# Ocean Sciences

## OS11A MCC: 3000 Monday 0800h

### Geological and Biogeochemical Processes in a Wet Tropical Setting: New Guinea, Source to Sink I *(joint with B, H)*

***Presiding:*** **R C Aller,** State University of New York at Stony Brook**; C A Nittrouer,** University of Washington

### OS11A-01 0800h

#### Holocene Evolution of the Middle Fly River, Papua New Guinea

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The Fly River headwaters descend steeply from high tropical mountains in Papua New Guinea (PNG) and enters a lowland platform of very low relief: 800 km from the sea, the floodplain is only 18 m above sea level. From this point, river sediment is muddy sand. At Everill Junction, 400 km downstream, the Fly is joined by the Strickland River, which has a larger discharge ( 3100 vs 2250 m3s-1) and larger sediment load ( 6x107 vs 8x106 t yr-1). The river continues across the lowlands for a further 300 km and enters the Gulf of Papua through a large tide-dominated delta. The Fly floodplain comprises a tract of highstand sediments (HST) deposited during the last 7000 years of relatively stationary sea level, which overlies a transgressive tract (TST) deposited during the Post-glacial sea level rise (PSR). Radiocarbon-dated boreholes show TST sedimentation rates were 5-15 times greater than HST rates, reflecting a change in the fluvial system from trapping to bypassing, driven by changing accommodation and sea level (a change of sediment input is unlikely: despite lower Pleistocene treelines, Pleistocene yields from PNG highland catchments apparently remained fairly constant). The delta apex arguably migrated up the paleo-valley early in TST deposition; towards the PSR culmination about 7000 yrs BP it may have been only 60 km below Everill Junction. Downstream of the junction, Strickland River sediment drove fluvio-deltaic development during the TST and HST, but for a distance of about 80 km above the junction, TST sedimentation only just kept pace with rising base level, and shallow off-river water bodies probably were more extensive than today. However, the system remained fluvially continuous, and the landward limit of sea-level influence at the PSR culmination lay close to the upstream limit of today's floodplain. The skeleton of today's Fly was established at the PSR culmination, including meander-dominated reaches in the middle and upper floodplain. Three factors interacted in development of the HST: progradation of the delta, ponding in the Fly above Everill Junction induced by Strickland-driven sedimentation, and isostatic warping driven by post-glacial rising seas. The first two factors induce HST aggradation whereas isostatic warping gently steepens the basement gradient, relative to a 7000 BP horizontal surface, arguably inducing minor incision. Although there is no HST incision, radiocarbon dating shows that net HST aggradation in the middle Fly is relatively slight, especially in floodplain lagoon and oxbows. The HST river reworks itself through meandering, and much of the catchment-derived sediment apparently passes through, or did so before establishment of Ok Tedi mine increased sediment input severalfold. Comparison with Holocene evolution of the Sepik - a river of similar size and sediment input in northern PNG - suggests that rivers of this type more efficiently transmit their load seawards, once coastal progradation effectively ceases.

### OS11A-02 0815h

#### Morphodynamic Modeling of the Co-evolution of Channel and Floodplain in Large, Sand-bed Rivers

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The Strickland River, Papua New Guinea, provides an example of a dynamic large, lowland sand-bed river in which channel and floodplain have co-evolved. We are developing a general model to predict such co-evolution. The key new element of the analyis concerns fine-grained material, which heretofore has been considered as wash load and assumed to play no morphodynamic role. In the model described here sand plays the role of bed material load and mud plays the role of floodplain material load. In the present simple implementation only two grain sizes are used, one for the sand and one for the mud. Three active and one passive sediment reservoirs are considered; a) the active layer of the bed, b) a basal floodplain layer, c) an upper floodplain layer and d) the (passive) substrate below these layers. An enforcement of conservation of sediment mass in each of the active reservoirs makes it possible to model the evolution of bed and floodplain elevation, and the fractions of sand and mud in each reservoir and the water column. Flux of sediment from the channel to the floodplain is modeled in terms of an overbank sediment deposition model. Flux of sediment from the floodplain to the channel is modeled in terms of a net loss associated with channel meander migration. The model offers an explanation of bankfull channel characteristics. That is, when the channel is too shallow, (the floodplain elevation is too low), the river floods frequently, so that overbank deposition overwhelms the loss of sediment associated with channel migration and mean floodplain elevation increases in time. When the channel is too deep, (the floodplain is too high), overbank deposition is so infrequent that it is overwhelmed by floodplain removal due to channel migration, causing mean floodplain elevation to decrease in time. In the absence of bed elevation changes, the channel evolves toward a depth where overbank deposition just equals floodplain erosion due to migration. We present preliminary results of the model. Although it is too early to apply the model directly to the Strickland and Fly Rivers in Papua New Guinea, our ultimate goal is to extend the model to this case, so as to include a) multiple grain sizes, b) channel aggradation/degradation and c) base level rise.

### OS11A-03 0830h INVITED

#### Evidence for Low Sea Level Incision of the Gulf Of Papua Shelf by the Fly River and by Tidal Currents During the Quaternary

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Multibeam sonar and seismic mapping at the northern end of Australia's Great Barrier Reef in the Gulf of Papua, have revealed a shelf valley system up to 220 m deep that extends for more than 80km across the continental shelf. Two valley types are evident. Relict fluvial valleys located in the Gulf of Papua exhibit lateral accretion surfaces in seismic profiles and incised margins that intersect and truncate underlying strata. Over-deepened valleys located adjacent to the northern Great Barrier Reef exhibit closed bathymetric contours and are floored with well-sorted carbonate gravelly sand containing a large relict fraction. The deepest valley segments were probably the sites of lakes during the last ice age, when Torres Strait formed an emergent land-bridge between Australia and Papua New Guinea. Post-glacial transgression of the shelf transformed the relict fluvial valleys into estuaries where terrigenous and marine sediments were deposited, as documented by cores and seismic data. Radiocarbon ages of mangrove peat samples range from 8,597 to 11,733 years BP in water depths of from 35 to 81 m. The southern valleys, however, would have formed estuarine embayments, whose origin owed nothing to fluvial erosion processes, and where minimal terrigenous deposition occurred. Numerical modelling indicates that the strongest tidal currents occur over the deepest, outer shelf segment of the valleys when sea level is about 40-50 m below its present position, suggesting the channels are Pleistocene in age and of relict origin. At such low sea-level times, strong tidal currents at the northern end of the Great Barrier Reef prevents the deposition of sediment derived from Papua New Guinea's rivers that would otherwise bury the coral reefs.

### OS11A-04 0845h

#### Submarine Rivers of Mud and Sand: Channels Dispersing Sediment Across the Fly River Clinoform

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The subaqueous delta of the Fly River has a clinoform structure prograding onto transgressive shelf deposits. The clinoform contains numerous channels, which appear to have ancestral origins. Perhaps they were subaerial stream valleys during lower stands of sea level, but they presently can be buried partially or completely by modern and late Holocene sediment deposits - especially toward shore (i.e., beneath topset deposits). Some of the larger channels extend from the topset across the foreset region, and seem to be linked to distributary channels of the Fly delta. Some extend onto the bottomset and outer shelf. Others can be recognized only in subbottom profiles. The channels can be dramatic features with steep walls rising 50 m, and can contain 20 m or more of infilled sediment. Most extant channels (i.e., still morphological depressions) appear to be active conduits for rapid transport seaward of sediment and carbon. The boundary-layer regions of the water column within channels contain high concentrations of sediment ($>$1 g/l) and the seabed is relatively unconsolidated and accumulating rapidly. Sedimentary structures found in the thalwegs of channels indicate graded deposits resulting from density flows, which may be shelf turbidity currents. The channelized morphology and resulting mechanisms for sediment dispersal differ from other portions of the clinoform structure in the Gulf of Papua. They also differ from modern shelf clinoforms elsewhere in the world, although they probably have ancient analogs (Cretaceous Seaway of North America).

### OS11A-05 0900h

#### Sediment Transport Under Monsoon Conditions on the Fly River Clinoform, Papua New Guinea

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As part of the NSF Margins Source to Sink program, sediment-transport studies on the Fly River clinoform were performed during the monsoon season to establish the transport mechanics during this quiescent season and to explore the occurrence of high density near-bed suspensions thought to contribute to clinoform formation. Profiles of suspended-sediment concentration and water-column properties were collected in conjunction with seabed coring and geochemical studies on the subaqueous delta and to the northeast of the Fly River mouth. In addition, a time-series bottom-boundary layer tripod was deployed for a 7-day interval in 16-m water depth to document near-bed currents, waves and suspended sediment concentrations. Results show that suspended-sediment concentrations on the delta itself were low and increased to the northeast. In all cases suspended-sediment concentrations and surface bed sediment porosities were greatest in depths of less than 10 meters. Although there was minimal wave activity at the time of sampling, concentrations observed near shore reached 1 g/l. Tidal currents measured at the time-series site exceeded 15 cm/s at the approach to spring tide, suggesting that tidal currents may be the mechanism that suspends these relatively high concentrations in the bottom boundary layer and maintains seabed sediment in an unconsolidated state. The data, combined with seabed observations, suggest that there is temporary storage of sediment in shallow water to the northeast of the Fly River mouth during the monsoon season. Subsequent data collection will determine if trade-wind conditions are sufficiently strong to generate wave-supported fluid mud and downslope gravity flows which are hypothesized to transfer sediment to the foreset of the Fly River clinoform and contribute to the high accumulation rates observed there.

### OS11A-06 0915h

## Relationships Between Early Diagenetic Processes, Carbon Remineralization, and Sedimentary Dynamics in the Gulf of Papua Deltaic Complex

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A range of diagenetic environments is found within the central Gulf of Papua clinoform, each characterized by different balances between sedimentary dynamics, net accumulation, physical and biogenic transport processes, and biogeochemical properties. Sediments are generally diagenetically reactive, with $\Sigma CO_2$ production and benthic $O_2$ fluxes typically ranging between 10 - 40 mmol / $m^2$ / d (upper 20 cm). Highest remineralization rates occur within mobile inner topset and channel muds (1-20 m depth) and in the high accumulation rate rollover region of the topset - foreset beds (40-50 m). Lowest rates are found inshore along sandy channels, middle topset, and the deeper foreset (75 m). Topset deposits are typically suboxic, nonsulfidic over the upper ~0.2 - 1 m, due to various combinations of physical reworking and deep bioirrigation. Pore water sulfate can be measureably depleted at depths > 0.3 m, however dissolved sulfide remains below detection (upper ~1-2 m). Sedimentary C / S ratios are ~4 - 6 within the topset regions but decrease to < 3 in offshore foreset beds and inshore mud banks where sulfidic diagenesis dominates. Remineralization patterns are independent of relative abundance of terrestrial or marine sedimentary carbon, both are efficiently remineralized. $C_{org}$ isotopic analyses ($^{13,14}C$) demonstrate that although terrestrial sources can be primary substrates at inshore sites, young marine $C_{org}$ preferentially dominates pore water $\Sigma CO_2$ relative to bulk $C_{org}$ in the upper foreset A small quantity of young, rapidly recycled marine organic material is often superimposed on a generally older, less reactive terrestrial background.

### OS11A-07 0930h INVITED

## Geochemical Budget for Barium on the Wet Tropical Continental Shelf & Slope of the Gulf of Papua, Papua New Guinea.

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Most of the riverine supply rate of Ba to the Gulf of Papua from wet tropical mountains and coastal plains of southern New Guinea is in particulate form. Freshwater dissolved Ba concentrations are low (60 nM), but increase by 4-5 times in the salinity gradient of the upper deltas. This salinity enhanced dissolved Ba may come from suspended and bottom sediment cation exchange, or from groundwater inputs. Ba is also supplied to the water column of the inner shelf from sediment pore water diffusion. The distribution of shelf and slope sedimentary concentrations of Ba is presented, along with estimates of sediment mass accumulation rates from core profiles of excess 210Pb and 137Cs. We estimate that century scale burial of Ba on the inner shelf is less than 25% of total Ba supply from rivers, the remainder being exported to the northern Coral Sea and the New Guinea Coastal Current. Ba removal rates in the northern Coral Sea, as estimated from sediment traps and a few cores, are small but cover a large area. Maximum Ba concentrations in sediment are found in deep (greater than 2000 m) water of the northern Coral Sea, where sediment accumulation rates are very low. Variations in sediment core Ba profiles appears to be due to variations in the ratio of supply rate of river aluminosilicate minerals to marine carbonate supply, and not easily related to a proxy for productivity.

URL: http://www.aims.gov.au/tropics

### OS11A-08 0945h INVITED

## Platinum Group Element Fractionations in Sediments in the Gulf of Papua, New Guinea

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The elemental concentration pattern for the platinum group elements (PGEs), and their periodic table neighbors Au and Re in modern seawater, is highly fractionated relative to their proportions in the upper continental crust, mantle or meteorites. This may be due to a combination of factors, including chemical weathering and estuarine fractionations. As yet little is known about the geochemical behaviors of the PGEs in estuaries. Because of the importance of the wet tropics in contributing solutes and sediments to the oceans, the Gulf of Papua is a good location to investigate PGE fractionations. The Fly River is one of the largest rivers draining into the Gulf of Papua and is and among the world's top rivers in terms of discharge and sediment yield. By analyzing both the source (river sediment) and sinks, we can begin to understand both the on-land and estuarine fractionations that take place in this system. We have measured the concentrations of Pt, Pd, Ir and Os in surface sediments from the Gulf of Papua, New Guinea and compare these to the concentrations and concentration ratios of Os/Ir and Pt/Pd in Fly River sediment. The Os/Ir of sediment from the upper Fly River is ~4. This value is elevated in comparison to the crust, mantle and meteorites, all of which have Os/Ir of about 1. By contrast, the Os/Ir ratio of seawater is approximately 110. Sediments in the Fly River Delta and Gulf of Papua have Os/Ir ratios that are all lower than the upper Fly River, and may indicate that Ir is preferentially scavenged in the oxic sediments that are typical of the Gulf of Papua. Although a correlation between organic carbon and Os burial was previously indicated, the Ir concentrations do not appear to be correlated with the organic carbon. In the central Gulf, farther from the influence of the Fly river and nearer to the Purari and Kikori Rivers, both of which may have a larger ultramafic component in their catchments, the Os/Ir ratio in the sediments approaches the mantle value of 1, indicating a predominance of a detrital source in those sediments. The other sediments in the Gulf of Papua are interpreted to have been affected by variable amounts of oxic scavenging. Preferential removal of Ir in the estuarine environment can help to explain the extremely elevated Os/Ir of seawater. Although the variations are more subtle for Pt/Pd, there is evidence of preferential removal of Pd relative to Pt in the estuarine and marginal marine sediments. The relatively high Pt/Pd in seawater (~3) compared to the crust (~ 1.8) can be explained by oxic scavenging of Pd in sediments such as those in the Gulf of Papua.

# OS11B MCC: 3000 Monday 1020h

## The Arctic and North Atlantic Oscillations: Past, Present, and Future I *(joint with A, H, PP, C)*

***Presiding:*** **D A Darby,** Old Dominion University**; L Mysak,** McGill University

### OS11B-01 1025h

## Variability in Summer Arctic Temperature and Arctic Oscillation Over the Past 600 Years

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Spatial arrays of high-resolution (annual-decadal) paleoclimate records from throughout the Arctic were used to distinguish different modes of variability and trace their behavior back in time. A previous compilation of primarily annual-resolution records provided a view of average Arctic summer temperature during the past 400 years, documenting dramatic 20th-century warming that ended the Little Ice Age in the Arctic and caused dramatic retreats of glaciers, melting of permafrost and sea-ice, and alteration of terrestrial ecosystems. Some evidence suggests that these recent changes may be linked to an increasing positive phase of the Arctic Oscillation (AO), and that this trend in the AO itself may theoretically be due to greenhouse warming. Multi-century records of temperature and AO behavior are needed to identify natural background variability and evaluate potential linkages. A new international collaboration has created a spatial array of high-resolution Arctic paleotemperature records for the past 600 years. Annually resolved archives were used wherever possible (e.g., tree rings, varved lake sediments, and annual ice layers), but sub-decadal resolution records from ice cores and high deposition-rate lake and marine sediments were included as well. Empirical Orthogonal Function (EOF) analysis was used to characterize the spatial and temporal modes of variability contained in the proxy array. The three leading modes of proxy variability all have highly significant correlations to the three leading modes identified in NCEP-NCAR reanalysis data, and are associated with dynamically significant processes, including: 1) a circum-Arctic average temperature trend with rapid 20th-century warming; 2) the Arctic Oscillation; and 3) a Urals Trough wave number three circulation pattern. Our analyses demonstrate the ability to identify the major modern observed modes of Arctic SAT variability within an array of proxy data, and reconstruct these modes back in time. These results provide insight into the long-term natural background variability of the AO and its relation to average Arctic temperature, and place their recent positve co-variation into a pre-anthropogenic context.

URL: http://www.ncdc.noaa.gov/paleo/parcs/hi_res_whoi.html

### OS11B-02 1040h

## A Holocene Record of Changing Arctic Surface Ice Drift, Analogous to the Effects of the Arctic Oscillation

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The Arctic Oscillation (AO) controls the strength and location of the Trans Polar Drift (TPD), a system that exports ice through Fram Strait into the Nordic Seas. There, changing amounts of sea ice influence surface water salinity and the formation of North Atlantic deep water (NADW), and this, in turn has an impact on the global climate. Therefore, in order to understand how the global climate system functions it is imperative to know how the TPD changed over the last millennium or more. To that end we performed a provenance study on ice rafted sand grains in a sediment core located near the confluence of the counterclockwise TPD and the clockwise Beaufort Gyre. The core has more than 200 cm of Holocene sediment with intervals dominated by grains from the Siberian shelves alternating with intervals of abundant grains from North American sources. Grains matched to Siberian shelves indicate that the TPD was shifted toward North America similar to what occurs during a more positive phase of the AO. This scenario alternated with intervals where few grains matched to Russian sources. During the last 1300 years increased influx of Russian grains occurred approximately every 50-150 years. We suggest that this periodicity represents the long-term fluctuation of the AO, which produces the same TPD shift today. In addition, we found evidence for ice drift changes corresponding to the Medieval Warm interval from 900-1200 AD and at the end of the last deglaciation when glacial iceberg rafting rapidly declined. These more recent changes prior to the Little Ice Age were opposite in sense to the mineralogic changes at the last termination, and might indicate changes leading to the onset of the Little Ice Age.

### OS11B-03 1055h INVITED

## AO/NAO Patterns in the North Atlantic - Arctic Ocean?

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