OS21K-07 1020h

Heat and Salt Storage Variability In the Indian Ocean from TOPEX/Poseidon between 1993 - 2000

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Estimates of the heat and salt budget computed using TOPEX/Poseidon (T/P) altimetry , Reynolds SST and hydrographic data (World Ocean Atlas; WOA98) are used to study the redistribution of heat and salt storage of the Indian Ocean. The accuracy of derived temperature and salinity is evaluated using hydrographic data collected on WOCE Transindian Ocean Section I1 hydrographic data. Significant seasonal and interannual variability is found in the Indian Ocean Sector. Except the seasonal change in solar radiation and the rainfall, the major ocean processes that affect the heat and salt storage redistribution include monsoon-related upwelling and Ekman pumping, seasonal change of ocean circulation, propagation of Rossby wave and Kelvin wave. Significant interannual heat storage variability could be found during this period (1993 - 2000). EOF analysis shows that the first four EOFs explain nearly 60 % of the total variance of the heat storage variability with the interannual mode to be the first dominant mode. The salt storage variability is not consistent with the heat storage variability, the dominant mode explains 1/3 of the total variance of the salt storage variability in the Indian Ocean. This mode is attributed to the seasonal climate change between hemispheres. The heat and salt storage during the 1997 - 1998 Dipole years are also studied. The significant heat storage change could well explain the dominant heat storage interannual mode. The heat storage anomaly from the regular year during 1997 - 1998 is in the same order of the annual variability of the heat storage variability while the salt storage anomaly is much less than the annual variability of the salt storage.

OS21K-08 1035h

Impact of Intraseasonal Atmospheric Forcing on Eastward Surface Jets in the Equatorial Indian Ocean

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Nonlinear and linear versions of an intermediate ocean model are used to investigate the impact of intraseasonal atmospheric forcing (20–90 day periods) on the eastward surface jets that develop along the Indian Ocean equator during the spring and fall, the Wyrtki jets (WJs). Both the spring and fall WJs exhibit a strong intraseasonal variability, with a perturbation amplitude of 40–60 cm/s during JASMINE period. The intraseasonal fluctuation of WJs is driven primarily by intraseasonal zonal winds, which has a basin scale and possesses a significant seasonality. The intraseasonal winds can cause a lower frequency currents that rectify the WJs strength due to the asymmetric property of the positive and negative phases of the intraseasonal forcing and to the nonlinear response of the ocean to the winds. Strength of the WJs can vary by 10–40 cm/s (10–40 percent of the climatological WJs amplitude) because of the intraseasonal winds, and therefore the basewide heat and salt transport associated with the WJs can be considerably affected. The rectified WJs by the intraseasonal winds may generate variabilities in zonal SST gradients at the equator and therefore potentially influence the air-sea interaction at seasonal-interannual time scale.

OS21K-09 1050h

Observations of the Great Whirl

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The summer monsoon winds blow as a steady, southwesterly jet off Somalia and across the Arabian Sea between June and September each year. This "Findlater Jet" drives a complex pattern of ocean currents, which is dominated in the west by an intense, northward boundary flow (the Somali Current) and a quasi-steady, anti-cyclonic eddy called the Great Whirl. Previous understanding of the structure of the Great Whirl is that of a shallow, surface-intensified feature, although observations, particularly deep ones, are scarce. In addition ship drift data and modelling studies have illustrated the Great Whirl as stationary (once developed), with some interannual variability.

Recent observations have changed these ideas dramatically. Direct velocity measurements have revealed strong currents of order 10 cms^{-1} at 3000 m depth in the Great Whirl, and satellite altimetry has shown intense variability on short time scales. The position and shape of the Great Whirl changes over periods less than 10 days and 30-40 day period fluctuations modify its velocity field. We use these observations, plus GCM simulations, and analogy to process models to gain insight into the possible mechanisms governing the variability and penetration of the Great Whirl. For instance, it is proposed that the Great Whirl is an inertial recirculation of the Somali Current, consistent with observations that the Somali Current dies back with the winds, while the Great Whirl lasts well into November, spinning down only as a result of eddy viscosity. In addition we hypothesise that the Great Whirl itself instigates a Rossby wave mode through its internal instabilities, producing the 30-40 day variability in its velocities.

OS21K-10 1105h

The Agulhas Return Flow as Studied from Altimetry, Hydrography and Mooring Data

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A hydrographic study was carried out in the South West Indian Ocean from 6th January to 21st February, 1995 on RRS Discovery as part of the World Ocean Circulation Experiment. This dynamic region is a poorly surveyed part of the world's oceans. The cruise objectives included: the recovery of eight moorings deployed two years earlier between the Agulhas Plateau and Crozet Island; surveying the Agulhas and Subtropical Fronts between 30E and 50E; and surveying the Subantarctic Zone north of the Crozet Plateau between 30E and 50E. Some sections of the survey track, in particular across the Agulhas Return Current near 45E, were run along TOPEX/POSEIDON altimeter tracks. We examine ocean variability of this region as observed by the altimeter in relation to the hydrographic data collected during the cruise and the long time series mooring data collected during the cruise. We also present an analysis of the combination of remotely sensed data and hydrography as it relates to the dynamics of the ocean fronts in the region.

OS21K-11 1120h

Large-Scale Forcing of the Agulhas Variability: The Seasonal Cycle

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In this presentation we will examine the kinematics and dynamics of the seasonal cycle in the western Indian Ocean from and eddy-permitting numerical simulation. The analysis of the model results indicates that the transport of the Agulhas Current has a seasonal variation with a maximum at the transition between the austral winter and spring and a minimum between the austral summer and autumn. Regional and basin-scale mass balances indicate that although the mean flow of the Agulhas Current has a substantial contribution from the Indonesian throughflow, there appears to be no dynamical linkage between the seasonal oscillations of these two currents. Instead we found evidence that the seasonal cycle of the western Indian Ocean is the result of the oscillation of barotropic basin modes directly forced by the wind.

OS21K-12 1135h

The Seasonal Variability of the South Indian Ocean in POCM and T/P

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In this study we compare the annual cycle of sea surface heights (SSHs) obtained from an eddy permitting global circulation model (POCM-4C) with observations from TOPEX/POSEIDON mission in the South Indian Ocean and for the period 1993 to 1998. The analysis includes model/data comparisons of wave propagation, EOFs, and harmonics. Model and observations compare well except in a narrow region close to the equator where the amplitude and phase of the model anomalies differ from the observations. The westward propagation of SSHs anomalies appear to be affected by the bottom topography, both in the model and in the observations. The amplitudes of the modeled seasonal component are lower than those observed but their spatial distributions compare well. Our analysis indicate that the main forcing for the annual cycle are the wind stress curl and the discharges associated with the Indonesian Throughflow.

OS21L HC: 317 B Tuesday 0830h

Linking Modern and Past Biogenic Fluxes I

Presiding: **R Francois,** Woods Hole Oceanographic Institution; **R A Jahnke,** Skidaway Institute of Oceanography

OS21L-01 0830h

Global Synthesis of Organic, Inorganic Carbon Particles and Opal Fluxes at the Ocean Interior

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We have identified published results/data from 228 individual sediment traps, most of them samples collected in time-series for about one year or more, deployed at 136 locations in the world ocean as of 2001. We estimated the recycling of Corg, Cinorg and Sibio in deep water below 1.5 km by comparing fluxes measured at different depths, after correction for trapping efficiency using a radiochemical method on key samples. By using this relatively coherent export data set we constructed 2°-grid model of the global ocean particle flux at the interior and to the floor, then we estimated the "total global export" of Corg, Cinorg and opal. Finally, by applying global biogeochemical ratios, we propose a hypothesis regarding the provincialism of the biological pump in the global oceans that explains the functional difference and the efficiency in exporting atmospheric CO2-carbon to the oceanic interior. Such oceans functional provincialism at present involves applications to paleoproxy in understanding global change in time and space.

OS21L-02 0845h INVITED

Comparing Productivity Maps from Inverse Modeling with Satellite Based Estimates: Examples from the Southern Ocean and North Atlantic

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The oceanic distributions of oxygen, dissolved nutrients and carbon are strongly affected by the production of particulate matter and its subsequent remineralization during sinking or after deposition on the sea-floor. Dissolved nutrient data thus provide valuable information for the determination of the underlying biogeochemical rate constants using inverse modeling. Here, a global ocean circulation model is presented that exploits the existing large sets of hydrographic, oxygen, nutrient and carbon data and determines rates of export production and vertical particle fluxes compatible with the concentration data. The model is fitted to hydrographic, oxygen, nutrient and tracer data by systematically varying circulation, air-sea fluxes, production and remineralization rates simultaneously. The adjoint method is applied as an efficient tool for the iterative optimization procedure and is able to produce simulated fields that are in very good agreement with observations.

Comparison of the export production in the model with satellite based productivity estimates show a relatively good agreement over most of the ocean. However, two regions - the Southern Ocean and the North Atlantic - stand out and show large discrepancies independent of the particular satellite productivity algorithm or model solution used. In the Southern Ocean (<50°S) the model fluxes are systematically higher than the satellite based values by factors between 2 and 4. Evidence from sediment trap data also suggests that satellite productivity estimates might be too low in this region. Possible explanations are frequent subsurface chlorophyll maxima undetectable by satellites and a generally poor calibration database in this area. In the North Atlantic between 40 and 55°N satellite maps show high productivity rates, however, the model export fluxes amount to only about one quarter of what would be expected from the satellite values. This is in line with benthic studies in this region, which show relatively small carbon fluxes to the sea floor.

OS21L-03 0900h INVITED

Temporal Variability of Upper Ocean Biology in the Northeast Atlantic and the Link to Deep Water Particle Flux.

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Fifty years of data from the continuous plankton recorder survey (CPR) have been used to examine surface water plankton communities in the region of the JGOFS North Atlantic Bloom Experiment (NABE). There is considerable interannual variability in the abundances of several groups and an indication of a long term decrease since 1950. Since 1989 downward particle flux has been measured at this site at several depths below 1000m using time series sediment traps. These flux data also demonstrate significant interannual variation both in the magnitude of the annual flux and in the timing of maxima. Surface water phytoplankton data were obtained from ships during NABE, from satellite colour sensors and of a more qualitative nature from the 50 year CPR data set. Climatic variability was estimated using the North Atlantic Oscillation index. The relationship between these various data sets is explored and compared to output from a biogeochemical model driven by meteorology. This improves our understanding of the various factors that control downward particle flux and in particular the efficiency with which material is lost from the upper ocean.

OS21L-04 0915h INVITED

Decoupling Surface Production from Deep Remineralization and Benthic Deposition: The Role of Mineral Ballasts

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Global models of the oceanic carbon cycle have two moving parts: a production part, which is used to calculate primary (organic matter) production in the ocean's mixed layer as a function of light and nutrient availability, and an export-and-remineralization part, which is used to partition primary production into that which is remineralized (returned to inorganic form) within the mixed layer, and that which is exported to the deep ocean. A vast amount of effort has been expended on describing production, in the belief that production has the greatest influence on the ability of the ocean to take up and store carbon. Recent analyses suggest, however, that fluxes of particulate organic carbon at deep stations are linked mechanistically to fluxes of silicate and carbonate mineral ballasts, and that organic matter production at the ocean surface may be a much weaker predictor of carbon transport to the deep ocean than had previously been thought. It is rapidly becoming recognized that an accurate, mechanistic description of the coupling between surface production and export to the deep ocean is of paramount importance. Here we review evidence for the fundamental disconnect between the concept of ballast-mediated oceanic carbon sequestration and the production-centered view that still prevails in the oceanographic community. We argue that a more balanced, deeper view of the oceanic carbon cycle is long overdue.

OS21L-05 0930h

Non-steady state diagenesis in Argentine Basin sediments: Reconstruction of sedimentary events by modeling pore water and solid phase geochemical data

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Non-steady state sedimentary conditions may lead to characteristic geochemical imprints in the pore water and the solid phase of marine sediments. In this regard, the correct interpretation of the sedimentary record is crucial for the reconstruction of past environmental conditions and of the timing of sedimentary events.

In the Argentine Basin massive downslope transport of material by slides and turbidity currents from the continental shelf leads to very high sedimentation rates on the slope and in the basin. Thus, intense mineralisation of organic material occurs at the sediment-water interface and within the deeper sediment layers. This is typical for the whole continental slope and is de-coupled from any water depth relation. A specific region is the Rio de Plata mouth where sulfate reduction by methane oxidation is most intense at mid-slope depths decreasing up- and downslope. Generally, pore water profiles obtained from all sediments in this region reflect transient conditions which means a readjustment of newly created pore water gradients via diffusion triggered by strong differences in the redox potential between older and younger deposits. The overall results are: (1) The characterization of a variety of sulfate pore water profiles revealed their control by the upward movement of dissolved methane and/or by the occurrence of sedimentary events. (2) Combining geochemical data from pore water and solid phase analysis with hydro-acoustic and physical properties data it is possible to estimate the time-scales of sedimentary events by using a numerical transport and reaction model. (3) Due to the massive accumulation of organic rich sediments, there is a significant quantitative importance of anaerobic methane oxidation as a sink for sulfate in this region.

OS21L-06 0945h

Linking Oceanic Carbon Cycling, Climate and Sediment Records: The Need for a Consistent Measure

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Developing a quantitative understanding of the large-scale vertical cycling of carbon in the ocean is critical to assessing the impacts and feedbacks between anthropogenic and natural variations in the exchange rates of carbon among its important reservoirs and for relating paleoceanographic proxies contained in sediment records to ocean conditions and processes. Numerous studies have attempted to relate rates of primary biological production, new production and export production estimated across relatively shallow depth horizons to large-scale vertical carbon fluxes and burial. Unfortunately, direct correlations between these parameters and deep fluxes are poor at best. Here, simple models are described that demonstrate how surface water biological community composition and maximum mixed layer depth (MMLD) decouple deep fluxes from surface production. Variations in the efficiency with which the surface grazer and heterotrophic communities intercept and recycle primary production is observed to yield sustainable changes in the rate of regenerated and, hence, primary production but only temporary changes in vertical flux. Similarly, these calculations reveal that export to the deep water column is sensitive to variations in the MMLD. The deeper the MMLD, the smaller the export relative to primary production. These observations provide an explanation as to why deep water and benthic studies conclude that equatorial and low and mid-latitude margin environments dominate organic matter fluxes to the deep ocean while fluxes based on satellite-derived surface productivity and ecosystem models are dominated by high latitude regions. Future studies of large-scale carbon biogeochemistry and paleo-reconstructions must focus on evaluating fluxes across the MMLD or permanent thermocline as fluxes across shallower horizons are ambiguous.

OS21L-07 1020h

Improving Biogenic Silica as a Paleoproductivity Proxy: A Global Study of Si and C Decoupling in the World Ocean

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Biogenic silica (opal) has a high potential as a paleoproductivity proxy. The deciphering of this sedimentary record, however, is complicated by spatial and temporal variations in opal preservation and by the decoupling between Si and C biogeochemical cycles. Building on recent studies devoted to improving our understanding of spatial variations in opal preservation, the present study will focus on Si/C decoupling. Within the EU-SINOPS project, data sets of Si and C production, water column fluxes and accumulation in underlying sediments have been gathered for the Atlantic, Indian and Pacific sectors of the Antarctic Circumpolar Current, as well as for the north Atlantic, the equatorial Pacific and the north Pacific. 9 regional budgets of Si and C fluxes have been built, for 5 sites located inside the Southern Ocean and for 4 sites located outside. Within each reservoir, the highest Si:C flux ratios are found in the Southern Ocean. The mean values calculated for the 5 sites inside the Southern Ocean are 6-times higher than outside, in surface waters as in deep waters and in the sediments. Only during export, is this difference reduced because of higher Corg export efficiency in the Southern Ocean. Regional differences in Si:C production ratios encompass one order of magnitude and can be explained by silicic acid availability in the intermediate waters of the various basins considered. These differences are transported quasi-unchanged down to the sediment. At all sites, the strongest downward increases in the Si:C flux ratio are found between production and export (factor 6), and between the rain and the accumulation (factor 4). It is suggested that trophic food webs in these two zones play a major role in the relative enrichment of the biogenic particles with Si. During the transfer through the deep waters, the Si:C flux ratio increases only slightly (factor 1.3). A unique equation has been formulated, of wide applicability, which allows a good prediction of the fate of the Si:C flux ratio at each depth once the Si:C production ratio is known, and vice-versa. It is tested on the basis of a data set of sediment trap fluxes collected at ca. 90 sites, to reconstruct surface Si:C ratios and compare those with (1) known characteristics of surface waters and (2) outputs of the Hamburg HAMOCC model. That both horizontal and vertical decoupling between Si and C can be understood and even predicted represents an important step for the calibration of biogenic opal accumulation rates as a paleoproductivity proxy.

OS21L-08 1035h

Natural Variations in Silicon Isotope Abundances as Indicators of Silica Production in the Southern Ocean

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Diatoms are the only primary producers that utilize silicon and function as key exporters of organic matter and silica to the deep ocean. Recent studies showed that the open ocean around Antarctica accounts for a much higher fraction (10-15%) of global silica production than previously estimated. These high production rates give rise to the opal-rich band of sediments that circle the Antarctic continent south of the Polar Front. The marine silicon cycle needs to be studied in greater detail throughout the world oceans. Natural variations in the abundance of silicon isotopes provide a tool to carry out such widespread studies.

Application of silicon isotopes as tracers for temporal and spatial variations in silica production requires an understanding of the mechanisms underlying variations of silicon isotope abundances in seawater silicic acid and diatom opal. Changes in the silicon isotopic composition of opal in sediment cores can then be better interpreted and combined with other proxies for reconstructing past biogeochemical conditions.

We measured the silicon isotopic composition of silicic acid in surface waters on samples collected along 170°W in the vicinity of the Antarctic Polar Front during four cruises (October 1997 to March 1998) as part of the US JGOFS AESOPS program. δ^{30}Si values decreased southward from +2.9 to +1.8$^{o}/_{oo}$ along the strong meridional gradient in dissolved silicon. δ^{30}Si values were inversely correlated with silicic acid concentration and imply an enrichment factor, ϵ, of -0.8$^{o}/_{oo}$ similar to the value of -1.1$^{o}/_{oo}$ obtained for cultured diatoms. These are the first data that document changes in the δ^{30}Si value of silicic acid as it is consumed by diatom growth in a natural system; thus they provide direct evidence that silicon isotope fractionation in the sea conforms to a simple Rayleigh model.

δ^{30}Si of particulate silica from a sediment trap located in the Polar Front at 1031 m depth from November 1996 to January 1998 increased sharply from +0.6 to +1.5$^{o}/_{oo}$ during the course of a diatom bloom, after which the δ^{30}Si signal dropped to pre-bloom conditions. The increase in the δ^{30}Si values of particulate silica in the trap paralleled that of silicic acid in surface waters with an offset of approximately -1.1$^{o}/_{oo}$.

The results support the use of natural variations in silicon isotope abundances in surface waters as a proxy for dissolved silicon utilization and support the use of the δ^{30}Si of diatom opal recovered from sediments to reconstruct the history of relative silicic acid use in surface waters.

OS21L-09 1050h

Ge:Si Fractionation in Continental Margin Sediments: Balancing the Ge Budget

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While the modern oceanic silica budget is reasonably well-constrained, the sink term for the germanium budget is poorly defined. This lack of fundamental geochemical information limits our ability to interpret glacial-interglacial Ge:Si variations observed in biogenic opal. While opal burial is certainly one important sink for Ge, budget calcuations suggest that there is at least one additional significant sink. Recently our group showed that at several stations along the California continental margin, germanium is fractionated from silica in iron-rich sediments, with germanium being sequestered in an unidentified sediment phase (GCA, 2000, 64 : 2453 - 2465). We present here sediment porewater data from the Peru-Chile continental margin and additional in situ benthic incubation and sediment core incubation data from the California continental margin. These additional results show that the magnitude of this diagenetic fractionation is 50% in reducing, iron-rich margin sediments. At abyssal depths, the Ge:Si benthic regeneration ratio is consistent with no fractionation from the ratio in opal. Calculations indicate that fractionation in the depth range 0.1-1 km is sufficient to balance the Ge budget. We conclude that sequestering of Ge in iron-rich continental margin sediments is the"missing" Ge sink. Temporal variation in the strength of this sink could be sufficient to drive fluctuations in the glacial-interglacial Ge:Si oceanic ratio.

OS21L-10 1105h

The Effect of Ocean Temperature on the Ge/Si Ratio of Seawater

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Although the water column cycling of inorganic Ge and Si in sea water are remarkably similar, the ratio of Ge/Si in opal has varied through time in concert with changes in global climate. Results published by Froelich, Mortlock, Shemesh, and their colleagues have demonstrated that ratios have ranged from the present value of 0.7 RU (1 RU = 10e-6 atoms Ge/atom Si), to 0.5 RU during the last glacial maximum, to approximately 0.9 RU during the mid-Miocene. Weathering (approximately 0.5 RU) and hydrothermal (approximately 11 RU) sources provide the two largest inputs of these elements, and the temporal variation of the ratio in opal has often been interpreted to reflect variations in their relative importance. The recent discovery and quantification of a substantial sink for Ge in anoxic, iron-rich sediments provides an alternative explanation for the temporal variation of seawater Ge/Si. The importance of this newly discovered Ge sink depends on the rate at which opal reaches the sea floor in margin environments.

Water column temperature is a key factor in determining the fraction of opal produced that reaches the sea floor. Based on the temperature dependence of water column opal dissolution determined in situ by Erez et al. (EPSL 59,1982), a decrease of 3°C in surface water in the CA margin should increase the opal rain at 1 km by 1.4-2.0 times; an increase in T of 2°C should decrease it by 0.4-0.7 times. These temperature changes are published estimates of changes during the last glacial maximum and the mid-Miocene, respectively, and the calculated changes in opal reaching the sea floor at 1 km are sufficient to account for the temporal variation in oceanic Ge/Si. The range in the calculated flux reflects different scenarios for the water column temperature structure. Other important factors, such as weathering rates, dust dissolution, opal production, changes in the methylgermanium cycle, or the areal extent of iron-rich anoxic sediments could also vary, but it appears that their effects might be secondary. One implication of these results is that the effective depth of opal regeneration in the ocean varies in response to climate. Whether this might influence the rate or oceanic distribution of diatom production is unknown at present.

OS21L-11 1120h

New Insights Into the Mechanism of Barite Formation in Seawater and Implications for Paleoproductivity Reconstruction

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Ba accumulation in marine sediments has often been used as a proxy for past changes in ocean productivity, but a better understanding of the mechanism of barite formation in seawater is necessary to develop the approach as a quantitative method.

To this end, we have conducted time-series decay experiments of cultured and coastal plankton. Barite crystals, monitored by SEM, were produced during each experiment. Chemical leaching was applied to the coastal plankton before and after decay. The results show that plankton accumulates a relatively large pool of labile Ba, which is rapidly released during decomposition and acts as the main source of Ba for barite formation in supersaturated microenvironments. This contrasts with earlier suggestions that barite saturation in microenvironments might be achieved by increasing sulfate concentration. Since mass balance indicates that only a small fraction (2 to 4 percent) of the labile-Ba pool is converted to barite, the availability of microenvironments that could locally concentrate Ba released by plankton decay seems to be the main controlling factor for barite precipitation. This may explain the higher barite yield that is typically observed in the field, and the seasonal and geographic changes that have been observed in the Ba/Corg ratio of settling particles collected with sediment traps.

Since Ba uptake by phytoplankton seems to be the initial step for barite formation, these results are encouraging for realizing the potential of the approach, but they also caution against a simplistic interpretation of the Ba sedimentary record. Barite formation yield can vary between 3 percent in high productivity margin areas to 30 percent in open ocean sites. Using Ba as a quantitative paleoproductivity tool will thus require that we understand the factors controlling this yield and that we quantify the processes involved.

OS21L-12 1135h

Barium Benthic Fluxes Over a Range of Oceanic Environments: Testing the Utility of Barium as a Paleoproxy

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Observed biological associations of Ba in seawater plus correlations between fluxes of sedimentary barite and bio-Ba with organic carbon and/or opal fluxes in sediment traps and sediments have been used and tested by paleoceanographers as algorithm-driven paleoproductivity proxies. The details of this mechanism and its links to productivity, diatom shells and the sinking flux of organic carbon have not been firmly established. A second Ba-paleoproxy employs the current oceanic relationship between Ba and alkalinity to interpret Ba/Ca ratios in benthic foraminifera as a paleo-alkalinity proxy. However, the Ba:Alk relationship is not mechanistic but rather depends upon spatial coherence of parallel carriers and over-printing by thermohaline circulation. This leads to questions of whether the current Ba:Alk relationship in seawater is constant. Studies employing benthic landers to compare Ba and Alkalinity fluxes from sediments are one way to solve some of these problems. To this end, Ba-fluxes from benthic lander chamber samples have been determined for a wide variety of global environments. These fluxes have then been compared to the regeneration fluxes of bioactive constituents (carbon, alkalinity, silica), and to bottom water and sediment redox state to deconvolve the multivariate relationships with benthic Ba-fluxes. Our preliminary data extends the Ba-flux range several fold over previous data sets, and covers sites with high and low alkalinity fluxes, above and below the lysocline, high and low carbon- and opal-rain, and greatly differing bottom water oxygen concentrations. From this data, a Ba:Alk relationship from benthic fluxes of approximately 1:4500 is observed, significantly different from the ratio of 1:1500 observed from modern deep waters. This suggests the possibility that the paleo-Ba:Alk relationship in seawater may have differed from that observed today. Additionally, there are strong correlations between the Ba benthic flux and both the silica and TCO2 fluxes, as well as with depth.

OS21M HC: 315 Tuesday 0830h

Oceanic Time-Series Measurements: Assessment of the Past and Planning for the Future II

Presiding: **M W Lomas,** Bermuda Biological Station for Research, Inc.,**; N R Bates,** Bermuda Biological Station for Research, Inc.,**; J Dore,** University of Hawaii

OS21M-01 0830h INVITED

Time Versus Space: the Problems of Scale

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