contraction the Izu-Oshima volcano is located. The rise of magma level in the conduit of Mount Mihara-yama, Izu-Oshima, observed at the time of the Izu-Hanto-oki earthquake was attributed to the tectonic strain effect, or magma squeezed up from the reservoir (*7*). It may also have been caused by crustal phenomena similar to those discussed above. Additional support for these arguments comes from observations at Shimogamo hot spring and its vicinity, in the eastern contraction area of the Izu Peninsula, where a significant rise in the level of the hot spring and increase in water discharge were reported after the earthquake (*8*).

Three crustal movement observatories at Fujigawa, Aburatsubo, and Nokogiriyama, which are 70 to 110 km from the epicenter, are distributed within the area of present concern. At Fujigawa Observatory, the station nearest the epicenter, the strain steps on three components of the strainmeter showed the extension ranging (1 to ~ 6) $\times 10^{-8}$ (*9*). However, no significant changes in strain were observed at other stations.

It is rather surprising that wells less than 60 m deep could reflect tectonic strain, and further research is needed to confirm this. A more detailed discussion and description of the data will be published elsewhere.

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Oxygen and Carbon Isotopes from Calcareous Nannofossils as Paleoceanographic Indicators

Abstract. *Oxygen-18 and carbon-13 analyses of well-preserved calcareous nannofossils have been compared with those of foraminifera contained in Cenozoic cores collected in the Southern Ocean during the Deep Sea Drilling Project. The results indicate that calcareous nannofossils deposit calcium carbonate at or near equilibrium with oceanic surface waters and that they can be used as paleotemperature indicators.*

Calcareous nannofossils, principally Coccolithophoridae, a group of marine phytoplankton, are major contributors to pelagic sediments. They are widely used both in biostratigraphic age determinations and as paleoceanographic indicators (*1*) because of their rapid evolutionary changes, habitat, and apparently higher resistance to dissolution than planktonic foraminifera, as evidenced by their abundance in fossil carbonate sediments (*2, 3*). They have not, however, been the subject of any detailed stable isotope studies. We have determined $\delta^{18}O$ and $\delta^{13}C$ values (*4*) from calcareous nannofossils contained in three sediment cores collected in the Southern Ocean during Leg 29 of the Deep Sea Drilling Project (DSDP) and compared these data with similar published ones (*5*) for associated planktonic and benthic foraminifera contained in the same samples. The purpose of this comparison is to determine whether calcareous nannofossils preserve $\delta^{18}O$ and $\delta^{13}C$ values consistent with their euphotic habitat (*3*) or undergo exchange with bottom or interstitial waters during or after burial.

The Leg 29 cores (*5*) are well suited for such a study as they represent a relatively continuous sequence spanning the last 55 million years (*6*) and contain a well-preserved calcareous fauna and flora deposited at depths between 1200 and 3300 m. During this time interval, profound changes in the configuration, circulation patterns, and temperature structure of the Southern Ocean occurred (*7, 8*), and extensive ice sheets developed on Antarctica (*5, 7, 9*).

Relatively pure but polyspecific calcareous nannofossil fractions consisting of isolated coccoliths, coccospheres, and discoasters were separated from the fraction of samples < 44 μm from the three cores by using short centrifuge techniques (*10*), and each sample was checked for purity of nannofossil content and state of preservation by scanning electron microscopy. Values of $\delta^{18}O$ and $\delta^{13}C$ for calcareous nannofossils were determined by using standard mass spectrometer techniques (*11*).

The $\delta^{18}O$ profile for calcareous nannofossils (Fig. 1) closely parallels the foraminiferal profiles for most of its length, including intervals of rapid change of apparent temperature in the late Cenozoic and at the Oligocene-Eocene boundary. Nannofossil $\delta^{18}O$ values are occasionally slightly higher than those of associated planktonic foraminifera, indicating either differential isotope (vital) fractionation during growth or postmortem reequilibration produced by dissolution or secondary encrustations within sediments (*12*). However, none of our nannofossil $\delta^{18}O$ values are as high as those of the colder-water benthic foraminifera, which would indicate complete isotopic exchange with bottom waters. The majority of nannofossil samples from site 277 exhibit $\delta^{18}O$ values that are equal to or slightly lower than those of the planktonic foraminifera, indicating that the nannofossils are apparently preserving surface water temperatures.

The $\delta^{13}C$ profile for calcareous nannofossils (Fig. 2) also shows a tendency to parallel the foraminiferal curves. The progressive increase in $\delta^{13}C$ values from the benthic and planktonic foraminifera to the nannofossils at sites 279A and 277 suggests that carbon isotopes reflect the $\delta^{13}C$ of the surrounding media and may be indicative of the water depth during growth (*13*). The $\delta^{13}C$ of the ΣCO_2 in present-day South Pacific waters varies from about +2.0 per mil at the surface to around +0.5 per mil in bottom waters (*14, 15*).

The effects of dissolution and secondary encrustation with resultant isotopic reequilibration of calcareous nannofossils should be related to either water depth or subsequent burial history. At the present time planktonic foraminifera show slight dissolution effects below 1000 m, with appreciable dissolution occurring below 3000 m in the Central Pacific. Etching, fragmentation, and dissolution features are evident on coccoliths found below 3000 m, and further deterioration increases rapidly below 4000 m. Overgrowths are most prevalent on coccoliths deposited between 3500 and 4800 m and apparently can be produced at or near the sediment-water interface (*16*). Among the cores studied here, only sediment samples from site 279A now lie below a water depth of 3000 m and should contain the most evidence for dissolution. The isotope data from site 279A (3341 m), when compared with sediments from sites 277 and 281 (1214 and 1591 m), do not support such a depth-dependent reequilibration model.

Reequilibration of the nannofossils during or after burial should produce higher $\delta^{18}O$ values because of colder bottom water temperatures and lower $\delta^{13}C$ values because of incorporation of ^{13}C-depleted organic carbon (*14, 17*). Several samples we analyzed do show possible indications of reequilibration with deeper water when compared to planktonic foraminifera. Detailed electron microscopic examinations of nannofossils from site 277, core 28, and site 281, core 6, which have lower $\delta^{13}C$ and higher $\delta^{18}O$ values than planktonic foraminifera (Figs. 1 and 2), reveal that most of the nannofossil remains in these cores exhibit abundant evidence of dissolution and secondary calcite overgrowths and contain no whole coccospheres. However, samples where $\delta^{13}C$ values for nannofossils are higher than those for planktonic foraminifera, and $\delta^{18}O$ values are lower, such as from site 277, cores 4 and 9, contain numerous whole coccospheres and coccoliths which are well preserved. Thus, samples of nannofossils must be subjected to electron microscopic studies of preservation if meaningful paleoceanographic data are desired.

Examination of the Eocene portion of site 277 (Fig. 2) reveals a divergence in

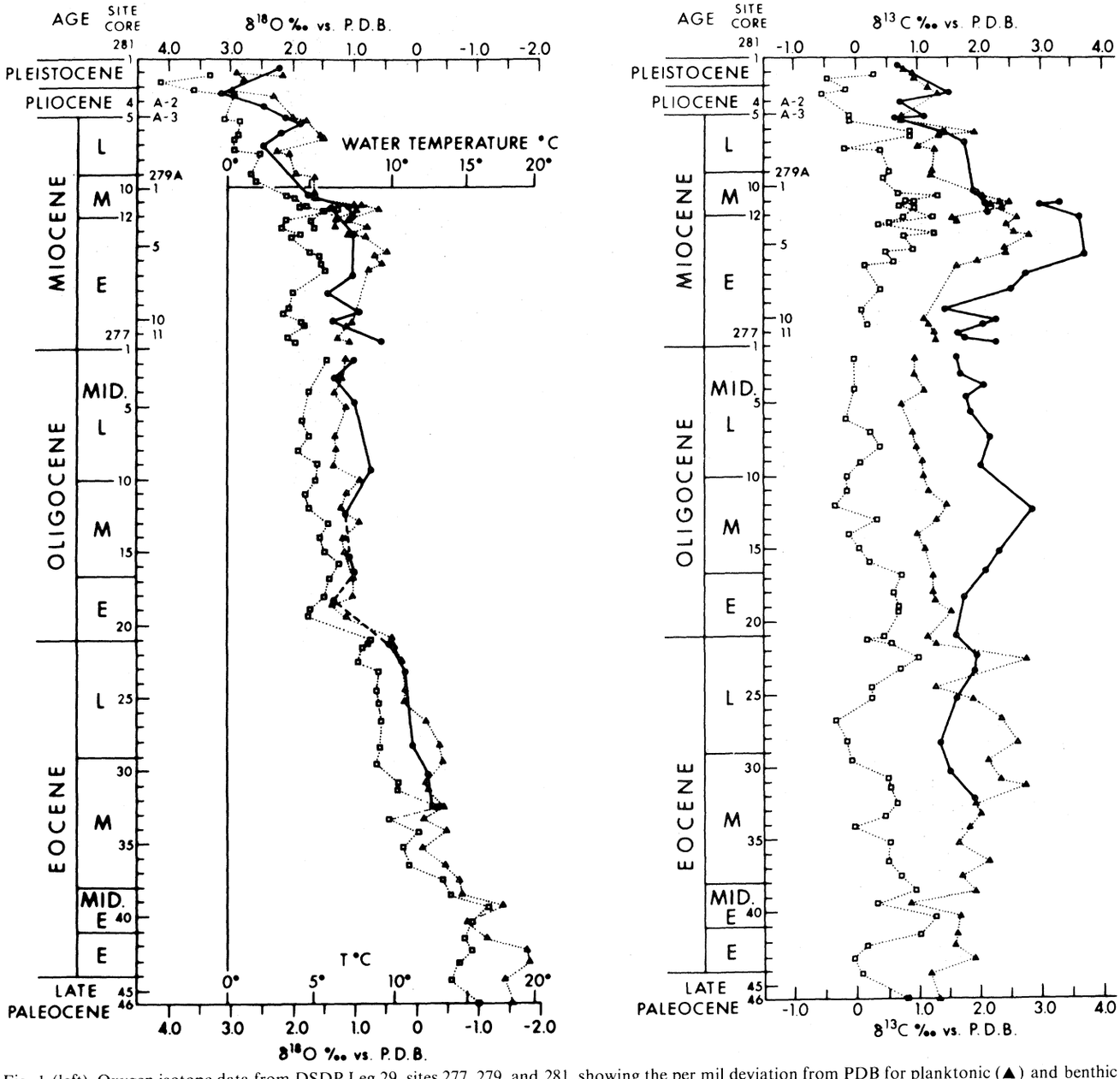

Fig. 1 (left). Oxygen isotope data from DSDP Leg 29, sites 277, 279, and 281, showing the per mil deviation from PDB for planktonic (▲) and benthic (□) foraminifera (*5*) and calcareous nannofossils (●) (this study). Note the close correspondence between nannofossil and planktonic foraminifera curves. Stratigraphic plots (*6*) are not based on thickness or age differences between samples, but represent relative positions in each cored interval. Water temperature values (*5*) are valid from base of sequence to middle Miocene only. Above core 10 at site 281 water temperature estimations are complicated by seawater isotopic changes (*5*). Calcareous nannofossils are assumed to be equilibrating with surface waters during growth. Nannofossil values that are higher than planktonic foraminifera values represent possible isotope exchange with deeper waters. Fig. 2 (right). Carbon isotope data from sites 277, 279, and 281 showing per mil deviation from PDB for planktonic (▲) and benthic (□) foraminifera (*5*) and calcareous nannofossils (●) (this study). Nannofossil $\delta^{13}C$ trends parallel those for foraminifera, but are higher than planktonic foraminifera values in Oligocene to middle Miocene samples. Nannofossil $\delta^{13}C$ values significantly lower than those for associated planktonic foraminifera represent possible isotope exchange with deeper waters. Stratigraphic plots are not based on thickness or age differences between samples, but represent relative positions in each cored interval.

$\delta^{13}C$ values for benthic and planktonic foraminifera between cores 22 and 34. Individuals of the species *Globigerapsis index* were used to obtain the planktonic foraminiferal values from these samples, whereas in other samples mixed planktonic species have been used (*5*). It has been found that there are definite species-dependent departures from isotopic equilibrium in planktonic foraminifera (*18*), so that surface water $\delta^{13}C$ values cannot be derived from planktonic foraminiferal measurements even if the depth habitat of the species is known (and it is not for extinct species). Polyspecific samples of calcareous nannofossils may provide a more reliable indication of surface $\delta^{13}C$ changes than planktonic foraminifera (*19*). Measurement of changes in surface water carbon isotopic composition with time may yield useful information on changes in oceanic productivity.

The reliability of nannofossils as indicators of surface water paleotemperatures can be tested by growing pure cultures of coccolithophorids at varying temperatures (*20*). Preliminary oxygen isotope data for samples of these species indicate that during coccolith growth, oxygen isotopes are incorporated in equilibrium with the growth medium, when compared with the empirically determined paleotemperature curve (*21*). Similar isotopic results have been obtained for cultures of *Emiliania huxleyi* (*22*).

Our evidence indicates that $\delta^{18}O$ values obtained from well-preserved polyspecific samples of calcareous nannofossils can be used to estimate surface water paleotemperatures. The $\delta^{13}C$ values appear to reflect the depth of growth for benthic and planktonic foraminifera and calcareous nannofossils when compared with $\delta^{13}C$ profiles for today's oceans. These preliminary results add a new and potentially important method to the paleoclimatologist's arsenal for studying changes in the world's oceans. Many deep-water carbonate cores spanning critical intervals in the Mesozoic and Cenozoic lack planktonic foraminifera but often contain calcareous nannofossils, and these now can be used for detailed isotope paleotemperature studies.

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Hybridization Analysis of Histone Messenger RNA: Association with Polyribosomes During the Cell Cycle

Abstract. *Hybridization of cell cycle stage-specific polyribosomal RNA's to histone complementary DNA indicates that histone messenger RNA sequences are present on polyribosomes of Hela S_3 cells only during the period of DNA replication.*

A functional relation between histone synthesis and DNA replication is suggested by the fact that the synthesis of these proteins and their deposition on the DNA is restricted to the S phase of the cell cycle (*1, 2*). Further support for the coupling of histone and DNA synthesis comes from the observation that inhibition of DNA replication results in a rapid shutdown of histone synthesis (*2, 3*). It has previously been shown, with the use of cell-free protein synthesizing systems derived from reticulocytes and Ehrlich ascites cells, that the RNA isolated from polyribosomes of S phase HeLa cells supports the synthesis of histones (*4*). These findings indicate that translatable histone messenger RNA's (mRNA) are associated with polyribosomes exclusively during the S phase of the cell cycle. However, the possibility still exists that histone mRNA's are components of the polyribosomes during other periods of the cell cycle, but have in some way been rendered nontranslatable. Such a possibility would have important implications for the mechanism operative in the regulation of histone gene expression. Therefore, in order to establish that the mRNA's for histones are associated with polyribosomes only during S phase, we examined G_1, S, and G_2 polyribosomal RNA's for their ability to hybridize with histone complementary DNA (cDNA).

[^{3}H]DNA complementary to the five classes of histone mRNA's was synthesized as follows. The 7*S* to 12*S* RNA was isolated from the polyribosomes of S phase HeLa S_3 cells and material containing polyadenylic acid [poly(A)] was removed