | 0.58 | 3.71 | 0.05 | 1.13 | 0.02 | 31.83 | 0.59 | 35.53 | 0.60 | 59.2 | 2.85 |
| 24X-5, 32-34 | 213.51 | | | 1.42 | 0.20 | 22.20 | 0.32 | 4.30 | 0.24 | 1.32 | 0.04 | 24.94 | 0.38 | 29.24 | 0.45 | 53.7 | 1.87 |
| 27X-5, 33-35 | 232.79 | | | 1.81 | 0.62 | 33.11 | 1.07 | 4.45 | 0.07 | 1.40 | 0.02 | 36.32 | 1.24 | 40.77 | 1.24 | 53.2 | 1.74 |
| 28X-4, 32-34 | 241.32 | | | 2.18 | 0.50 | 30.37 | 0.86 | 4.11 | 0.09 | 1.21 | 0.09 | 33.76 | 0.99 | 37.87 | 1.00 | 56.4 | 1.48 |
| 29X-2, 68-70 | 249.08 | | | 1.51 | 0.19 | 20.43 | 0.77 | 2.15 | 0.02 | 0.81 | 0.03 | 22.75 | 0.80 | 24.90 | 0.80 | 71.0 | 1.99 |
| 30X-5, 33-35 | 256.43 | | | 1.41 | 0.26 | 43.14 | 0.45 | 4.43 | 0.04 | 1.31 | 0.03 | 45.86 | 0.52 | 50.29 | 0.52 | 57.9 | 3.29 |
| 31X-5, 33-35 | 261.79 | | | 1.66 | 0.37 | 25.86 | 0.37 | 3.58 | 0.21 | 1.06 | 0.04 | 28.57 | 0.53 | 32.15 | 0.57 | 63.6 | 7.44 |
| 32X-5, 33-35 | 271.81 | | | 3.62 | 0.50 | 40.02 | 0.39 | 7.20 | 0.36 | 1.98 | 0.07 | 45.62 | 0.64 | 52.82 | 0.74 | 50.6 | 3.22 |
| 33X-5, 33-35 | 281.07 | | | 2.47 | 1.66 | 48.81 | 0.85 | 5.16 | 0.03 | 1.89 | 0.07 | 53.17 | 1.87 | 58.33 | 1.87 | 50.8 | 2.12 |
| 34X-5, 33-35 | 291.83 | | | 5.09 | 1.87 | 45.13 | 0.38 | 4.14 | 0.13 | 2.00 | 0.14 | 52.23 | 1.91 | 56.37 | 1.92 | 48.5 | 1.61 |
| 35X-5, 33-35 | 300.73 | | | 2.20 | 0.96 | 29.78 | 0.61 | 3.85 | 0.29 | 1.48 | 0.09 | 33.46 | 1.14 | 37.31 | 1.18 | 46.4 | 1.81 |
| 37X-5, 33-35 | 319.63 | | | 3.27 | 1.40 | 31.50 | 1.84 | 3.51 | 0.13 | 1.50 | 0.07 | 36.26 | 2.32 | 39.77 | 2.32 | 54.6 | 2.09 |
| 38X-4, 32-34 | 328.92 | | | 4.04 | 2.04 | 36.80 | 0.72 | 3.54 | 0.11 | 1.67 | 0.11 | 42.51 | 2.17 | 46.04 | 2.17 | 50.6 | 2.60 |
| 39X-5, 33-35 | 338.26 | | | 2.00 | 0.97 | 28.07 | 0.78 | 4.17 | 0.02 | 1.56 | 0.09 | 31.64 | 1.25 | 35.81 | 1.25 | 62.1 | 2.58 |
| 40X-4, 32-34 | 347.09 | | | 2.04 | 0.55 | 24.78 | 0.88 | 4.08 | 0.05 | 1.46 | 0.08 | 28.29 | 1.04 | 32.37 | 1.04 | 61.8 | 2.84 |
| 41X-5, 38-40 | 359.03 | | | 2.90 | 1.10 | 40.24 | 0.94 | 6.62 | 0.55 | 2.28 | 0.12 | 45.41 | 1.46 | 52.03 | 1.56 | 39.4 | 1.82 |
| 42X-5, 40-42 | 369.00 | | | 1.33 | 0.34 | 24.58 | 0.60 | 3.99 | 0.27 | 1.20 | 0.08 | 27.11 | 0.69 | 31.09 | 0.74 | 70.0 | 2.78 |
| 43X-5, 33-35 | 386.83 | | | 0.84 | 0.64 | 42.12 | 0.92 | 7.73 | 0.84 | 1.69 | 0.08 | 44.64 | 1.12 | 52.37 | 1.40 | 53.6 | 2.29 |
| 44X-5, 32-34 | 396.97 | | | 0.88 | 0.30 | 66.92 | 1.68 | 9.35 | 0.03 | 2.43 | 0.12 | 70.23 | 1.71 | 79.58 | 1.71 | 28.6 | 2.54 |
| 45X-5, 32-34 | 406.33 | | | 0.93 | 0.54 | 78.19 | 2.28 | 11.66 | 1.38 | 1.91 | 0.11 | 81.03 | 2.35 | 92.70 | 2.72 | 43.8 | 2.18 |
| 46X-5, 32-34 | 415.65 | | | 1.57 | 0.80 | 32.23 | 0.80 | 5.57 | 0.20 | 1.48 | 0.09 | 35.29 | 1.14 | 40.85 | 1.15 | 63.6 | 1.73 |
| 47X-5, 33-35 | 424.93 | | | 1.62 | 0.34 | 46.57 | 0.49 | 9.03 | 0.40 | 2.62 | 0.14 | 50.81 | 0.62 | 59.84 | 0.73 | 32.9 | 1.88 |
| 48X-5, 29-31 | 434.99 | | | 1.90 | 0.48 | 70.08 | 1.10 | 13.52 | 1.30 | 2.64 | 0.13 | 74.62 | 1.21 | 88.14 | 1.78 | 32.6 | 1.43 |
| 49X-5, 33-35 | 445.14 | | | 4.27 | 1.46 | 103.25 | 5.51 | 7.95 | 0.51 | 3.22 | 0.10 | 110.75 | 5.70 | 118.69 | 5.73 | 8.6 | 2.35 |

Note: * = For the first ten samples, analyses were performed using both the five- and four-step procedures. SD = standard deviation, blank = quantity not determined for that sample.

**Table 5. Sedimentary geochemical results for Site 1016.**

| Core, section, interval (cm) | Depth (mbsf) | P concentrations (µmol/g sediment) | | | | | | | | | | | | $CaCO_3$ (wt%) | Biogenic opal (wt%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Oxide associated | | Authigenic | | Detrital | | Organic | | Total reactive | | Total | | | |
| | | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | | |
| 167-1016A- | | | | | | | | | | | | | | | |
| 1H-3, 27-29 | 3.37 | 0.82 | 0.04 | 9.65 | 0.14 | 5.60 | 0.05 | 4.38 | 1.46 | 14.85 | 1.46 | 20.44 | 1.46 | 3.4 | 3.10 |
| 3H-4, 26-28 | 21.86 | 1.35 | 0.03 | 13.69 | 0.45 | 6.84 | 0.04 | 2.07 | 0.09 | 17.12 | 0.46 | 23.96 | 0.46 | | 3.77 |
| 5H-4, 32-34 | 40.92 | 4.59 | 0.22 | 41.70 | 2.73 | 6.32 | 0.02 | 1.93 | 0.56 | 48.21 | 2.79 | 54.53 | 2.79 | BDL | 4.45 |
| 7H-4, 32-34 | 59.92 | 0.99 | 0.08 | 8.06 | 0.07 | 5.05 | 0.04 | 2.05 | 0.13 | 11.09 | 0.17 | 16.14 | 0.17 | | 2.01 |
| 9H-3, 145-150 | 78.55 | 1.02 | 0.06 | 8.24 | 0.10 | 4.57 | 0.57 | 1.37 | 0.02 | 10.63 | 0.12 | 15.19 | 0.58 | 10.4 | 4.14 |
| 9H-4, 32-34 | 78.92 | 1.34 | 0.13 | 6.93 | 0.42 | 4.11 | 0.04 | 1.55 | 0.03 | 9.82 | 0.44 | 13.93 | 0.44 | 8.8 | 2.71 |
| 12X-3, 145-150 | 100.75 | 0.88 | 0.05 | 10.46 | 0.05 | 4.44 | 0.01 | 1.14 | 0.01 | 12.48 | 0.07 | 16.92 | 0.07 | BDL | 4.08 |
| 12X-4, 32-34 | 101.12 | 1.10 | 0.07 | 11.37 | 0.11 | 4.80 | 0.06 | 1.58 | 0.05 | 14.05 | 0.14 | 18.85 | 0.15 | | 2.43 |
| 15X-3, 145-150 | 129.65 | 1.55 | 0.09 | 9.11 | 0.09 | 2.02 | 0.11 | 0.70 | 0.03 | 11.35 | 0.13 | 13.38 | 0.17 | BDL | 4.75 |
| 15X-4, 33-35 | 130.03 | 1.53 | 0.10 | 9.01 | 0.20 | 2.70 | 0.06 | 1.00 | 0.09 | 11.55 | 0.25 | 14.25 | 0.25 | 9.1 | 4.55 |
| 18X-3, 145-150 | 158.45 | 0.73 | 0.04 | 13.79 | 0.27 | 4.49 | 0.04 | 1.31 | 0.11 | 15.82 | 0.29 | 20.31 | 0.30 | | 3.57 |
| 18X-4, 32-34 | 158.82 | 0.77 | 0.08 | 12.73 | 0.03 | 4.49 | 0.01 | 1.05 | 0.00 | 14.55 | 0.08 | 19.04 | 0.08 | | 2.46 |
| 18X-4, 32-34 | 158.82 | 1.97 | 0.16 | 12.15 | 0.42 | 3.75 | 0.09 | 1.11 | 0.01 | 15.23 | 0.45 | 18.98 | 0.46 | 28.9 | 5.09 |
| 19X-4, 32-34 | 168.42 | 0.36 | 0.18 | 16.95 | 0.37 | 5.99 | 0.04 | 1.37 | 0.04 | 18.68 | 0.41 | 24.66 | 0.42 | | 4.12 |
| 19X-4, 32-34 | 168.42 | 0.60 | 0.08 | 15.39 | 0.20 | 6.01 | 0.02 | 1.63 | 0.17 | 17.62 | 0.27 | 23.64 | 0.27 | | 8.09 |
| 20X-4, 33-35 | 178.03 | 0.27 | 0.06 | 14.30 | 0.19 | 4.56 | 0.03 | 1.08 | 0.03 | 15.65 | 0.20 | 20.21 | 0.20 | 23.4 | 4.87 |
| 20X-4, 33-35 | 178.03 | 0.69 | 0.04 | 13.77 | 0.05 | 5.28 | 0.41 | 1.24 | 0.03 | 15.69 | 0.07 | 20.97 | 0.42 | | 9.82 |
| 21X-4, 32-34 | 187.62 | 0.59 | 0.08 | 10.34 | 0.09 | 2.71 | 0.08 | 1.02 | 0.01 | 11.95 | 0.12 | 14.65 | 0.15 | | 9.01 |
| 21X-4, 32-34 | 187.62 | 0.98 | 0.02 | 9.32 | 0.10 | 4.35 | 1.44 | 1.29 | 0.13 | 11.59 | 0.17 | 15.93 | 1.45 | 58.9 | 8.63 |
| 22X-4, 73-75 | 197.73 | 0.18 | 0.09 | 10.85 | 0.40 | 1.92 | 0.00 | 0.95 | 0.04 | 11.98 | 0.41 | 13.90 | 0.41 | | 5.37 |
| 22X-4, 73-75 | 197.73 | 0.84 | 0.18 | 9.81 | 0.05 | 3.29 | 0.01 | 1.05 | 0.01 | 11.70 | 0.19 | 14.98 | 0.19 | | 4.63 |
| 23X-4, 32-34 | 206.92 | BDL | | 8.73 | 0.55 | 1.61 | 0.03 | 0.81 | 0.04 | 9.54 | 0.55 | 11.15 | 0.55 | 44.2 | 3.07 |
| 23X-4, 32-34 | 206.92 | 0.56 | 0.07 | 7.61 | 0.01 | 1.84 | 0.03 | 0.92 | 0.03 | 9.09 | 0.08 | 10.93 | 0.09 | | 4.05 |
| 24X-4, 131-133 | 217.51 | 0.38 | 0.10 | 19.90 | 0.32 | 4.09 | 0.05 | 1.18 | 0.01 | 21.45 | 0.34 | 25.54 | 0.34 | 8.4 | 2.32 |
| 25X-4, 51-53 | 226.31 | 2.23 | 0.10 | 9.84 | 0.28 | 2.68 | 0.02 | 1.10 | 0.05 | 13.17 | 0.30 | 15.85 | 0.30 | | 3.63 |
| 26X-6, 106-108 | 239.46 | 0.66 | 0.09 | 14.82 | 0.46 | 3.61 | 0.01 | 1.15 | 0.01 | 16.63 | 0.46 | 20.24 | 0.46 | BDL | |
| 27X-4, 32-35 | 245.42 | 1.58 | 0.11 | 9.28 | 0.67 | 2.72 | 0.01 | 0.82 | 0.01 | 11.67 | 0.68 | 14.39 | 0.68 | | |
| 28X-4, 32-34 | 255.02 | 0.21 | 0.06 | 15.77 | 0.80 | 3.54 | 0.05 | 0.96 | 0.01 | 16.95 | 0.80 | 20.49 | 0.80 | 28.5 | |
| 29X-3, 73-76 | 263.53 | BDL | | 8.45 | 0.54 | 1.30 | 0.02 | 0.58 | 0.01 | 9.02 | 0.54 | 10.32 | 0.54 | | |
| 30X-4, 53-55 | 274.53 | BDL | | 17.15 | 0.07 | 3.49 | 0.11 | 0.98 | 0.03 | 18.13 | 0.07 | 21.63 | 0.14 | BDL | |
| 31X-4, 32-34 | 284.02 | BDL | | 17.04 | 0.29 | 2.45 | 0.02 | 0.75 | 0.01 | 17.78 | 0.29 | 20.23 | 0.29 | | |
| 32X-4, 32-34 | 293.62 | 1.00 | 0.11 | 13.53 | 0.25 | 2.78 | 0.01 | 0.71 | 0.21 | 15.23 | 0.34 | 18.01 | 0.34 | | |

Note: SD = standard deviation, BDL = below detection limit, blank = quantity not determined for that sample.

**Table 6. Sedimentary geochemical results for Site 1017.**

| Core, section, interval (cm) | Depth (mbsf) | P concentrations (µmol/g sediment) | | | | | | | | | | | | $CaCO_3$ (wt%) | Biogenic opal (wt%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Oxide associated | | Authigenic | | Detrital | | Organic | | Total reactive | | Total | | | |
| | | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | | |
| 167-1017B- | | | | | | | | | | | | | | | |
| 1H-3, 145-150 | 4.45 | 1.95 | 0.04 | 13.80 | 0.05 | 0.46 | 0.09 | 2.00 | 0.07 | 17.75 | 0.10 | 18.21 | 0.13 | 6.5 | 2.75 |
| 1H-4, 145-150 | 5.67 | 1.90 | 0.99 | 15.60 | 2.45 | 0.58 | 0.07 | 1.99 | 0.16 | 19.48 | 2.64 | 20.06 | 2.64 | 6.5 | 2.02 |
| 2H-3, 145-150 | 9.75 | 2.64 | 0.15 | 15.29 | 2.15 | 0.56 | 0.04 | 2.41 | 0.12 | 20.34 | 2.16 | 20.90 | 2.16 | 6.0 | 2.36 |
| 3H-3, 145-150 | 19.25 | 2.28 | 0.10 | 13.15 | 1.42 | 0.50 | 0.04 | 2.48 | 0.15 | 17.90 | 1.43 | 18.40 | 1.43 | 4.9 | 1.42 |
| 4H-3, 145-150 | 28.75 | 2.12 | 0.15 | 16.51 | 0.31 | 0.51 | 0.03 | 1.66 | 0.14 | 20.28 | 0.37 | 20.79 | 0.37 | 7.6 | 2.44 |
| 5H-3, 145-150 | 38.19 | 2.42 | 0.35 | 16.69 | 3.24 | 0.54 | 0.08 | 1.79 | 0.01 | 20.90 | 3.26 | 21.44 | 3.26 | 5.8 | 2.33 |
| 6H-3, 145-150 | 47.75 | 3.21 | 0.52 | 17.79 | 2.35 | 0.64 | 0.09 | 1.76 | 0.01 | 22.75 | 2.41 | 23.39 | 2.41 | 9.7 | 3.15 |
| 9H-3, 145-150 | 76.25 | 2.67 | 0.23 | 19.59 | 3.71 | 0.57 | 0.04 | 1.70 | 0.06 | 23.95 | 3.72 | 24.52 | 3.72 | 8.7 | 1.90 |
| 12H-3, 145-150 | 104.75 | 1.97 | 0.71 | 16.21 | 2.55 | 0.44 | 0.03 | 1.61 | 0.09 | 19.79 | 2.65 | 20.23 | 2.65 | 4.7 | 2.22 |
| 15X-3, 145-150 | 122.88 | 1.94 | 0.18 | 21.09 | 1.03 | 0.49 | 0.02 | 1.15 | 0.05 | 24.18 | 1.05 | 24.67 | 1.05 | 6.0 | 2.85 |

Note: SD = standard deviation.

**Table 7. Sedimentary geochemical results for Site 1021.**

| Core, section, interval (cm) | Depth (mbsf) | P concentrations (µmol/g sediment) | | | | | | | | | | | | $CaCO_3$ (wt%) | Biogenic opal (wt%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Oxide associated | | Authigenic | | Detrital | | Organic | | Total reactive | | Total | | | |
| | | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | | |
| 167-1021B- | | | | | | | | | | | | | | | |
| 1H-2, 32-34 | 1.82 | 1.02 | 0.09 | 8.48 | 0.09 | 6.34 | 0.05 | 2.47 | 0.05 | 11.98 | 0.14 | 18.32 | 0.15 | 1.9 | 5.61 |
| 1H-5, 32-34 | 6.32 | 1.67 | 0.11 | 7.60 | 0.14 | 8.32 | 0.02 | 2.35 | 0.06 | 11.62 | 0.19 | 19.94 | 0.19 | 5.3 | 4.01 |
| 2H-2, 32-34 | 9.82 | 1.61 | 0.16 | 9.93 | 0.23 | 6.20 | 0.05 | 2.31 | 0.16 | 13.84 | 0.32 | 20.04 | 0.32 | BDL | 3.65 |
| 2H-5, 32-34 | 14.32 | 1.37 | 0.14 | 7.84 | 0.16 | 8.03 | 0.04 | 1.81 | 0.01 | 11.01 | 0.22 | 19.05 | 0.22 | 8.7 | 4.64 |
| 3H-2, 34-36 | 19.34 | 0.95 | 0.11 | 8.39 | 0.07 | 5.55 | 0.06 | 1.81 | 0.10 | 11.16 | 0.17 | 16.71 | 0.18 | 8.7 | 4.61 |
| 3H-5, 32-34 | 23.82 | 0.89 | 0.13 | 9.31 | 0.22 | 5.75 | 0.08 | 1.73 | 0.04 | 11.93 | 0.26 | 17.69 | 0.27 | BDL | 4.96 |
| 4H-2, 32-34 | 28.82 | 1.36 | 0.11 | 5.84 | 0.15 | 7.71 | 0.04 | 1.76 | 0.03 | 8.97 | 0.19 | 16.68 | 0.20 | 7.2 | 4.88 |
| 4H-5, 32-34 | 33.32 | 1.08 | 0.05 | 5.68 | 0.15 | 7.33 | 0.06 | 1.62 | 0.07 | 8.38 | 0.17 | 15.71 | 0.19 | 6.9 | 6.91 |
| 5H-5, 33-35 | 42.83 | 0.96 | 0.01 | 5.23 | 0.14 | 7.77 | 0.08 | 1.66 | 0.05 | 7.85 | 0.15 | 15.62 | 0.17 | 5.0 | 5.32 |
| 6H-5, 34-36 | 52.34 | 0.67 | 0.03 | 6.67 | 0.08 | 6.76 | 0.08 | 1.50 | 0.06 | 8.84 | 0.11 | 15.61 | 0.13 | 0.9 | 7.54 |
| 7H-5, 33-35 | 61.83 | 1.39 | 0.11 | 3.74 | 0.10 | 6.14 | 0.35 | 1.25 | 0.03 | 6.38 | 0.15 | 12.52 | 0.38 | 24.2 | 7.79 |
| 8H-5, 33-35 | 71.33 | 0.77 | 0.02 | 5.41 | 0.07 | 7.37 | 0.09 | 1.36 | 0.02 | 7.53 | 0.08 | 14.90 | 0.12 | 5.3 | 10.64 |
| 9H-5, 34-36 | 80.84 | 1.44 | 0.10 | 5.51 | 0.19 | 8.01 | 0.04 | 1.28 | 0.03 | 8.23 | 0.22 | 16.23 | 0.22 | 12.1 | 3.54 |
| 10H-2, 31-33 | 80.84 | 1.48 | 0.02 | 5.23 | 0.04 | 6.80 | 0.02 | 1.24 | 0.06 | 7.95 | 0.07 | 14.75 | 0.08 | 23.1 | 2.80 |
| 11H-5, 33-35 | 99.83 | 2.40 | 0.03 | 4.50 | 0.22 | 4.59 | 0.06 | 0.92 | 0.03 | 7.82 | 0.22 | 12.41 | 0.23 | 48.0 | 1.58 |
| 12H-5, 32-34 | 109.32 | 0.67 | 0.04 | 5.64 | 0.19 | 6.86 | 0.01 | 1.57 | 0.11 | 7.89 | 0.22 | 14.74 | 0.22 | 2.7 | 2.72 |
| 13H-5, 32-34 | 118.82 | 0.54 | 0.04 | 5.91 | 0.21 | 5.98 | 0.08 | 1.48 | 0.03 | 7.92 | 0.22 | 13.91 | 0.23 | BDL | 2.92 |
| 14H-5, 35-37 | 128.35 | 1.72 | 0.06 | 5.87 | 0.21 | 7.47 | 0.36 | 1.17 | 0.09 | 8.76 | 0.24 | 16.23 | 0.43 | 21.6 | 2.27 |
| 15H-5, 32-34 | 137.82 | 0.54 | 0.09 | 6.57 | 0.44 | 5.70 | 0.03 | 1.31 | 0.06 | 8.43 | 0.45 | 14.12 | 0.45 | BDL | 9.05 |
| 16H-5, 32-34 | 147.32 | 0.46 | 0.05 | 6.92 | 0.11 | 5.81 | 0.10 | 1.40 | 0.02 | 8.79 | 0.12 | 14.59 | 0.16 | 1.3 | 5.59 |
| 17H-5, 32-34 | 156.82 | 0.51 | 0.00 | 6.56 | 0.09 | 5.16 | 0.08 | 1.26 | 0.02 | 8.34 | 0.09 | 13.50 | 0.12 | BDL | 9.85 |
| 18H-5, 32-34 | 166.32 | 0.57 | 0.02 | 7.63 | 0.15 | 6.40 | 0.03 | 1.57 | 0.05 | 9.76 | 0.15 | 16.16 | 0.16 | 1.8 | 5.38 |
| 19X-5, 51-53 | 176.01 | 0.50 | 0.03 | 7.45 | 0.36 | 6.62 | 0.05 | 1.19 | 0.01 | 9.14 | 0.36 | 15.76 | 0.37 | 1.2 | 8.22 |
| 20X-2, 31-33 | 177.21 | 0.54 | 0.05 | 5.96 | 0.09 | 5.89 | 0.11 | 1.09 | 0.02 | 7.59 | 0.10 | 13.48 | 0.15 | 3.0 | |
| 21X-5, 31-33 | 191.31 | 0.75 | 0.07 | 9.80 | 0.79 | 5.18 | 0.01 | 1.30 | 0.09 | 11.86 | 0.79 | 17.04 | 0.79 | BDL | 4.00 |
| 22X-5, 24-26 | 200.94 | 1.28 | 0.15 | 8.89 | 0.20 | 6.03 | 0.04 | 1.40 | 0.04 | 11.58 | 0.26 | 17.61 | 0.26 | BDL | 3.91 |
| 23X-5, 31-33 | 210.61 | 0.62 | 0.12 | 6.65 | 0.19 | 3.47 | 0.03 | 1.02 | 0.05 | 8.29 | 0.23 | 11.76 | 0.23 | BDL | 19.53 |
| 24X-5, 84-86 | 220.84 | 0.50 | 0.03 | 5.53 | 0.03 | 4.55 | 0.02 | 0.96 | 0.04 | 6.99 | 0.05 | 11.54 | 0.06 | BDL | 20.60 |
| 25X-5, 31-33 | 229.91 | 0.69 | 0.03 | 6.42 | 0.26 | 4.64 | 0.09 | 1.16 | 0.03 | 8.27 | 0.26 | 12.91 | 0.27 | 6.8 | 11.90 |

Note: SD = standard deviation, BDL = below detection limit, blank = quantity not determined for that sample.

**Table 8. Sedimentary geochemical results for Site 1022.**

| Core, section, interval (cm) | Depth (mbsf) | P concentrations (µmol/g sediment) | | | | | | | | | | | | $CaCO_3$ (wt%) | Biogenic opal (wt%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Oxide associated | | Authigenic | | Detrital | | Organic | | Total reactive | | Total | | | |
| | | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | | |
| 167-1022A- | | | | | | | | | | | | | | | |
| 1H-3, 33-35 | 3.33 | 1.29 | 0.08 | 7.46 | 0.54 | 10.81 | 0.11 | 1.25 | 0.01 | 9.99 | 0.54 | 20.80 | 0.55 | 5.4 | 1.84 |
| 2H-3, 33-35 | 7.83 | 0.59 | 0.05 | 4.85 | 0.10 | 11.26 | 0.22 | 1.49 | 0.14 | 6.92 | 0.18 | 18.19 | 0.29 | BDL | 5.52 |
| 4H-4, 32-34 | 28.32 | 0.67 | 0.05 | 4.77 | 0.18 | 11.10 | 0.17 | 1.33 | 0.04 | 6.76 | 0.19 | 17.86 | 0.25 | 1.5 | 3.78 |
| 5H-4, 33-35 | 37.83 | 0.65 | 0.06 | 5.40 | 0.14 | 10.58 | 0.05 | 1.36 | 0.00 | 7.40 | 0.15 | 17.98 | 0.16 | 14.0 | 4.41 |
| 6H-4, 33-35 | 47.33 | 1.81 | 0.04 | 4.99 | 0.19 | 10.25 | 0.16 | 1.24 | 0.01 | 8.04 | 0.19 | 18.28 | 0.25 | 11.1 | 6.34 |
| 7H-4, 31-33 | 56.81 | 1.29 | 0.05 | 4.78 | 0.34 | 10.53 | 0.09 | 1.35 | 0.02 | 7.41 | 0.34 | 17.95 | 0.36 | 9.4 | |
| 8H-4, 31-33 | 66.31 | 1.42 | 0.08 | 5.15 | 0.06 | 10.61 | 0.09 | 1.35 | 0.02 | 7.92 | 0.10 | 18.53 | 0.13 | 4.0 | |
| 9H-4, 33-35 | 75.83 | 0.95 | 0.05 | 4.83 | 0.03 | 10.02 | 0.12 | 1.43 | 0.01 | 7.20 | 0.07 | 17.23 | 0.14 | 17.1 | 3.97 |
| 10H-4, 33-35 | 85.33 | 2.09 | 0.08 | 4.36 | 0.16 | 9.22 | 0.17 | 1.19 | 0.01 | 7.64 | 0.18 | 16.86 | 0.25 | 14.7 | |
| 11H-3, 33-35 | 93.33 | 1.75 | 0.06 | 4.20 | 0.14 | 10.14 | 0.06 | 1.26 | 0.01 | 7.21 | 0.15 | 17.35 | 0.16 | 21.6 | |
| 13H-4, 32-34 | 113.82 | 2.38 | 0.25 | 4.98 | 0.38 | 8.80 | 0.28 | 1.16 | 0.07 | 8.52 | 0.46 | 17.32 | 0.54 | 15.6 | |
| 15H-4, 33-35 | 132.83 | 2.12 | 0.04 | 4.84 | 0.10 | 8.72 | 0.06 | 1.34 | 0.01 | 8.30 | 0.11 | 17.02 | 0.13 | 4.4 | 3.55 |
| 17H-4, ,33-35 | 151.83 | 1.00 | 0.10 | 5.80 | 0.28 | 9.89 | 0.42 | 1.41 | 0.07 | 8.20 | 0.30 | 18.09 | 0.51 | 15.8 | |
| 167-1022C- | | | | | | | | | | | | | | | |
| 18X-4, 30-32 | 164.30 | 1.38 | 0.08 | 5.40 | 0.06 | 8.56 | 0.16 | 1.48 | 0.03 | 8.26 | 0.11 | 16.82 | 0.19 | 1.1 | 5.26 |
| 20X-4, 30-32 | 179.60 | 1.06 | 0.07 | 5.66 | 0.31 | 9.52 | 0.05 | 1.27 | 0.04 | 7.99 | 0.32 | 17.51 | 0.32 | 1.3 | |
| 24X-4, 30-32 | 218.00 | 0.66 | 0.06 | 7.11 | 0.59 | 10.02 | 0.56 | 1.37 | 0.02 | 9.14 | 0.60 | 19.15 | 0.82 | 2.4 | |
| 26X-4, 30-32 | 237.30 | 0.87 | 0.02 | 6.90 | 0.21 | 11.15 | 0.07 | 1.44 | 0.03 | 9.20 | 0.21 | 20.36 | 0.22 | BDL | |
| 38X-4, 29-31 | 256.59 | 0.50 | 0.03 | 6.77 | 0.11 | 8.50 | 0.32 | 1.26 | 0.07 | 8.54 | 0.13 | 17.04 | 0.35 | BDL | |
| 30X-4, 29-31 | 275.79 | 0.79 | 0.04 | 6.63 | 0.27 | 8.54 | 0.13 | 1.31 | 0.01 | 8.73 | 0.27 | 17.27 | 0.30 | BDL | |
| 33X-4, 30-32 | 304.70 | 0.93 | 0.09 | 7.77 | 1.02 | 9.00 | 0.12 | 1.31 | 0.02 | 10.02 | 1.03 | 19.02 | 1.04 | 3.5 | |
| 37X-4, 32-34 | 343.42 | 0.34 | 0.05 | 5.70 | 0.08 | 5.83 | 0.10 | 1.04 | 0.07 | 7.08 | 0.11 | 12.91 | 0.15 | 10.1 | |
| 40X-4, 30-32 | 372.20 | 0.39 | 0.04 | 6.96 | 0.44 | 9.29 | 0.16 | 1.50 | 0.00 | 8.85 | 0.44 | 18.14 | 0.47 | BDL | |

Note: SD = standard deviation, BDL = below detection limit, blank = quantity not determined for that sample.