

EUG XI



Symposium RCM5

Sediment Supply, Transport and Deposition:
The Link from Land to Ocean Margin

Convenor

Maria Mutti

RCM5 Sediment Supply, Transport and Deposition

Sunday PM Session

RCM5 : SUPm25 : F3 Unravelling the Significance of Sand Compositional Changes across Boundary Surfaces of Stratigraphic Units

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Tectonics, eustasy and climate do not only govern stratal patterns and the stratigraphic signature of the sedimentary record but also exert a major control on the qualitative and quantitative compositional changes of sediment supply. The primary factors for compositional changes include: tectonic exhumation, type and areal distribution of source rocks, bathymetric profile of shelves, presence of multi-sourced systems, neovolcanic input, chemical weathering and vegetation cover, new generation of chemical and biochemical grains, shelf colonisation by organisms, hinterland physiography, base-level variations and changes in accommodation, unroofing of different lithological units, changes in types of transport processes and sediment dispersal pattern, rate of sediment supply. Sensitivity of depositional systems to most of these factors is greatest in the coastal area, where compositional variations due to relative sea-level changes are amplified. Although the relationships between factors controlling compositional changes within a stratigraphic unit can be very complex, properly conceived petrography, suitable to frame information given by compositional changes both in space and through time, can offer a useful approach, which help in monitoring land-ocean linkages and their evolution through time. To hit this target grain types need to be classified by taking into consideration three basic attributes: composition (carbonate versus non carbonate grains), spatial relationships (intra-basinal versus extra-basinal grains), and time relationships (grains coeval or non coeval with respect to the considered unit). On the basis of case studies from Eocene to Quaternary deposits of the Apennines, Pyrenees and the subsurface of the Po Plain, the relationships between sand compositional changes in the stratigraphic record and a hierarchy of depositional cycles can be envisaged. Particularly, sand compositional changes at the scale of third-order cycles are likely to be controlled primarily by basin reorganization due to tectonic activity. In contrast, variations in sand composition at the key surfaces of fourth- and fifth-order cycles can generally be explained by sea-level changes under a predominantly glacio-eustatic control. In tectonically-controlled depositional settings unconformity-bounded sequences generally are fingerprinted with peculiar detrital composition, with petrological discordances marking roughly across the basal unconformities. However, alternative possibilities have been tested, including i) lack of compositional changes across sequence boundaries, ii) different compositional changes across the sequence boundary at different sites of the sequence, and iii) similar compositional changes at different sequence boundaries. In eustasy/climate-dominated settings, especially within coastal and deltaic depositional systems, distinctive compositional changes generally occur close to the boundaries between systems tracts (especially the sequence boundary and the transgressive surface) suggesting an overall allocyclic control on sedimentation. Autocyclic processes become increasingly important in continental systems and during sea-level highstands, resulting in major compositional changes that may not be detected by conventional stratigraphic approach.

RCM5 : SUPm26 : F3 Quantifying Timescales of Sediment Recycling at the Continental Margin

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Laserprobe Ar/Ar geochronology applied to detrital white micas from offshore sediments can play a key role in unravelling the timescales involved in sedimentary processes at the continental margin. Detrital white mica age data from a restricted region of the Norwegian Sea span 55 Ma, from sandstones with deposition ages spanning 150 Ma in age. The supply of detritus of such a restricted age over such a long period of time has not been commonly recognised since most continental margin studies have focussed on the provenance of sandstones.

In the case of these Norwegian Sea data, either the hinterland shed detritus for 150 Ma during uplift that was sufficiently slow not to be fully reflected by the Ar/Ar isotopic system in white micas, or uplift occurred for 55 Ma and sediment transportation to the basin was protracted. The relationship between sediment age and detrital white mica ages in each individual sample from the Norwegian Sea reveals that a two-stage erosion-deposition cycle is responsible for sedimentation, and it is likely that detritus is eroded and transported from the hinterland to a basin, which is in turn inverted, causing sediment to re-deposit in its current location. The total transportation times required for this range from 150 Ma (for Cretaceous samples) to 300 Ma (for Triassic samples), calculated on the basis of detrital age minus sediment age. Detrital white mica ages reflect the time at which they were at approximately 10 km depth in the crust and given the uplift rates in the Norwegian Caledonides in the Devonian it can be assumed that they will take approximately 10 Ma to reach the erosion surface. The molasse basin receiving the detritus is likely to have been the Vestfjord Basin/Nordland Ridge, which was a subsiding basin between the Devonian and Permian and began uplifting as a horst block during the Permo/Triassic. Previous estimates of transport times of proximal molasse deposits range between 0 and 10 My (e.g. Copeland and Harrison, 1990; Kelley and Bluck, 1992; Turner et al., 1996), if we allow for 10 Ma for the Caledonian detritus to arrive at the erosion surface and a further 1 Ma to deposit in the molasse basin, there are still 139 Ma (Cretaceous samples) and 289 Ma (Triassic samples) unaccounted for. We conclude that the detritus resided in the Devonian molasse basin for up to 138 Ma (Cretaceous samples) to 288 Ma (Triassic samples) prior to the uplift of the Nordland Ridge region.

Ar/Ar applied to detrital white micas has the potential for providing time information and identifying sediment recycling in sedimentary systems, which is not possible using heavy mineral analysis and zircon-based studies due to the almost infinite capabilities of such mineral species to undergo recycling.

Copeland P & Harrison TM, *Geology*, **18**, 354-357, (1990).
Kelley SP & Bluck BJ, *Chemical Geology*, **101**, 143-156, (1992).
Turner SP, Kelley SP, Vandenberg AHM, Foden JD, Sandiford M & Flottmann T, *Geology*, **24**, 941-944, (1996).

RCM5 : SUPm27 : F3 3.6 Ga Zircon Deposited in a Near-Shore to Upper-Slope Environment in the Svecofennian Västervik Basin

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The Västervik area in south-eastern Sweden consists of well-preserved Proterozoic metasedimentary rocks, earlier interpreted as deposited in a delta. Previous reconnaissance studies of Svecofennian metasedimentary rocks from Finland and Sweden indicate that they contain detrital zircons with ages that are poorly represented in the presently exposed crust. The previously reported dominating age fraction is Proterozoic, with ages of 1.9-2.1 Ga. An Archaean component also occurs, with ages of typically 2.6-2.9 Ga, up to 3.3 Ga. No source rock of that age has yet been identified.

In this study we combine sedimentological analyses and U-Pb zircon datings in order to determine provenance area and depositional history of the Västervik basin. The sedimentological fieldwork includes lateral mapping, measurements of vertical sections and measurements of paleocurrent directions. U-Pb zircon datings were performed at the NORDSIM ion microprobe at the Swedish Museum of Natural History. Preliminary results suggest deposition in a near-shore to upper slope environment, with fluvial, tidal flat, tidal dominated shallow marine and turbidite deposits. At times the sea-level appears to have been close to the shelf edge, since successions of turbidites and fluvial deposits are interbedded. The U-Pb data display ages of 1.87-2.15 Ga and 2.65-3.0 Ga, but one zircon is as old as 3.6 Ga. The first two ages correspond well with

earlier results, but 3.6 Ga is substantially older than what has previously been found in the area. No Archaean rocks in the Baltic Shield are known to be that old. The 3.6 Ga crystal may be derived from Archaean crust that has later been removed by e.g. rifting or strike-slip movement, or metamorphosed beyond recognition. Alternatively it may have undergone long transport and repeated redeposition. Archaean crust with ages as old as 3.6 Ga is known from the Ukrainian Shield.

RCM5 : SUPm28 : F3 Indus Fan and River Initiation Following Latest Paleocene India-Asia Collision and Uplift of Southern Tibet

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The Indus River is one of the largest rivers on the Asian continent. Unlike the Ganges-Brahmaputra system, the drainage basin of the Indus is dominated by the western Tibetan Plateau, Karakoram and the tectonic units of the Indus Suture Zone, rather than the High Himalaya. The modern Indus cuts Paleogene fluvial sedimentary rocks of the Indus Molasse Group located along the Indus Suture Zone in Ladakh, northern India. It appears that the Indus has remained stationary as these earlier deposits were deformed by northward folding and thrusting associated to the Zaskar backthrust at ~20 Ma. Following India-Asia collision paleo-current data from the Indus Molasse Group suggest a reversal of flow in the old Eurasian forearc basin (Jurutze Fmn.) from SSW towards the NNE as fluvial conditions were established (Chogdo Fmn.). Shortly above the last marine incursion dated as latest Paleocene a dominant westward paleo-flow in the Indus Molasse is noted (Nurla Fmn.), suggesting that these sediments were deposited from a paleo-Indus River. A change in provenance accompanies the change in flow direction. Nd isotope data from shales and Pb isotope data from single detrital K-feldspars in sandstones measured by Cameca ims 1270 ion microprobe, both indicate increasing influx of material from South Tibet, confirming that drainage within the Indus Molasse Basin is not just a local pattern within a restricted basin. The increasing Tibetan flux suggests that Indus River initiation accompanied and may have been caused by uplift of Southern Tibet after collision. Moreover, the recognition of detrital feldspars derived from the suture within mid Eocene sections of the Indus Fan, now located on the Murray Ridge within the Arabian Sea, indicates a fully developed Indus river/fan system by that time. Seismic reflection work confirms that ~35% of the Indus fan pre-dates High Himalayan unroofing and uplift of the Murray Ridge, similar to the mass of rock in the Paleogene Makran Accretionary Complex. A mass balance of the erosional record onland, derived from thermochronology, with deposited rock volumes in the Indus Fan and associated basins suggests that only ~40% of the Neogene sediment in the fan is derived from the Indian Plate.

RCM5 : SUPm29 : F3 Morphology and Seismic Structure of the Present Zaire Channel-Levee (ZaiAngo Project)

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The Zaire turbidite system is huge and covers a large part of the Congo, Zaire and Angola continental margin (West Africa). It is fed by a unique canyon, which strongly erodes the continental shelf and directly connects with the Zaire River estuary. The present-day activity of the Zaire turbidite system has been underlined by submarine-cable breaks near the canyon that might have been caused by submarine prolongation of Zaire River floods.

Several cruises were conducted since 1998 over the Congo-Gabon-Angola margin jointly by IFREMER and Total-Fina-Elf (ZaiAngo Project, Savoye et al. 2000). Data collected include Simrad EM12 and EM300 dual

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multibeam bathymetric and acoustic imagery, high-resolution seismic profiles, 3.5 kHz acoustic profiles, and piston cores. This complete data set covers most part of the deep-sea fan.

The quaternary fan is characterised by a multitude of fossil channel-levee systems still strongly visible on the present morphology of the sea-floor. The present and active channel is located in the axial part of the system. It is unique and highly meandering in its upper portion. It presents several changes of direction but it flows globally from East to West. The channel becomes quasi rectilinear down to the entry into a complex of distal lobes, which is located at a direct distance of 750 km from the Congo-Angola coast line and at 5000 m water depth. Due to its meanders, its total length is estimated at about 1200 km. The canyon is deeply incised. Its depth is higher than 1200 m upslope and it gradually decreases downslope.

The comparative analysis of the morphological parameters measured along the canyon and the channel (thalweg depth, slope, channel height, channel width, and sinuities) clearly displays an evolution along the channel. It includes different channel morphologies: canyon with V transversal profile, canyon with flanks structured by terraces, meandering channel bordered by levee constructions and concave lobe morphology. The detailed morphological study underlined that the sinuosity is not only due to local slope compensation, but probably also to channel behaviour and flow characteristics.

The second part of the study consisted of a precise analysis of a series of high-resolution seismic profiles crossing the present channel. Different seismic facies and sedimentary bodies associated to the present channel are recognised: levee facies and geometries, high-amplitude reflector units and chaotic packets. A quantitative analysis of architectural parameters, such as height and lateral extension of levees, thickness of the present system deposit, estimation of the over-deepening, shows that the channel has an important over-deepening along its whole path. The strong erosion of the channel floor can be explained by equilibrium profile adaptation to margin deformations (diapirism) or avulsion phenomena, or by flow characteristic evolution (erosional peneplain).

Savoie B, Cochonat P, Apprioual R, Bain O, Baltzer A, Bellec V, Beuzart P, Bourilliet JF, Cagna R, Cremer M, Crussion A, Dennielou B, Diebler D, Droz L, Ennes JC, Floch G, Foucher JP, Guiomar M, Harmegnies F, Kerbrat R, Klein B, Khun H, Landure JY, Lasnier, *Comptes-Rendus de l'Académie des Sciences de la Terre et des Planètes*, **331**, 211-220, (2000).

RCM5 : SUPM30 : F3 Holocene Sediment Accumulation Rates on the Zaire Deep-Sea Fan

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The Zaire deep-sea fan is a huge accumulation of turbidites at the mouth of the Zaire River, off the Congo-Angola margin. It extends westward over more than 1000 kilometres at water depth up to 5000 metres. The Quaternary fan is a stack of numerous channel-levee systems organised in three complexes (north, south and axial) (Savoie et al., 2000). At a given time only one channel-levee system is active. The present channel-levee system is located on the axial complex. It extends westward over 750 km but due to the sinuosity the overall length of the channel is about 1200 km. It is terminated by a sandy lobe complex.

Several piston cores of a maximum length of 18 metres were retrieved during the ZaiAngo 1 & 2 cruises, in the channel, on the levees and on the distal lobe complex. Accumulation rates calculation is mainly based on radio-carbon dating (mainly on plant remains). Conventional biostratigraphic methods (foraminifera, calcareous nannofossils) failed on the turbiditic sediments due to a strong dilution and reworking. Siliceous microfossils are quite abundant and reveal a variability that still must be calibrated. The last century accumulation rates were determined from excess ²¹⁰Pb of surface sediment.

The collected sediment is almost always of Holocene age and usually younger than 6 ka BP. Accumulation rates vary a lot, both in space and time, from a few cm.ka⁻¹ up to 28 m.ka⁻¹. No time related variation is noticed. As expected, according to the morphology, on a channel-levee system the highest accumulation rate occurs on the top of the levee and the lowest one in the channel. Accumulation rates on the levees are also related to the channel-levee height. On two transects, from upstream to downstream, the channel-levee height decreases from 140 metres to 90 metres and the average accumulation rate increases from 79 cm.ka⁻¹ to 276 cm.ka⁻¹, which gives a gradient of ~4 cm.ka⁻¹ per metre of channel-levee height. Average accumulation rates on the distal lobe complex are similar to those of the levees, i.e. lower than 200 cm.ka⁻¹.

The end of excess ²¹⁰Pb was not detected on surface cores (up to 80 cm long). This makes the last century average accumulation rates much higher than the average Holocene rates, both on the lobe complex and on the channel-levee system (~600 cm.ka⁻¹).

According to calculations on data from Jansen et al. (1984) the hemipelagic accumulation rates decrease with the water depth from ~5 cm.ka⁻¹ (2500 metres) to ~1 cm.ka⁻¹ (4000 metres) which makes this contribution negligible in the building of the present deep channel-levee system.

Savoie B et al., *Comptes Rendus de l'Académie des Sciences - Series IIA - Earth and Planetary Science*, **331**, 211-220, (2000).

Jansen JHF, Van Weering TCE, Gieles R & Van Iperen J, *Netherlands Journal of Sea Research*, **17**, 201-249, (1984).

RCM5 : SUPM31 : F3 Morphology, Seismic Structure and Deposits of a Distal Lobe complex: The Zaire Case Study (ZaiAngo Project)

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Recent oil discoveries in mud-dominated turbidite systems like the Zaire have sparked a definite interest - new in the oil industry, which had neglected such turbiditic systems up until now. These sediment accumulations appear fairly substantially different from the models described on outcrops in tectonic contexts of intracratonic basins. The distinctive feature of these systems is the concentration and channelling of the terrigenous bed load from the mouth of large rivers (or the edges of platforms) to the abyssal plain. The study of the present Zaire turbiditic system appears a way to obtain the information required to develop a reliable depositional model of this type of system. Several cruises were conducted since 1998 over the Zaire fan jointly by IFREMER and Total-Fina-Elf (ZaiAngo Project, Savoie et al., 2000). Collected data include Simrad EM12 bathymetric and acoustic imagery, high-resolution seismic profiles, 3.5 kHz acoustic profiles, deep-tow sidescan sonar and seismic and piston cores. The Zaire turbidite system is comparable in size with the Amazon or the Mississippi. It is fed by a unique canyon, which connects directly with the Zaire River estuary. One of the main objectives of the ZaiAngo 1 cruise was to recognize the path of the present channel downstream its extremity, which was unknown. The bathymetric survey shows that the present channel is more than 760 km long. As it is highly meandering, that represents a unfolded length of about 1200 km. The channel is bordered in its distal part by thin levees and runs into a complex of 4 distal lobes, developed essentially on right side of the channel. The lobes are each 10 to 20 km in diameter, but only a few metres thick. Their top is cut by a very shallow, radial, distributary network giving way

further downstream of the lobe to a fine spread body. Without sonar imaging, the lobes would be difficult to detect as they are extremely discreet morphologically. Every lobe looks on EM12 sonar imagery as a semi-circular elongated body with an external highly reflective sonar facies fringe opposed to a low reflectivity central part. The most distal lobe presents a central channel, which is flat and just a few meters deep. This channel constitutes the true ending of the present Zaire system. The 3.5 kHz profiles across the lobe complex show poor or no penetration and some chaotic hyperbolic facies. They indicate that most of the sediment within the area consists of coarse material. Kullenberg cores taken in the lobes present sequences of thick sandy turbidites but also debris-flows and slumps deposits. When the ending of channels is observed in seismic lines, distal lobes are characterized with more or less spread chaotic facies, strong signal amplitude and very thin depositional units.

RCM5 : SUPM34 : F3 Temporal Variability of Turbiditic Facies on a Levee of the Rhone Neofan (Western Mediterranean Sea): Autocyclicity vs Allocyclicity. A Case Study from the IMAGES Core MD99-2344

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During the IMAGES V Cruise we retrieved the core MD99-2344 (10.77 metres thick) on the right levee of the neofan of the Rhone. The core covers up to 45% of the levee thickness. The sediments mainly consist of several turbiditic facies interbedded with hemipelagic layers. Three units are distinguished. The lower unit from the base to 3.40 (thickness 7.37 metres) is composed of more than a hundred of thin not bioturbated fine-grained turbidites, fining and thinning upward. The intermediate unit from 3.40 to 1.00 metres (thickness 2.40 metres) is composed of coarser bioturbated turbidites. The upper unit is composed of hemipelagic bioturbated sediments. The drastic change in the turbiditic facies at 3.40 metres can be explained by a change of the source and of the processes of the neofan supply. Thanks to a density current velocity profile from a model (Stacey & Bowen, 1988), and a turbiditic current velocity profile from grain-size data from the Var turbiditic system (Migeon, 2000), we show how the long trend turbiditic facies evolution can be explained by the levee aggradation and the increase of the channel-levee height. The high amplitude, metre scale, facies variations must be explained by variations in the volume of turbidity currents, due to fluctuations of the source and/or sea level fluctuations.

Stacey MW & Bowen AJ, *Journal of Geophysical Research*, **93**, 3528-3542, (1988).

Migeon S, *Thèse de doctorat, Université de Bordeaux I*, (2000).

RCM5 : SUPM35 : F3 End Miocene Tectonism and Growth Faults Associated with Messinian Salt - The Role in Creating Space for Sediments of the Plio-Quaternary Megasequence in the Gulf of Lions (Shelf Pro Deltas and Deep Basin Turbidites)

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Structural evidence for Miocene shelf erosion: Mio-Pliocene extension

The current morphology of the Gulf of Lions is partly inherited from its former structural framework that is essentially governed by Oligo-Miocene followed by end Miocene extension. The Gulf of Lions margin was broken up during the Oligocene and then Late Miocene along transfer zones perpendicular to the overall margin direction. These transfer zones and faults were active until

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Plio-Quaternary times. In the northwest, the Arlesian transfer zone separates the current steep margin of Provence from the Gulf of Lions. In the southwest, the Gulf of Lions margin is separated from Catalan margin by the Catalan transfer zone located in line with the Cap Creus Canyon. Between these two boundaries, within the shelf area, transfer zones running parallel to the Arlesian Fault offset extensional structures that were active up until the Messinian, in places Plio-Quaternary. These faults played a major role in the establishment of the Messinian paleovalleys on the margin.

Main structural trends related to salt tectonics and their control on turbiditic sedimentation in the deep basin

The structures associated with salt tectonics demonstrate that halokinesis had a considerable influence on the deposition of Plio-Quaternary sequences. The general trend of these structures is governed by the orientation of the continental slope, i.e. parallel to the main gradient of this slope. Rollover structures are also observed along listric fault planes. These structures are locally responsible for the major thickness variations seen in the Plio-Quaternary sequence, associated with the syn-sedimentary rotation mechanism. Furthermore, antithetic faults give rise to graben shaped structures that appear, when correctly oriented, to control the chenalee levee system of the Plio-Quaternary turbidites. Halokinesis was indirectly or directly involved in the process of widespread gravity sliding and in the morpho-structural control of the canyons. In places it played a noticeable role in the emplacement of canyons and the morphology of their flanks and sinuosity of their courses.

In conclusion, the inherited Oligocene and Messinian structural framework and the influence of salt tectonics should be considered as a major factor in the emplacement of the shelf-slope transfer systems, as well as in sedimentary remobilisation in the continental slope area of the Gulf of Lions.

RCM5 : SUPm36 : F3 Great Australian Bight Sediments: Linking a Mid-Latitude Cool-Water Carbonate Margin with Southern Ocean Paleooceanography

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The Great Australian Bight (GAB) is a cool-water carbonate depositional environment and the largest of its kind on earth today. Comprising a wide ramp-type shelf, the GAB directly opens to the Southern Ocean, and is wind-blown and wave-swept year round. The wide shelf is a site of abundant sediment production, but, due to the swell dominated environment, most biogenic material is swept seaward where it accumulates at the shelf edge and uppermost slope. Thus, one of the primary objectives of Ocean Drilling Program Leg 182 was to investigate the nature of such a cool-water carbonate depositional system and its response to paleoceanographic and paleoclimatic changes. Continuous cores from an extraordinary expanded, 450 m thick, Pleistocene wedge combined with well-preserved foraminifera allow for high-resolution and detailed studies of the paleoenvironment. The focus of this study aims at identifying Late Quaternary paleoceanographic changes within glacial - interglacial timeframes and their effects on the margins fauna and flora, thus influencing sediment accumulation and depositional architecture.

Oxygen isotope stratigraphy, together with downhole Natural Gamma Ray from logging and magnetostratigraphic datums, forms the basis of an accurate age model. Average sedimentation rates range from 28 to 35 cm/kyr, with shorter time intervals exceeding 40 cm/kyr rivaling the fastest sedimentation rates known in shallow-water tropical environments. XRD analysis demonstrate high-frequency, high-amplitude mineralogical fluctuations. Using these data, combined with new results on sea-surface temperatures, sediment accumulation rates and paleoproductivity proxies, we estimate circulation pattern and wind fields that influenced this margin during Late Quaternary glacial-interglacial time frames.

Geochemical, sedimentological and petrophysical characteristics of carbonates deposited in the GAB and drilled during ODP Leg 182 provide a systematic approach to link the shelf setting to the open ocean.

RCM5 : SUPm37 : F3 High-Resolution Cyclostratigraphy and Architecture of a Carbonate Platform Interior- The Latemar, Middle Triassic, Southern Alps

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The platform interior of the Latemar shows a distinct bundling of shallowing-upward microcycles into thinning-upward macrocycles. Based on 1:5 bundling patterns and spectral analyses of small parts of the cyclic succession previous researchers (Hinnov & Goldhammer 1991; Goldhammer et al. 1993; Preto & Hinnov 2000) assumed a precessional forcing for microcycles and an eccentricity forcing for macrocycles. New high-resolution 3D cyclostratigraphic data, complete chrono-biostratigraphic data and spectral analyses indicate different controls of the Latemar cyclicity. The cyclic succession comprises 5 major cyclostratigraphic units (tk=thickness, n=min.-max. cycle number; av=average thickness/cycle): (1) Lower Tepee Facies, tk=28.40-37.50 m, n=13-18, av=2.02-2.20 m; (2) Lower Cyclic Facies, tk=92.90 m, n=90-91, av=1.02-1.03 m; (3) Middle Tepee Facies, tk=118.90 m, n=201-221, av=0.54-0.59 m; (4) Upper Cyclic Facies, tk=169.40 m, n=226-268, av=0.63-0.75 m; (5) Upper Tepee Facies, tk=74.60 m, n=102-121, av=0.62-0.73 m. The total number of cycles is 626-745, considering different locations on the platform and minimum/maximum numbers of cycles. New zircon U-Pb isotopic ages by Mundil et al. (submitted, Geology) from two in-situ ash layers in the LCF and UCF yield an average time span of 0.5-2.1 My (average 1.3 My). In our sections both ash layers are separated by 398-441 cycles. Ammonoid faunas indicate that the cyclic succession was mainly deposited in a single biozone (*Secedensis Zone*; Rieber, oral comm.). Both bio- and chronostratigraphic data therefore clearly indicate sub-Milankovitch control for microcycles. Different spectral analyses methods (Blackman-Tukey, Multitaper, maximum entropy) applied to the complete cyclic series show highly significant ratios of 1:4 to 1:6, 1:10, 1:20 to 1:27 and 1:100. Ratios are largely constant over the cyclic succession. If Δt for one microcycle is set to 4.2 ky, Triassic orbital parameters (ratios, time intervals according to Berger & Loutre 1994) can be deduced at highly significant frequencies. This model indicates, that orbital forcing in the Milankovitch band is present in the larger-scale bundlings, not in the microcycles. Macrocycles in the Latemar represent precessional forcing, 1:10 bundlings obliquity forcing and 1:20 to 1:27 bundlings short eccentricity forcing. As general conclusion (1) 5:1 bundling between hierarchic cycles does not necessarily indicate precessional and eccentricity forcing; (2) genetic cyclostratigraphic models should be time-calibrated by chrono- and biostratigraphic data, i.e. model-independent data, and not simply by statistics.

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RCM5 : SUPm38 : F3 Termination of Middle Triassic Carbonate Production: A Key to Reconstruct Different Palaeoclimatic Regions within the Tethys

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During Carnian times carbonate production in the entire Alpine domain was terminated by a major event, called 'Reingrabener Wende' (Schlager and Schönberger, 1974). A distinct regression exposed the reefs and carbonate platforms of the Wetterstein-Formation. Subaerial exposure is documented by karstification of the tops of reefs and

carbonate platforms of the Wetterstein Formation in the Northern Calcareous Alps of Austria (NCA). Marls, sandstones and clays cover the carstified reefs and carbonate platforms of the more landward situated parts of the NCA. Distal situated reefs and carbonate platforms of the NCA miss this terrigenous cover.

In palaeogeographic reconstructions, the Triassic carbonates of the Julian Alps of Slovenia (JA) are part of the same carbonate platform-system, fringing the Tethys-ocean, as the platforms of the NCA (HAAS et al., 1995). Conodont-data, foraminifera and dasycladacea of a studied succession on Mt. Razor/Slovenia, showed that shallow-water carbonate-production was terminated synchronously in the JA and NCA. Recovery of reefs and carbonate platforms took place about 3 Ma years later in uppermost Carnian times, in the JA, as well as in the NCA.

In contrast to the NCA, the top of the Wetterstein-platform studied on Mt. Razor/Slovenia lacks signs of Karstification which document the regression at the beginning of the 'Reingrabener Wende'. This can be explained by more arid climate-conditions in the JA. C-isotope-analyses support this interpretation. A climatic difference between the NCA and the JA is even more probable in Norian times: Caliche pisoids, which indicate semi-arid climates, are abundant in member A of the Dachstein Formation in the JA (Sattler & Schlaf, 1999), whereas they are not known from the well studied Dachstein-limestones in the NCA. This facies-difference suggests that the JA were situated in a more arid climate than the NCA during major parts of Triassic times.

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RCM5 Sediment Supply, Transport and Deposition

Sunday PO Session

RCM5 : SUp01 : PO Controls on Depositional Facies and Sequence Architecture of Cretaceous Sediments of Southern Jordan

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Aptian to Santonian sediments accumulated along the southern Tethyan continental margin at the edge of the northeastern African-Arabian Plate range from nonmarine, marginal marine to marine deposits. During the early Cretaceous the paleo hinge line, separating deep marine from the shallow marine environments, corresponded approximately to the modern Mediterranean coastline. The shoreline was situated off northern Jordan, trending SW-NE. This arrangement generally persisted until the Coniacian. Exposed sections along the W-E trending escarpment between Ras En Naqb and Naqb Ateik provide an excellent insight into lateral and vertical changes of litho- and biofacies and depositional environments. The escarpment represents a key area which deciphers the parameters controlling the dynamics of mixed carbonate siliciclastic nearshore settings during the Cretaceous.

Detailed logging of sections allows us to perform high resolution facies analysis and to describe various facies types ranging from open shelf to nonmarine coastal plain depositional environments. The lateral and vertical architecture of depositional systems is characteristic for a microtidal barrier system with adjacent fluvial coastal plains and shelfal areas. Internally the facies types are arranged into small scale cycles which are mainly controlled by changes in sediment supply and accommodation space. Both controlling mechanisms are linked to repeated local tectonic movements and enhanced by climate changes. Facies successions again are arranged into four shallowing-upward sequences (regressive sequences) truncated by transgressive surfaces. Each sequence starts with marine sediments and gradually grades into marginal marine or terrestrial deposits, reflecting major sea level changes.

RCM5 : SUp02 : PO Present day Sedimentation Processes in the Nazaré Canyon, Western Iberian Margin

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The western Iberian margin is characterized by the presence of numerous submarine canyons, which are likely to play a significant role in the exchange of material between the shelf and the deep ocean. One of the largest is the Nazaré Canyon, which intersects the margin at about 39°30' N. The upper part of the canyon cuts across the full width of the shelf, with the canyon head even indenting the coastline. The middle part of the canyon is characterised by a narrow meandering bed, deeply incised in the slope. Below 4000 m, the canyon bed broadens into a flat long plain, which opens into the abyssal plain at about 4900 m depth. As a part of the EU supported Ocean Margin Exchange (OMEX) programme, sedimentation processes have been investigated in the Nazaré canyon to determine its role in sediment transport and deposition for the Iberian margin. This study is based on sediment cores collected during cruise 64PE138 in May, 1999. Canyon sediments have been studied using classical sedimentological parameters (grain size distribution, radiography) and analysis of the radionuclides ²³⁸Th and ²¹⁰Pb (α and γ spectrometry). Canyon results are compared to results obtained just outside of the canyon and on the margin further to the north.

There is a large spatial variability of sedimentation rates in the Nazaré canyon. However sedimentation rates are much higher than those observed for other parts of the Iberian margin, including stations immediately adjacent to the canyon. On a 100-days time scale, moderate bioturbation rates, together with evidence of high deposition rates (high excess ²³⁴Th inventories) seem to indicate high inputs of low-organic particles. On an annual time scale, sedimentary fluxes derived from ²¹⁰Pb profiles are very high in the canyon, showing major deposition in the upper and middle part of the canyon. On a century time scale, sediment deposits accumulated in the canyon are transferred to the abyssal plain by episodic turbidity current events.

The Nazaré Canyon thus appears highly efficient in capturing the longshore sediment transport and probably constitutes an important locus for sediment deposition on the western Iberian margin.

RCM5 : SUp03 : PO An Upper Burdigalian (Karpatian) Short Warm Spell in the Paratethys Area, Austria

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The Korneuburg basin, which is a half graben situated NW of the Vienna Basin (Austria), displays a typical shallowing upward succession from marine sediments, overlain by brackish to pure terrestrial deposits. The clastic sediments of the brackish and terrestrial facies have been analysed for organic facies and palynomorph data. Pollen analysis revealed, besides the typical Lower Miocene pollen assemblages (e.g. *Acer*, *Carya*, *Celtis*, *Cercidiphyllum*, *Decodon*, *Fagus*, *Ginkgo*, *Glyptostrobus*, *Ilex*, *Lithocarpus*, *Myrica*, *Nyssa*, *Parthenocissus*, *Platycarya*, *Reveesia*, *Symplocos* etc.), two frequently occurring taxa which give evidence of a short warming trend during the Karpatian. One of the taxa is the Black Mangrove (*Avicenniasp.*, *Avicenniaceae*), a very common pantropically distributed mangrove genus. The most northerly occurrences are slightly above latitude 30°N in Florida (USA) and the most southerly are in Victoria (Australia) around latitude 37°S; both are extremes and reveal scattered crippled and stunted individuals of *Avicennia*. The other taxa is *Calamus* sp. (*Arecaceae*), the Rattan palm, which today occurs in the wet tropics of SE Asia, Malaysia and Queensland. This species rich genus has a wide ecological amplitude and may range from brackish through lowland to hilly habitats. The genera *Avicennia* and *Calamus* are not typical of Miocene pollen assemblages and are therefore taken to indicate a short period of warmer and probably more humid conditions in the area of the Korneuburg basin during upper Burdigalian times. The Korneuburg flora is relatively diverse and altogether comprises 107 plant taxa, which are mostly represented by palynomorphs (77) and to a lesser extent by diaspores (33) and leaf fossils (15). From the 71 woody plant taxa, 44% are assumed to be deciduous, 23% evergreen, and 11% might be either evergreen or deciduous or both, depending on species, climate and ecology; of the rest we have no information. Foraminifera data from the directly underlying marine strata also suggest warmer currents in the Paratethys sea, thus providing more moisture and higher temperatures for the near coastal habitat.

RCM5 : SUp04 : PO A High-Resolution Stratigraphical Framework of Neogene Marine Deposits from the Southern North Sea: A Link between Oceanic and Continental Environments

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During Late Cenozoic times depositional history of the epicontinental North Sea Basin was dominated by regional subsidence accompanied by a very high clastic influx (up to 100 cm/kyr). This resulted in an Upper Cenozoic (post Middle Miocene) succession of clastic sediments reaching a thickness of approximately 1500 m along the axis of the

Central North Sea Graben. Such an environment provides the possibility to study variations of climate, sea level and sediment supply in unprecedented detail.

Former studies have described numerous sedimentary and seismic sequences above the distinct Middle Miocene unconformity in the off-shore areas of Denmark, Germany and The Netherlands. Age control of these studies is mainly based on foraminiferal biostratigraphy with a limited data set of low quality.

Our project aims to establish an integrated high-resolution stratigraphical and depositional framework for the Pliocene and Pleistocene sediments in the northern Dutch off-shore area. This is done by applying various biostratigraphical tools, including foraminifers, dinoflagellates and pollen together with paleomagnetic measurements.

An extensive database comprising recent 2D/3D seismics, well-logs (gamma-ray, sonic, density, susceptibility) and also discrete sediment samples (cuttings, sidewall- and core material) made it possible to integrate the biostratigraphical data and use them for detailed correlation of the sedimentary units. Moreover, we combined the regional pollen based stratigraphical zonation of Zagwijn (1998) with the newly established off-shore record. Through the magnetostratigraphical data of two boreholes the various biostratigraphical events could be placed in a global chronostratigraphical frame.

Our poster presents first results of this multidisciplinary approach showing an age control for both the seismic and sedimentary sequences which now enables complementary studies as frequency analysis and modelling to distinguish tectonic and paleoclimatic signals. In addition, this new chronology for the Dutch off-shore sector can be used for further correlation with the continental records of the southern mainland and with the marine Atlantic realm to the north.

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RCM5 : SUp05 : PO A Continental Margin with a Condensed Succession: The Lower Cretaceous Glaucyony-Rich Deposits of the Nice Area

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At the beginning of Cretaceous the accentuation of the diastrophism in the Piedmont - Ligurian Ocean, establishes, on the oriental margin of the European continent, a permanent basin (Vocontian Basin). The areas bordering the south side the Vocontian Basin show a really different sedimentation rate, with condensed and glaucyony-rich facies. They gradually pass into the Provençal Platform toward the W. The oriental zone (Arc of Nice) is characterized by very condensed deposits, having a total thickness lower than 40 m. They are formed by 5 lithofacies:

- Hard ground (Late Valanginian);
- Belemnitic Limestone (Hauterivian);
- Hard-ground (Barremian);
- Marlstones and limestones (Aptian);
- Glaucyonic complex (Albian - Early Cenomanian).

The study of glaucyony with morphological analysis (shape, surface texture, concentration, colour) and diffractometrical analysis in order to confirm the mineralogical structure of glaucyonic minerals allowed to distinguish two different populations of grains. The maturity of glaucyony was estimated on the basis of the potassium content (Odin & Matter, 1981). Both populations show a high degree of maturity and are interpreted to be autochthonous (i.e. grains that have not experienced significant transport from their place of origin) or parautochthonous (autochthonous intrasequential) (Amarosi, 1997). The data about glaucyonic grains origin carried to recognize the dynamic of the sedimentation on the south margin of Vocontian Basin and to detail the paleogeography. Two cycles of second order (longer than 3 Ma) have been recognized. However these cycles assume form as depositional sequences, in which the system tracts are recognizable. In the lower sequence the

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lowstand deposits are represented by the lower part of first hard ground, the transgressive system tract by the higher facies of hard ground (with high degree of maturity glaucony). The highstand system tract is represented by belemnitic limestones (without glaucony). In the higher sequence the hardground at the bottom marks a relative fall of sea level, followed by transgressive deposits with autochthonous mature glaucony (higher facies of hardground and marlstones and limestones). The glauconitic complex is very rich in mature glaucony, autochthonous or moderately parautochthonous and might mark the maximum flooding level. The trend of relative sea level fall can well correlate to the trend of fluctuation of second order cycles (Haq et al., 1988). The features of deposits and glaucony allowed to differentiate, during the deposition of belemnitic limestones a ramp (at SW) versus a basin zone (at NE). This boundary, modified by Barremian tectonic event is again shown by facies change during the deposition of glauconitic complex.

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RCM5 : SUpo06 : PO Architecture of a Channel-Levee Complex of the Middle Bengal Fan- Results from a Very High Resolution Seismic Survey

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In 1997 during R/V Sonne Cruise SO125 of the University of Bremen multichannel seismic and digital echosounder surveys were carried out in the Bay of Bengal to study the morphology and structure of the Bengal Fan and its Channel-Levee systems at different distances from the shelf. The Bengal Fan (the largest submarine fan in the world) is fed by sediment load of the Ganges and Brahmaputra rivers, which drain the Himalayan. This sediment reaches the deep sea fan through a canyon deeply incised into the shelf and connected to the active Channel-Levee System. The sediments were temporary trapped in the canyon and transferred episodically by turbidity currents on the fan. A main focus was the investigation of the active Channel-Levee system on the middle Bengal Fan at 16°30'S in 2600 m water depth. A closely spaced grid of Parasound sediment echosounder, Hydrosweep swath sounder and very high-resolution seismic data was collected, utilising a watergun with frequencies between 200 and 1600 Hz as well as a 0.4l GI Gun with frequencies between 100 and 400 Hz as seismic sources in an alternating operation mode. The bathymetric data show a highly sinuous active channel with an exceptional low gradient. More than 20 cut off loops, most of which were completely refilled, could be identified by combined interpretation of Parasound and Hydrosweep data. Channel jumping is probably controlled by the interaction between erosion and planform and seems to be occurring frequently. Parasound data indicate that sedimentation on the levees varies strongly and depends on the relative position to the apices of the channel loops. The two different seismic signals used here penetrated much deeper than the Parasound signal, which was limited to 100 m in this region. By compromising vertical and lateral resolution, the seismic data were suitable to completely image the active Channel-Levee system up from its basal plane as well as the vertical stacking of several Channel-Levee systems building the fan. Seismic and Parasound data were combined to analyse the sedimentary structures, the built-up process and controlling mechanisms of the active system on larger scales in time and space. In addition, the dependency of seismic facies and their interpretation from source frequency is illustrated and discussed. Seismic data also reveal numerous stacked systems, differences in form and size of buried systems as a function of age and burial depth and help to answer questions for the dominating geometries through the evolution of the Bengal Fan related to the properties of sediment influx. Therefore the link between the land related processes in the Himalayan as well as the delta plains and the marine geology record in the Bay of Bengal through sediment transport were analysed.

RCM5 : SUpo07 : PO Changes in the Seine Estuarine Sediments (France): Consequences of Estuary Management

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Since the middle of the XIXth century, the industrial fitting in the Seine estuary (France) and the improvement of navigation conditions lead to extensive morphological and sedimentary readjustments : important decrease of the estuary areas, shifting and filling of the north and south channels, while the present navigation channel must be deepened by intense dredging. Facies, mineralogy and geochemistry (major and trace elements) were analyzed on sediments cored in diverse places of the estuary in order to precise their origin. Sediments sampled upstream from Honfleur are influenced by erosion of the catchment rocks. On the other hand, sediments sampled south of the outlet are much influenced by erosion of the Jurassic clayey cliffs of the Calvados coast. Sands and mud cored in the mouth of the navigation channel are characterized by diverse geochemical composition and sedimentary structures which can be connected to the morphological evolution of the estuary.

RCM5 : SUpo08 : PO Indications for the Development of the Cenozoic Sedimentation Environment in the Southern Cape Basin

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The Benguela Current System is part of one of the greatest upwelling regions of the world. Due to its high sedimentation rates it represents an excellent climate archive and offers the possibility of paleoceanographic reconstructions.

As part of ODP Leg 175, three sites (Sites 1085, 1086, 1087) were drilled in the southern part of the Cape Basin. At two of the sites downhole logging was carried out (Sites 1085 and 1087). With a maximum depth of 610 mbsf (Site 1085a) the sites span the time period between Holocene and late Miocene (0-15 Ma).

The location of the sites were chosen in order to document the history of the Benguela Current and contain information on both, the influence of warm water from the Indian Ocean, brought by the Agulhas Current, as well as incursions of cold Antarctic waters. Beside climate informations (e.g. glacial-interglacial stages) the sites contain records of slumping events.

In order to reconstruct the development of the upwelling system and to identify modifications within the circulation system in the southern Cape Basin, the results of the ODP Leg 175 Sites 1085-1087 are correlated with seismic data collected in 1996 during the METEOR Cruise M34/1. Aim is to extrapolate the informations of the sites spatially.

In this contribution we present a first correlation between the properties of the sites and the seismic profiles. Base for this link are synthetic seismograms, derived from density and P-wave velocity data of the cores and loggings, as well as all other available data like sedimentological parameters (e.g. grain size), bio- and magnetostratigraphy, magnetic susceptibility, natural gamma ray, resistivity, and chemical properties (e.g. carbon and carbonate content).