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9th INTERNATIONAL CONFERENCE ON FLUVIAL SEDIMENTOLOGY - TUCUMAN, ARGENTINA

2009

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Lecturers provided interesting keynotes and agreed to form the Award Committee.

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SERGIO M. GEORGIEFF
Convenor, 9th ICFS

Field Excursion Leaders

Pre – Conference Field Excursions

1.- **From the Cretaceous rift to the Pliocene Foreland basins (NW Argentina): Tectonic and Sedimentation**
Cecilia Del Papa - CONICET.

2.- **Evolution of the Fluvial System in The Tertiary Andean Foreland Basin (Precordillera, Argentina)**
Carlos O. Limarino. Universidad de Buenos Aires – CONICET.

3.- **Fluvial Syntectonic Features in Cenozoic Pampean Deposits**
Gerardo E. Bossi, Sergio M. Georgieff and Sebastián Moyano, Universidad Nacional de Tucumán – CONICET.

Mid – Conference Field Excursions

4.- **Mezoic and Cenozoic Fluvial Deposits of Northern Tucumán**
Gerardo E. Bossi and Sebastián Moyano, Universidad Nacional de Tucumán - CONICET.

5.- **San Javier - Raco, Precambrian, Creaceous-Neogene**
Guillermo Aceñolaza, INSUGEO - CONICET. Universidad Nacional de Tucumán

6.- **Tafí and Amaicha Valleys: Paleoclimatic and Paleoenvironmental Neogene Evolution**
Miriam M. Collantes, Lucía M. Ibañez, and José Busnelli, Universidad Nacional de Tucumán – Fundación Miguel Lillo.

Post – Conference Field Excursions

7.- **Paraná River, Miocene to Present**
Oscar Orfeo, CONICET – Universidad Nacional del Nordeste.

8.- **Sedimentary Evolution of the Golfo San Jorge Basin, Central Patagonia, Argentina**
José Paredes, Universidad Nacional de la Patagonia San Juan Bosco.

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Keynotes

ON THE INTERACTIONS BETWEEN TURBULENT FLOWS, SEDIMENT TRANSPORT AND BEDFORM DEVELOPMENT IN ALLUVIAL CHANNELS: 28 YEARS ON

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Understanding the interactions between the trinity of turbulent flow, mobile sediment and bedform development lies at the heart of interpreting fluvial form and process. This 'trinity' was used as the basis of the seminal paper by Leeder (1983) that arose from the 2nd ICFS, held in Keele, UK, in 1981. These ideas were grounded in the exciting developments that were made in turbulent boundary layer research in the late 1970's, with the paper of Jackson (1976) being one of the first that attempted to link turbulent boundary layer structure with sediment transport, bedform generation and stability. Since these advances in our thinking in the 1980's, the tools that we can use to investigate the complex feedbacks in this trinity have improved beyond our 1970/80's dreams! - in laboratory technology, field methods and numerical tools. Where has this brought us and what are the key issues that now face us in quantifying, understanding and predicting the morphodynamics of alluvial bedforms?

This talk will review some of the key developments in the field of alluvial bedform morphodynamics over the past 28 years, and show results from the laboratory (using a range of optical and acoustic techniques), field (highlighting acoustic methods) and computational modelling (LES realizations of flow over bedforms). This review will encompass the feedbacks between bed morphology and large-scale vorticity, the interactions between bedforms, the influence of fine-grained sediment on turbulence modulation within the flow, and some commonalities of bedforms generated in different sized bed sediment. The talk will conclude with examples of how bedforms are key in understanding some of the larger-scale aspects of river channel morphodynamics, and highlight some areas of current research that raise issues concerning bedform development in both laminar and turbulent flows and the scaling of bedforms within unidirectional flows.

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ROLE OF CONTINENTAL MARGIN INCISED-VALLEY SYSTEMS IN THE EMERGING SOURCE-TO-SINK PARADIGM

Mike Blum

ExxonMobil Upstream Research Company, Houston, Texas

The emerging source-to-sink paradigm seeks to develop a holistic understanding of sediment production, transport, and storage from source regions in tectonic hinterlands to sinks within deep ocean basins. River systems are an important component, the "to" in source-to-sink: this presentation discusses how the evolution of incised-valley systems in response to allogenic controls play a fundamental role in modulating sediment transfer across continental margins.

Continental margins incised valleys form in response to sea-level fall, as fluvial systems extend across newly emergent shelves to the lowstand shoreline and shelf margin. But what is the shelf, anyway? It has long been recognized that modern shelf margins

correspond with the depth of sea-level fall during late Pleistocene lowstands, and numerous studies illustrate the important role of deltaic progradation during lowstands to construct the shelf margin. However, a growing body of evidence now suggests that shelves are fundamentally terrestrial landscape elements (although they clearly have a marine overprint). The view taken here is that shelves are essentially the lowstand coastal plain, river long profiles are graded to shelf margins, and shelf margins are simply the end of the fluvial sediment dispersal system. In this view, the surface across which rivers extend during sea-level fall is a byproduct of the fluvial system itself, part of the equilibrium profile, rather than a surface inherited from a different suite of processes.

The evolution of linked coastal-plain and cross-shelf incised-valley systems modulates source-to-sink sediment routing from erosional continental interiors to deepwater environments through the storage and export of sediments. Incised valleys form in a stepwise manner, with short periods of incision punctuated by extended periods of lateral channel migration and valley widening, and with contemporaneous deposition of channel-belt sands. Short periods of incision likely produce an insignificant amount of sediment export, but periods of lateral channel migration, valley widening, and channel-belt deposition significantly increase downstream flux, such that periods of fluvial deposition within incised valleys correspond to increased sediment delivery to the shelf margin and beyond. Moreover, drainage basins commonly merge as channels extend across the shelf, such that signals of increased or decreased flux of sediment to the shelf margin and beyond may reflect geomorphic response to sea-level change —the merging of drainages as they transit a broad shelf— rather than changes in sediment supply from the hinterland.

High-frequency cyclical isostatic adjustments to changes in water and sediment loads may be intrinsic to the evolution of incised-valley systems. First, isostatic uplift of the shelf in response to sea-level fall will enhance incision, whereas sea-level rise and flooding of the shelf will have the opposite effect. Second, the development of incised valleys results in sediment unloading and loading, which likely produces a cyclical pattern of isostatic uplift and subsidence as well. Cyclical uplift and subsidence, either due to hydroisostasy or sediment unloading and loading, should amplify valley incision and filling, play a key role in development of valley-fill architecture, and play and important role in sediment export or storage.

UNIT-BAR DEPOSITS IN ANCIENT RIVER-CHANNEL ALLUVIUM

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Modern river-channel deposits comprise flood-generated sedimentation units, unit-bar deposits, and compound-bar deposits. Although all of these scales of deposits are recognized in all modern river-channel deposits, unit-bar deposits are not commonly reported from ancient river-channel deposits. However, unit-bar deposits have been recognized explicitly in ancient river-channel deposits by McCabe, Jones, Bridge et al, and Haszeldine. Ancient unit-bar deposits have also been misinterpreted by Allen, Roe and Hermanson. One of the reasons for the apparent lack of unit-bar deposits in ancient alluvium is because they are very similar to flood-generated units. Similarities include: both types of stratasets are dominated by medium-scale trough cross strata formed by dunes superimposed on bar surfaces; stratasets are decimeters to meters thick; stratasets commonly fine upward from an erosional base; stratasets commonly have stratal discontinuities with overlying and underlying stratasets. Differences are: unit-bar stratasets are commonly mound-shaped or dip downstream, and; bases of medium-scale trough cross sets are variable in dip and rarely approach the angle of repose, thus giving rare large-scale cross strata associated with the avalanche face of a unit bar.

Here, ancient unit-bar deposits are recognized in re-interpreted ancient alluvium.

SEDIMENTOLOGICAL AND STRATIGRAPHIC MODELS: INTEGRATION AMONG SCIENCE, TECHNOLOGY AND OIL INDUSTRY. EXAMPLES IN OIL FIELD OF GOLFO SAN JORGE BASIN, CHUBUT AND SANTA CRUZ PROVINCES, ARGENTINA

Luciano Di Benedettto

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At the present, Argentina has five main oil basins and even some new efforts are conducted to explore its marine platform. YPF SA is working in the all basins and has also realized exploration in the named frontier basins.

Since 1907, the Golfo San Jorge Basin (GSJB) is the pioneer oil basin in Argentina and already has produced 0,3 Mbbl/days and 14,713Mm3/days gas. The main production of oil is coming from Cretaceous fluvial deposits. The principal characteristic of the oil field production is a rapid development, for instance since middle '90 the drillings were around 200 wells per year, only by YPF SA. These intensive developments become a daily challenge to optimization the production and keep hydrocarbon reserves.

The GSJB was an extensional basin during Early Jurassic and Middle Cretaceous; it became compressive from Late Cretaceous but mainly during Tertiary. The sedimentary column is formed by fluvial, lacustrine, volcaniclastics and volcanic deposits. The basin hosts deposits of economic importance in the sandstone sequences in all of their Cretaceous lithostratigraphic units.

The studies realized in these deposits are focused to understand the external and internal controls of the plays. The development of quantitative models and the comprehension of tectonosedimentary evolution using new technologies and optimizing the available resources (field, lab and research) are the main goals to improve the prediction of new plays.

The sandstone bodies hydrocarbon-bearing belong to the Castillo and Bajo Barreal Formations (Chubut Group). These units are formed by fluvial channel belts with thicknesses from 2m to 10-12m and widths between few tens of meters to 600m. The channel belts flowed onto a silt-sandstone floodplain toward east or southeast as isolated fluvial belts. The floodplain deposits are represented by splays and splay-channels with a high proportion of volcanic ashes and volcaniclastic deposits like surges and lahars. Even channel belts show high proportion of volcaniclastic and pyroclastic materials. Thus, the poro-permeability characteristics are very variable into the same sandstone bodies and the induced fractures are normal in the primary oil recovery.

The sedimentological and stratigraphic studies allowed to understand the depositional setting of Chubut Group in the The Guadal Area through the merge of surface and subsurface data (outcrops, wells, 3D seismic, geochemistry of oils, mudstone composition, petrography, and poro-permeability studies).

AN OVERVIEW OF EROSION AND SEDIMENTATION PROBLEMS IN FLUVIAL SYSTEMS OF NORTHERN ARGENTINA

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The North-West region of Argentina shows a variety of fluvial systems and associated erosion-sedimentation problems. Most of the large scale watersheds have their heads along the Andean and Sub-Andean zones, and they are characterized by a very heavy sediment yield. On the other hand, the lower reaches of the rivers, mainly located on the Grand Chaco plain area, are characterized by a wide range of morphological processes, among others, net sedimentation and channel aggradation.

Several problems related with erosion and sedimentation processes in the study area are examined from an engineering point of view.

For instance, the continuous aggradation of the Pilcomayo River, which defines the international boundary between Argentina and Paraguay countries, causes several problems. In fact, channel shifting and avulsion processes difficult the river water resources management for several uses in both countries and define a challenge to river engineers about the location and features of discharge diversion works.

Bermejo River also flows from the Andes to Chaco and the sediment yield of its watershed is among the world highest ones. The lower reaches of the river show a meandering pattern with a remarkable trend to develop lateral migration processes, which causes a lot of problems in works located in the river environment, such as water intakes, bridge crossings, agriculture land loss due to bank erosion, etc.

Most of these problems are discussed in the presentation, along with erosion-sedimentation aspects observed in other interesting fluvial systems in the region, such as Juramento-Salado and Salí-Dulce.

FATHER OF THE WATERS: UNLOCKING THE SECRETS

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The Paraná River System, the "Father of the Waters" (in translation from aboriginal Guaraní), is the 6th largest river system in the world and as such is the most significant in southern South America. The Paraná, as well posing as a flooding risk for millions of people who live on its floodplain, also provides a water supply, hydro-power, and a major trade conduit in the region. Despite its clear economic and social importance we have a limited understanding of how many components of the system functions and there is thus a vital need to improve our knowledge of channel morphodynamics and improve our predictive capacity and thus ensure sustainable development of this immense watershed.

Large river systems have posed a considerable challenge to Science, owing to the magnitude and complexity of factors that regulate their dynamics. For instance, the Paraná has vast volumes of solid and liquid discharge, a subtropical climate with a range of temporal and spatial variability, a diversity of relief and basin lithology, rapid changes in the fluvial form, extensive floodplains, and considerable influence of both autochthonous and allochthonous tributaries. Additionally, many human imparted changes have already exerted significant influence on the system, including the effect of large dams, rectified channels, dredged channels, fluvial transit alterations, intensive development of ports, building of hydroelectric plants, the rapid development of cities, and changes in land-use, have or are complicating the functioning of the entire system.

The study of modern large fluvial environments is very much an incipient activity. This paper provides an outline of the research conducted by a large multi-national group of scientists, who have begun to identify some key processes operating within the Paraná System. This research for example has begun to address questions over mixing rates and flow structure at the Paraná-Paraguay confluence, the influence of bedforms on channel scale flow processes and the morphodynamics and sedimentology of large compound bars. This synthesis will highlight key findings and point to future research that aims to unlock more secrets of this wonderful fluvial system.

HISTORICAL PLANIMETRIC CHANNEL CHANGES IN AN ITALIAN RIVER: THE CECINA RIVER

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Fluvial planimetric form is affected by continuous changes as a consequence of channel adjustments in response to varia-

tions in the balance between sediment supply and transport capacity. Channel changes may be caused by geomorphic response to natural changes (e.g. climate) or human disturbances. Human activities have had a strong impact on most of the European alluvial rivers over the last centuries.

Nowadays, advances in Geographical Information System (GIS) technology has significantly increased the contribution that historical data can give to the analysis of channel planform changes.

The aims of this study are twofold: (1) to develop and apply a systematic methodology for measuring and analyzing channel changes by remote sensing and GIS technology; (2) to describe and interpret in a case study the spatial and temporal patterns of channel changes which have affected the Cecina River.

The Cecina River is located in southern Tuscany (Central Italy). It is a gravel bed river with large alternating lateral bars, 79 km long, and has a drainage area of about 900 km^2 characterized by a Mediterranean climate.

A Geographical Information System has been developed, and historical maps and aerial photographs of different scales and dates have been used to identify, measure and analyze planimetric channel changes.

The active channel was defined and digitalized from all the aerial photographs. The river course was divided into relatively homogeneous reaches, and a series of basic planimetric parameters, such as channel width, sinuosity and braiding index, have been measured. This analysis has made it possible to measure temporal and spatial changes in Cecina River channel. In some representative reaches, changes in land-use and forest cover floodplain were analyzed and quantified by comparing aerial photographs using GIS data processing.

Results indicate that all reaches have been subjected to progressive channel narrowing since 1883. Channel width measures indicate that the total channel narrowing varies between 60-80% of the initial width in the period of time analyzed. This adjustment is characterized by two phases: the first one started at the end of 19th century, the second and more intensive one began at the end of 20th century. The main causes of Cecina channel changes are associated with man-induced activity such as sediment mining and catchment land use changes (e.g. reforestation). It is observed that channel narrowing is associated with a progressive increase in sinuosity, in some reaches with a change from a multithread pattern towards a sinuous-meandering configuration. All the measurements are used to analyze in detail the spatial and temporal trends in planimetric adjustments and ultimately to derive a conceptual evolution model illustrating the spatial and temporal trends of adjustments.

Abstracts

LOWER PALEOZOIC FLUVIAL DEPOSITS OF ARABIA: FACIES, ENVIRONMENTS AND DEPOSITIONAL STYLES, SAUDI ARABIA

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The fluvial deposits in the lower Paleozoic succession in Saudi Arabia are dominantly siliciclastic sediments that are mostly sandstone dominated with subordinate siltstone or mudstone facies. These lower Paleozoic rocks are exposed locally nonconformably on the Arabian Shield basement complex rocks and also as a long, curve-linear belt around the Arabian Shield in central Saudi Arabia. On and around the Arabian Shield, the main lower Paleozoic siliciclastic fluvial deposits include the Siq Formation, Yatib Formation, Quweira Formation and Saq sandstone Formation in the central and northwestern parts and the Wajid Formation in the southwestern part. The Arabian Shield, which consists of igneous and metamorphic metasedimentary and metavolcanic rocks, is the main sediment detrital sources. In addition, recycled sediments represent a secondary source. These fluvial formations show similarities and differences in their facies, lithology, texture and composition, however, all seem to be characterized by sand dominated stream system with little or scarce fine sediments. Moreover, the fluvial formations show variations in facies types, architecture and their abundances and their vertical and lateral stacking patterns. Different factors appear to have influenced the sedimentation of these formations in terms of facies and depositional styles of their stream systems. These factors include complex controls varying from tectonics, sediment source/basin relief, climate, weathering history and sediment supply. All these factors, in addition to stream autocyclic processes, have contributed to facies and sequence development of these formations from their proximal to distal depositional setting. The sedimentary depositional heterogeneity of these formations has its impacts on their aquifer and reservoir characteristics.

FLUVIAL DYNAMICS, ALLUVIAL ARCHITECTURE AND PALAEOHYDROLOGY OF AXIAL AND TRANSVERSE DRAINAGE SYSTEMS IN AN EXTENSIONAL SETTING: LOS ADOBES FORMATION (APTIAN), CAÑADÓN ASFALTO BASIN, ARGENTINA

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The recognition of axial and transverse drainage systems in extensional settings requires a careful analysis of distribution and scale of fluvial sandstone bodies, palaeocurrent data and changes in fluvial styles across the depocentre. The variable slope and extent of the channels network can be interpreted by variations in sediment flow and discharge of both systems. The fieldwork is based on the analysis of 114 fluvial sandbodies of the Bardas Coloradas Member (Los Adobes Formation) in the Paso de Indios depocenter of the Cañadón Asfalto Basin, covering an area of 420 km2. Major normal faults of the area are NNW-SSE oriented, and the palaeocurrent analysis reveals three main regional sediment flow directions: W-NW (transverse), S-SW (axial) and E-SE (major trunk system). The succession consists of five lithofacies associations (bar deposits, talweg fill deposits, abandoned channel, proximal floodplain and distal floodplain) and eight architectural elements (channel, gravel bed form, sand bed form, dowstream and lateral accretion macroforms, hollow, top bar hollow and overbank fines). Dominance of multi-storey, broad ribbons (61%) and narrow sheets (38%) reflect

bank resistance and rapid filling. Braided sandstone bodies (85%), low sinuosity fluvial sandstone bodies (12%) and meandering channels (3%) were recognized. Axial sandstone bodies show a mean thickness (T) of 5.9m, the mean true width (W) increases downstream from 25m to 109m, and their W/T ratio changes from 14.8 to 42.2 and a meandering system develops downdip. The mean discharge of the axial system decreases downdip from 83 m3/s to 49m3/s, as result of infiltration and evaporation. The thickness of transverse systems increases downstream from 3.5m to 6.2m; their mean width (W) range from 40m to 86m. A maximum bankfull discharge (mbd) of 1535m3/s was obtained at the downstream point of the confluence zone with a transverse tributary system that have a mbd of 1314 m3/s. In a basinward direction the axial channel network links to a regional trunk system draining to the E-SE, the later having a mbd of 4143 m3/s. The proposed sedimentary model is characterized by transverse tributaries that join an axial drainage system, and a major trunk system basinward. The fluvial system records very important changes in water discharge (short and sharp floods) and migration by avulsion mechanism.

VOLCANIC BEDROCK MORPHOLOGY AS A CONTROL ON FLUVIAL PATTERN IN A SEMI-ARID SETTING

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Downstream changes in the fluvial pattern can be imposed by lateral changes in the nature of the substrate, or bedrock proximity. This study analyzes an ephemeral, braided channel that cross an uplifted block of Jurassic basement at Bahía Bustamante, in the northern margin of the Golfo San Jorge basin. Ground Penetrating Radar and vertical trenches were carried out in the valley to characterize the subsurface stratigraphy. GPR transects allowed us to identify six radar facies: 1) subhorizontal, 2) low angle, 3) high angle, 4) concave, 5) convex, 6) irregular and discontinuos. Three radar facies associations were defined: 1) channel, 2) channel fill deposits and 3) bar deposits. The three-dimensional organization of radar facies and superficial features (e.g. braid bars) are consistent with a braided pattern. The width of the river varies from 40 m to 260 m, braid bars ranges from 50 m to 77 m in width and are 79 m-266 m long.

Specific stream power index (SSP) is defined as the Stream Power/Width of the channel belt. SSP data were obtained in five positions along the course of the river. Although the river behaves as a braided river along their entire course, it shows systematical change in the braiding index and SSP, defining aggradational and degradational zones along the course. Degradational zones are characterized by narrow valley widths, they have values of SSP of 0.0156 m2/s and 0.00547 m2/s. The largest SSP value is obtained where the river crosses the volcanic basement, which is also the place where the valley river is narrowest. Aggradational zones show wider valleys, and have SSP values of 0.00049 m2/s, 0.00315 m2/s and 0.000317 m2/s.

The spatial distribution of aggradational and degradational zones along the course of the braided river is interpreted as a response of the river to the location of the volcanic basement along the course. Both the braided pattern and the SSP values evidence the developement of degradational zones where the resisting power<stream power, and aggradational zones where the resisting power > stream power.

ALTERNATING FLUVIAL STYLES WITHIN THE MARITIMES BASIN COMPLEX OF ATLANTIC CANADA: A RECORD OF EQUATORIAL CLIMATE CHANGE DURING THE LATE PALEOZOIC ICE AGE

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The Maritimes Basin complex of Atlantic Canada preserves a thick stratigraphic succession deposited within a low latitude, predominantly continental setting during the Late Paleozoic. Within the Maritimes Basin, a newly recognized fluvial style has been utilized in order to interpret paleoclimatic changes during the Late Paleozoic. This fluvial style is characterized by 1) erosionally based sandstone bodies that display complex and abrupt lateral variations of sandstone and pedogenic mudstones, 2) an abundance of sedimentary structures deposited by high flow conditions such as plane bedding and convex-upward antidune stratification, 3) complex internal stratification produced by plant sediment interactions, and 4) in situ arborescent trees preserved within densely spaced groups that are consistently tilted in a downflow orientation. These characteristics have been interpreted to represent fluvial sandbodies deposited under a tropical climatic regime characterized by flashy, strongly seasonal discharge.

The recognition of this distinct fluvial style has allowed for a refinement of the paleoclimatic evolution of the Maritimes Basin. Four discrete stratigraphic intervals have been recognized lasting from 3-6 m.y. where this fluvial style is prominent, suggesting that a subhumid, strongly seasonal paleoclimate was the dominant imprint on these preserved successions. Fluvial channel bodies characteristic of humid conditions dominate other stratigraphic intervals mainly from the early to middle Pennsylvanian, while fluvial styles characteristic of semiarid to arid environments are dominant in the lowermost and uppermost portion of the studied interval. The recognition of these changes in fluvial style from one stratigraphic interval to the next suggests that systematic changes in paleoclimate of at least regional extent are preserved within the Maritimes Basin. Additionally, these intervals broadly coincide with major periods of southern hemisphere glaciation. Similar periods of fluvial instability are recognized within low latitude fluvial systems within the Cenozoic during periods of major climatic transitions and the fluvial successions within the Maritimes may record a similar, although highly time-averaged, response. The recognition of punctuated periods of strongly seasonal paleoclimate represented by the newly described fluvial style may aid in refining the paleoclimate evolution of similar successions elsewhere in the paleotropics.

MULTIPLE VALLEY FILLS FROM THE LATE QUATERNARY RECORD OF THE TUSCAN COASTAL PLAIN (ITALY)

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Three consecutive, time-equivalent valley fills of Lateglacial-Holocene age (13 to 8 cal kyr BP) were identified in the Tuscan coastal plain, across a 30 km long transect approximately parallel to the present Tyrrhenian Sea shoreline. From South to North, the Arno valley fill is 35-40 m thick and 5-7 km wide, the Serchio valley fill is 15-20 m thick and 7-8 km wide, while the Camaiore valley fill is 20-30 m thick and 8-10 km wide. The three valley fills display remarkably similar facies

architecture, with basal fluvial deposits overlain by a variety of transgressive, mud-dominated coastal plain and estuarine deposits. The valley bodies are capped by a sheet-like, late transgressive succession of shoreline sands grading vertically into offshore clays.

Beneath present Arno River, the valley body consists internally of three superposed millennial-scale cycles bounded by flooding surfaces (parasequences). These cycles display a similar facies architecture, with sharp-based central/outer estuarine clays grading upward into inner-estuary, bay-head delta and coastal-plain deposits. Overall, the three parasequences display an aggradational, rather than retrogradational stacking pattern, which is interpreted to reflect the complex relation between eustatic sea-level rise and sediment supply during the post-LGM transgression. Diagnostic changes in vegetation patterns, driven by opposite climate conditions, enable documentation of parasequence development as a function of climate change. Pollen spectra invariably show expansions of broad-leaved forests at parasequence boundaries, suggesting that rapid shifts to warmer climate conditions accompanied episodes of sea-level rise. In contrast, stillstand phases saw the development of cold-temperate communities, suggesting transition to temporary colder climate conditions.

Stratigraphic architecture beneath the Lateglacial-Holocene valley bodies shows that the coastal system of Tuscany experienced multiple cycles of fluvial incision and subsequent valley filling in response to late Quaternary sea-level fluctuations. Below the LGM fluvial deposits, an older set of estuarine clays is observed at depths ranging from 40 to 90 m. Based upon physical correlations with nearshore deposits, these valley fills are likely to record an older phase of generalized fluvial incision, which is tentatively assigned to the MIS 6-5 transition.

DEVELOPMENT AND EVOLUTION OF A LATE QUATERNARY FLUVIAL CHANNEL BELT: IMPLICATIONS FOR THE INTERPRETATION OF ANCIENT ANALOGUES

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Defining age of ancient fluvial deposits is generally a very difficult task, owing to lack of reliable chronological indicators. In contrast, Quaternary stratigraphy, due to a well known climatic and eustatic history combined with radiometric dating, may provide a well constrained chronostratigraphic framework.

Detailed stratigraphic analysis of middle-late Quaternary fluvial deposits from the Po River Basin, in Northern Italy, reveals distinctive cyclic changes in lithofacies and channel stacking patterns, falling in the Milankovitch (100 kyr) band . Stratigraphic correlations with the coeval nearshore successions document that the lower portions of fluvial cycles, characterized by isolated sand bodies, were deposited during phases of relatively high-accommodation (episodes of sea-level rise under interglacial conditions). In contrast, accumulation of laterally amalgamated fluvial bodies (channel belts) took place during phases of relatively low accommodation, marking the "regressive" maxima (*i.e.*, OIS 2 and OIS 6). A well constrained chronostratigraphic framework indicates that eight major channel belts (aquifer systems), separated by thick mud-prone floodplain successions, were deposited during the last 870 ka, while development of the youngest (LGM) channel-belt took place during an interval of time of about 20 ka.

Comparison of the late Quaternary succession of the Po Basin with the fluvial analogue Escanilla Formation, an Eocene formation commonly applied for reservoir studies,

documents striking analogies in terms of both tectonic setting and fluvial architecture. These include: i) sedimentation in a highly subsiding, actively folded basin; ii) overall thickness of about 800 m; iii) similar cyclic architecture (100 m-thick cycles), with development of 6-8 laterally extensive channel belts.

Whilst new data are increasingly capable of providing a refined stratigraphic framework for the Escanilla Formation, no direct dating is available, and duration of its deposition (1.5 or 7 Ma?) is still problematic. Based upon similarities with modern channel belts, we suggest that most of the Escanilla Formation (i.e., the 550 m-thick Olson Member) is likely to span less than 1 My, and that the unconformities with both underlying Mondot Member and overlying Collegats Formation could account for major stratigraphic hiatuses. This interpretation is consistent with the remarkable homogeneity in terms of both lithology and facies architecture observed across the Olson member, along with lack of highly mature palaeosols throughout the formation.

FLUVIAL EVOLUTION AND SEQUENCE MAPS OF INTRAMOUNTAIN BRAIDED RIVERS, CATAMARCA PROVINCE, ARGENTINA

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The systematic study of sedimentary processes in the present day rivers allows identifying the influence of the individual controls, allocyclic and/or autocyclic, in the fluvial evolution of intramountain braided rivers (Moyano *et al.* 2005, Grignola *et al.* 2006, Georgieff, 2006).

A series of thematic maps were recorded for the Hualfín and Corral Quemado Rivers (Catamarca Province, Northwest of Argentina). Aerial photographs (from 1969), satellite images (from 1996 to 2004) and theodolite and gps mappings (from 2006 to 2008) form the database use to compare seasonal river stages.

Rivers are coming from the boundary between Puna and Pampean Ranges, flow towards south along tectonic valleys and join near the San Fernando Village. The climate is semi-arid with summer torrential rains, noticeable thermal amplitude and poor vegetal cover. These characteristics determine important changes in dynamics and hydraulics of both rivers, e.g.: variations in the channel belt width (banks erosion), bar migrations (lateral and downstream movements) and changes in their patterns after the confluence zone.

In particular, the Corral Quemado River is an ephemeral stream, torrential regime, and the grain size is predominantly sandy (very fine to medium sand, with little contribution of gravel and pebbles); whereas the Hualfín River is semi–permanent stream and the grain size is dominantly coarse (pebbles and cobbles).

The maps overlapping define erosion and deposition areas, changes in the channel belt width, bar migrations and results of the man management as intent to avoid floods. 3D maps of the study area were performed by using field measurements, which allow visualizing better the morphologic changes. Therefore, some results are: a) the relief and the climatic variability of the region determine that both rivers and their confluence present a high rate of erosion and therefore a continuous internal morphologic variation; b) the greater rate of erosion corresponds to the Hualfín River and would indicate a low potential of preservation of its deposits in comparison to the Corral Quemado River. The preservation rate is even smaller downstream of the confluence zone.

UPPER CRETACEOUS - SEDIMENTARY PALEOENVIRONMENTS IN THE NORTHEASTERN MARGIN OF THE NEUQUINA BASIN – THE ANACLETO FORMATION AND THE LOWER MEMBER OF THE ALLEN FORMATION. ARGENTINA

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A detailed sedimentary analysis of Upper Cretaceous deposits, especially those that correspond to the Anacleto Formation and to the lower member of the Allen Formation, was carried out in the northeastern margin of the Neuquina Basin (Neuquén and Río Negro Provinces). The study area is located in the boundary sector between the provinces of Neuquén and Río Negro and the outcrops are located at the north of the Neuquén City (Neuquén Province), along the Route 234 and in the proximity of Cinco Saltos (Río Negro Province) on the left margin of the Neuquén River.

The definition of lithofacies and architectural elements allowed the interpretation of sedimentary paleoenvironments and the realization of a depositional model.

Using information obtained from the facies association, the following fluvial architectural elements were determined: channel, lateral accretion, downstream accretion macroforms, crevasse (channel and splay deposits) and floodplain. Elements influenced by tides were also defined: tidally influenced fluvial channel, tidal channels, levee, supratidal flats, intertidal flats, subtidal flats and tidal bars. The paleoenvironmental reconstruction for the Anacleto Formation consists of a fluvial system with braided, anastomosing and high sinuosity channels; besides of both upper and middle estuary system. Meanwhile a lower estuary system or estuary mouth is characteristic of the lower member of the Allen Formation.

Previous works have defined to the Neuquén Group as a succession of red layers entirely continental formed during a period of total disconnection with the Pacific Ocean. This work allows establishing the Neuquén Group is characterized by typical deposits of marine littoral environments. The contact between the Neuquén and Malargüe Groups was interpreted as the beginning of the Maastrichtian Atlantic ingression.

Based on the detailed study and correlation of the outcrops at regional scale, this work shows that the Anacleto Formation has the first evidences of the Atlantic ingression. Thus, the concepts at regional level of the extension and influence of the eustacy during the late Cretaceous in the ambit of the Neuquina Basin are modified. One of the main aspects that must now be established is the age of the Neuquén Group top or redefining the age of the Atlantic ingression.

TECTONIC GEOMORPHOLOGY OF RAMHORMOZ WATERSHED AREA IN THE ZAGROS FOLD BELT OF SOUTHWESTERN IRAN

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Ramhormoz watershed is part of the Zagros Fold Belt in Khuzestan Province of southwestern Iran. It includes three main rivers namely Rud Zard, Rud Talkh and A'la rivers which combine together to form Ramhormoz River which in turn joins with Jarahi River which enters the Persian Gulf southward. The geomorphology of the catchment area as part of the Zagros Simple Fold Belt is highly influenced by the local and regional tectonic of the area. Tectonic and structural controls on the Ramhormoz watershed are the main targets of this study due to the build of three dams in next future. The tectonic setting is characterized by large thrust faults and the occurrence of several landslides, which involve deformable and low competent sediments (especially marl, silt and evaporitic deposits). The most rivers are

tranverse-type which can be geomorphologically classified as antecedent drainage. In some parts, the rivers run parallel to the strike of anticlines being locally coincident with fault traces. The river courses through the mountainous part of the studied area are generally SE-NW (Zagros trend) whereas they change to NE-SW or N-S (Arabian trend) in the plain part. The location of the landslides is related to the fault junctions. Thrusting of conformable over more competent ones facilitated sliding in the area. This study shows the importance to analyze the tectonic geomorphology in order to improve the future watershed management projects related to geotechniques of the future dam reservoirs. The results also show that lithological diversity and complexity of the geological structures have key roles on the geomorphology of the area.

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HIGH FREQUENCE CICLICITY IN CONTINENTAL SYSTEMS: EXAMPLE OF FM. TORDILLO, UPPER JURASSIC NEUQUÉN BASIN ARGENTINA

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The genesis of the cyclicity in continental sediments without connection with the sea has been intensively studied in modern stratigraphy. The existence of upstream allogenic controls (tectonic and climate – Catuneanu 2006) and others associated with the dynamics of the own system (autogenic) give a very complex scenario in which is not always easy to recognize the prevalence of one above the other.

The existence in the continental rock record of different frequency cycles with high and low accomodation or humid and dry conditions alternated are very common.

Therefore we can predict that the external controls (allocyclic) are systematically present in continental deposition.

In the Neuquén basin the fluvial – eolian Tordillo Fm. is a very good example of the presence of different hierarchic cycles where the predominance of humid (fluvial – humid eolian intervals) or dry conditions (dry eolian systems) is of paramount importance in the reservoir behavior of the rocks and the prediction of hydrocarbon productivity.

The change in the correlation philosophy from a lithostratigraphic to a chronostratigraphic style have produced a very deep impact in the comprehension and predictability of the local to regional distribution of production zones in the most important reservoir interval of the Basin.

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THE PROCESSES AND DEPOSITIONAL ARCHITECTURE OF BIG RIVERS: THE RIO PARANÁ, ARGENTINA

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Little is known about the processes, dynamics and deposits of the world's largest multi-thread rivers and whether they are different from smaller (less than 1 km wide) rivers. This paper reports on a combined field and numerical modelling campaign on the sandy Rio Paraná, Argentina – the world's 6th largest river.

Bathymetric and 3D flow data were taken in a 38 km long, 4 km wide reach using single-beam echo sounders, acoustic Doppler current profilers and dGPS. Results demonstrate that the main channels of the Paraná at low flow are dominated by dunes up to 3.5 m high and less common unit bars 2-5 m high with some up to 10 m high. The deposits of eight km-scale mid-channel bars were characterised by 43 km of Ground 4~Penetrating Radar (GPR) with penetration down to 10 m, and 28, m-deep suction cores. The internal structure of mid-channel bars is dominated by (i) decimetre to sub-m high, stacked dune sets, (ii) up to 7 m thick, high-angle, bar margin sets, and (iii) decimetre-thick ripple sets, most commonly, but not exclusively found at the bartop. Re-activation surfaces on bar margins are common. Between 2-7 stacked unit bars make up a mid-channel bar.

Numerical modelling of flow, sediment transport and morphological change in the 38 km study reach show a good match between field and model flow distributions. Simulated channel change is characterised by talweg shifting and the formation and migration of low-relief bedforms with dimensions similar to unit bars observed in the field (height ~3-5 m, wavelength 1-2 km). Field-model data suggest a need to: (i) understand the contribution of unit bars to big river sedimentology, and (ii) establish why the majority of the Paraná channel-belt is stable over decadal time scales.

FACIES CHARACTERISTICS AND ORIGIN OF THE QUATERNARY SEDIMENTS IN THE NILE VALLEY, EGYPT

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The lithostratigraphic studies of the exposed Quaternary sequence at Idfu, Qena and Beni Suef in the Nile valley of Egypt allowed to differentiate it into six rock units namely, Idfu, Armant, Abbassia, Makhadma and Warsha Formations.

Representative samples were subjected for size analysis, heavy mineral separations and petrographic investigations.

The studied Quaternary sediments reflect aqueous sedimentation processes. The gravel of Idfu Formation are mainly rounded to well rounded reflecting long way run derived from different basement rock types of the Eastern Desert mixed with short way run sediments of Nile load origin.

The gravel of Armant, Makhadma and Issawia Formations are angular to subangular indicating short way run derived from the surrounded and nearby sedimentary sequences. The Warsha gravels which are mainly angular to subangular and rounded to subrounded pebbles and granules of sedimentary and fewly volcanic origin indicate derivation from nearby Eocene and volcanic rocks of the Eastern Desert.

Zircon, epidote, staurolite, kyanite, garnet, rutile and tourmaline are the main heavy minerals detected in the sands of Idfu and Armant Formations with varying degrees of abundance.

The combination of sedimentological characteristics of the studied Quaternary sed-

iments indicate that during the Quaternary (Pleistocene) torrential activities in the Eastern Desert together with Nile flooding led to the deposition of the studied rock units.

HIGH-FREQUENCY VARIATIONS IN ACCOMMODATION SPACE IN PUNTA SAN ANDRÉS ALLOFORMATION (PLIO-PLEISTOCENE), BUENOS AIRES PROVINCE, ARGENTINA

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The continental deposits of the Punta San Andrés Alloformation (Plio-Pleistocene) crop-out in the marine cliffs of south-eastern Buenos Aires Province (Mar del Plata City, Argentina). Deposits of this unit have been assigned to different sub-environments such as floodplains, fluvial channels and temporary water bodies according to their facies association and geometry (tabular, wedge-shaped or lenticular). Their lateral and vertical arrangement allows to identify three different sections, each of which represents a different sedimentary sub-environment and different accommodational conditions.

The first and lower section is characterized by floodplain deposits (crevasse-splay deposits and paleosoils). The few channel bodies found in this lower section have a simple geometry, with width/length ratio < 10 in all cases and monoepisodic filling. This lower section is considered to represent an area distal form the heads, where paleotopography, fluctuating climate and drainage design lead to the development of extensive floodplains cut by episodic, short-lived straight or low sinuosity channels associated to food events or storms. Regarding the paleosoils, a cyclic alternation was found between calcic paleosoils and hydromorfic paleosoils which was interpreted as cyclicity between dry and humid climates. Accommodation during this period was positive, but high-frequency fluctuations were defined between hydromorphic paleosoils – higher accommodation space- and calcic paleosoils – less accommodation space.

It's worth saying that channels in this lower section are amalgamated vertically with channels developed in the upper sections, constituting multistorey channels. Because of this, some areas are dominated by tabular geometries of floodplain deposits and others by channelized geometries which reflect areas that remained preferentially incised during Plio-Pleistocene times.

The middle section is characterized by coarser floodplain deposits and is much more dissected by channels, which have multiepisodic filling and a complex geometry. This section is interpreted as a floodplain proximal to the heads. Paleosoils in this section are represented by hydromophic horizons with little participation of calcic facies. Accommodation during this period is interpreted to have been positive but reduced when compared to the lower section.

The upper section is characterized by deposits of mobile, high-sinuosity channels. Floodplain deposits are barely represented and highly dissected. Development of fluvial channels is related to periods of diminishing accommodation space, probably due to a drop in local base level and/or an increase in precipitations. Filling of the channels indicates a subsequent raise in local base level and re-establishment of positive accommodation space.

To summarize, the geometric and facial analysis of Punta San Andrés Alloformation deposits allowed to identify depositional environments which vertical and lateral distribution show a progressive change in accommodation and plaeoclimatic conditions. Dry and arid periods related to little accommodation space alternate with wetter periods related to higher accommodation space and finally to a more important drop in local base level leading to general fluvial incision and negative accommodation space.

ON THE INFLUENCE OF DENSITY DIFFERENCES BETWEEN MIXING FLOWS AT RIVER CONFLUENCES

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Channel confluences form key nodes within all alluvial networks and extensive research over the past 25 years has shown how the dynamics of mixing at these sites, and nature of the bed morphology, are controlled by the junction angle, the momentum ratio between the two confluent flows, the junction planform shape and the nature of any bed height discordance between the two channels. Although remote sensing of many open channel confluences, particularly of larger rivers, often reveals a difference in turbidity between the two flows, there has been little work conducted on how the density differences that such turbidity contrasts may generate may influence the dynamics of mixing at confluences.

This paper presents results from a field study of flow and bed morphology at the confluence of the Río Bermejo and Río Paraguay, Argentina, where the sediment load, and thus bulk density, of the Río Bermejo flow is always greater than that of the Río Paraguay. The Río Bermejo is an important river in the Paraná basin as, although it may only contribute ~5% of the fluid discharge to the Río Paraná, it may contribute up to ~80% of the total wash load. Surveys of the confluence were undertaken in May 2005 and April 2007, when the discharge ratio between the two rivers (Bermejo: Paraguay) was 0.17 (combined discharge ~ 2800 m3s-1) and 0.23 (combined discharge ~ 5050 m3s-1) respectively. However, in 2007 the density excess of the Río Bermejo over the Río Paraguay was 5.1 kg m-3, whilst in the study period in 2005 it was 2.2 kg m-3. Fluid mixing at this site is dominated by a density underflow from the Río Bermejo that penetrates underneath the fluid of the Río Paraguay and then upwells at the outer bank of the Río Paraguay downstream from the confluence. Mixing occurs through instabilities along the shear layer between the two flows, fluid instabilities along the top of the underflow current, topographic forcing over bedforms and interactions with the channel banks. This paper will illustrate these mechanisms of mixing and the possible significance of density contrasts between confluent flows in determining the morphodynamics at such channel junctions.

VISUALIZATION OF DUNE AND BAR-GENERATED TURBULENCE AND SEDIMENT SUSPENSION: IMAGES FROM THE SOUTH SASKATCHEWAN RIVER, CANADA, AND IMPLICATIONS FOR SUSPENDED SEDIMENT RATING CURVES

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It has long been known that form roughness, such as dunes and bars, can generate large-scale turbulence that can dominate the temporary suspension of sediment within many rivers. Several studies have linked such large-scale turbulence to high instantaneous sediment fluxes, and shown how the fluid upwellings produced by form roughness may dominate the flow structure of many channels, especially those with high width:depth ratios. Such upwellings are commonly seen as 'boils' on the surface of many rivers and range from decimetres to metres in diameter.

This paper presents images of form-roughness generated macroturbulence that were recorded from low-level aerial photogrammetric surveys that were flown over the sand-bedded South Saskatchewan River, Canada. The South Saskatchewan River was dammed upstream of the study reach in 1964 and hence is now relatively clear, enabling suspended sediment fluxes to be visualized within the water column at most stages. We will present images, taken at a range of flow stages, which show the form of such upwellings associated with sand dunes and with the fronts of unit and compound bars. Dunes are seen to provide periodic point-source ejections of sediment that erupt on the flow surface, and are manifested as a trail of circular/ovoid upwellings on the water surface. Sediment suspension over bar fronts occurs over a greater width and appears to generate a more continuous source of partially-suspended sediment. The suspended sediment rating curve for the river now shows an increase in its slope at 330-403 m3s-1, and it is suggested this break corresponds to the increased influence of form roughness in generating sediment suspension.

CONTINENTAL SHELVES AS THE LOWSTAND FLUVIAL LONGITUDINAL PROFILE

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Lowstand fluvial profiles represent the first-order morphodynamic state for continental shelves, and river long profiles are fundamentally graded to shelf margins. Over the last 10^6 yrs mean sea level has been -60 to 65 m, with a mode at -85 to -90: for most of this time, the majority of shelves would have been subaerial. Long profiles for river systems have equilibrium times >10^4 to 10^5 yrs: they should be adjusted to mean conditions over time scales that are = equilibrium times, and insensitive to the anomalous and infrequent highstands like that of the Holocene. On a global scale, it is well known that channel gradients correlate inversely to drainage basin areas: similarly, shelf gradients and width correlate to onshore fluvial gradients and drainage areas, such that >50% of the variance in shelf width for the midlatitudes and tropics is explained by contributing drainage basin area alone.

In an icehouse world, high-frequency climate changes are coupled to changes in ice volume, and unsteadiness of sediment supply due to climate change is modulated by the transit of river mouths across the shelf. Moreover, transit of river mouths across a broad shelf results in the merger of drainage basins that, in a highstand world, discharge separately to the coastal oceans: merging of drainage basins increases individual point-source sediment supply, but there will be fewer river mouths and delta systems at the shelf margin than there are during highstand time. These relationships must be different in a Greenhouse world because the high frequency, long distance transit of river mouths, and merger of drainage basins should not occur to the same degree. In an Icehouse world, major high-frequency changes in fluvial-deltaic, shelf-margin, slope, and basin-floor stratal packages will reflect fluvial responses to sea-level change. By contrast, in a Greenhouse world, high-frequency stratigraphic packaging should be closely coupled to unsteadiness in sediment supply due to climate change, rather than modulated by fluvial transit of the shelf, and merging of drainages.

ROLE OF INCISED-VALLEY SYSTEMS IN SOURCE-TO-SINK SEDIMENT ROUTING AND STORAGE: EXAMPLES FROM THE LATE QUATERNARY NORTHERN GULF OF MEXICO MARGIN

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Incised-valley systems form in response to sea-level fall, as fluvial systems extend

across newly subaerial shelves to the lowstand shoreline and shelf margin. Recent work on Late Quaternary systems of the Gulf of Mexico passive margin illustrate how sediment supply might change over the course of a glacio-eustatic cycle, and how the evolution of incised-valley systems modulates source-to-sink sediment routing to deepwater environments.

First, empirical data that links sediment supply to climate suggests supply from the hinterlands should decrease during glacio-eustatic sea-level fall and lowstand due to temperature depression. Hence, supply from the hinterland may be (a) at a maximum when river mouths reside in highstand positions, and sediment storage takes place on the coastal plain and inner shelf, and (b) at a minimum when river systems are extended to the shelf margin lowstand shoreline and directly feeding the slope and basin floor.

Second, studies of late Quaternary systems, where deposits can be mapped and dated independent of sea-level change, make it clear that incised valleys form in a step-wise manner in response to sea-level fall and lowstand, with short periods of incision punctuated by extended periods of lateral channel migration, valley widening, and deposition of channel-belt sands. Step-wise incision and lateral channel migration is the process that creates the basal valley-fill surface, as well as controls the overall dimensions of the incised valley. The timing of incision and channel-belt deposition on the evolving valley-fill surface varies between river systems due to a variety of controls. The total volume of sediment exported during the period of incised-valley formation is a relatively small value compared to the ongoing flux from the hinterlands, and short periods of incision likely produce an insignificant amount. However, periods of lateral channel migration and valley widening significantly increase the export of sediment, perhaps by 25% over background rates, such that periods of fluvial deposition during sea-level fall and lowstand corresponds to increased sediment delivery to the shelf margin.

Finally, for low-gradient continental margins with broad shelves, like those of the Late Quaternary Gulf of Mexico, drainage basins merge as channels extend across the shelf, which in turn increases drainage areas that contribute to single point sources at the shelf margin. Apparent signals of increased or decreased flux of sediment to the shelf margin and beyond may reflect geomorphic response to sea-level change - the merging of drainages as they transit the shelf - rather than changes in supply from the hinterland.

LAS CUMBRES FORMATION (EARLY PLEISTOCENE), AN EXAMPLE OF THE OROGENY CLIMAX TECTOFACIES IN THE PAMPEAN RANGES

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Las Cumbres Formation is an Early Pleistocene coarsening-upward succession composed mainly by conglomerates laying over the Salicas (Pliocene) sandstones. The top of the unit is the original geomorphic depositional surface. In some places like, in Villa Mervil, the unit lays disconformably over the Salicas Formation but in others, like in Alpasinche, the formational limit is a long transition. At the northeast extreme of the Velasco Range, a ring of low hills (named Cumbres de Los Pozuelos) shows to the Las Cumbres Formation as a complex system of allounits separated by angular unconformities, which are related to Uscamayo Fault, an active synsedimentary fault in Pleistocen times.

Las Cumbres Formation is one of the typical conglomerate units developed as very extensive alluvial bahada coming down from the emerging ranges during the climax of the tectonic inversion of the area. The conglomerates entered deep into the “Bolson de Pipanaco”, the biggest intramountain basin of the Pampean Ranges. The sedimentary

succession shows an alternation of lenticular bodies of either massive or graded coarse conglomerates and ill-laminated better sorted fine conglomerates. The coarser facies form tabular bodies with occasional oversized blocks and were interpreted as debris flows while the better sorted facies were assigned to water laid deposits related to ephemeral channels and chutes forming a distributary system. Texture, angularity and composition of the pebbles indicate a combined provenance from the Velasco (South), Vinquis and Zapata (North) and Paimán (West) Ranges, according to the measured paleocurrents. Paleocurrent and maximum pebble size maps composition indicate displacements of the compositional facies from the location of their source areas, which could be related to the activity of a regional left transcurrent fault (known as Lineamiento Tucumán), and moved the whole sedimentary system during the deposition of the conglomerates.

THE RED BEDS OF HUALFÍN FORMATION IN THE SYNRIFT STAGE OF PAMPEAN RANGES, NORTHWEST OF ARGENTINA: PALEOGEOGRAPHIC AND ENVIRONMENTAL IMPLICATIONS

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Hualfín Formation represents the early infill of the Santa María – Hualfín Basin in the Northwestern Pampean Ranges of Argentina. The unit is composed of well indurated dark red sandstones alternating with minor shale's, laying over the Pampean Peneplain. Facies associations are dominated by massive to parallel laminated medium to fine grained sandstones forming tabular lateral extensive beds (80%), irregularly cut by lenticular medium sandstones with trough cross bedding (15%), assumed to be shallow channel facies and thin tabular fine laminated shales. Conglomerates are scarce and concentrated near the base of the succession. Isolated small and rounded pebbles occur in the channel facies. The clasts are mainly from granite and low grade metamorphic rocks, with minor proportion of volcanic rocks and tuff paraclasts. Associated with the water laid facies there are also very thick horizons of crossbedded sandstones, laying over a flat erosive surface. Fine grain fall lamination alternates with grain flow thicker lamina indicates an eolian origin.

Most indirect age evidence located the sedimentation time in the Paleogene, in a time previous to the developping of the near basin eastern volcanic arc of the Puna. In the Hualfín Range and in the Campo del Arenal, the sedimentation of the unit was controlled by a normal synsedimentary fault system oriented NE-SW, that imposed local variation of the thickness of the unit (between 50 to 200 m).

Dominant facies indicates sheetflood sedimentation in a very extensive plain near sea level, under an arid climate with distant and low relief source areas, strongly oxidizing. Channel deposits are thin lenticular units composed of trough cross - bedding sandstone with minor indication of channel and bar developpings. The eolian horizons are located in the upper part of the unit when these sandy units reached the maximum development The normally ephemeral and dry fluvial system was an excellent repository for the dune fields formed by better sorted sandstones.

Another unit of similar age with extensive dune fields interstratified with the same fluvial facies is known as Quebrada de los Colorados Formation, outcropping about 300 km to the north of the study area, in the Calchaquí Valley. In some places where the unit is absent, as in El Cajón Valley, the surface of the Pampean Peneplain is full of impact marks generated by wind erosion.

The low land paleogeography of the area during Paleogene times associated with the convergence of the Hadley-Ferrel atmospheric cells is a well fitted scenario for the highly oxidized arid fluvial facies alternating with eolian field.

NATURAL AND ANTHROPICAL FACTORS AFFECTING MODERN RIVERS AND RESERVOIRS IN A SEMIARID BASIN. TAPIA - TRANCAS BASIN, TUCUMÁN, ARGENTINA

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Present day rivers are certainly affected by human activity and natural factors. In the same way, the dam construction increases the impact on the modern rivers. Among others anthropical factors, mainly agriculture and deforestation, the amount of runoff and sediment transported to rivers and deposited in reservoirs are increasing during the last decades.

Celestino Gelsi reservoir is the biggest reservoir in the Tucumán Province, Argentina. Since 1966, sediment deposition and loss of impoundment capacity were documented and referred as consequences of mismanagement practices, on agricultural lands and, deforestation in the Tapia – Trancas upstream area (Adler, 2004).

RUSLE model, (Renard *et al.*, 1997), was applied to quantify soil loss for the basin area. R-factor was calculated, according to Renard and Freimund (1994), two periods were considered: 1) from 1935 to 1962 and, 2) from 1963 to 1990. The values of R factor, obtained were greater in the period 1963-1990 than in the period of 1935-1962, probably related to an increase in mean annual and monthly rainfall in the source area during the second period. Same trend in rainfall amount was reported by Minetti and Gonzales (2006) for other areas in NW region of Argentina and Piovano *et al.* (2002) for central area of Argentina. Also increased amounts of discharge entering the Reservoir were registred for the period 1967 to 1996, according to the database from Hydrologic Resources Department (Dirección de Recursos Hidricos of Tucumán).

Satellite images (Landsat 5 TM from1988/08/15, 1997/08/24 and 2007/07/19) were analyzed to detect changes in vegetative cover, specifically deforestation, and changes from natural vegetative cover to agricultural lands, for the last 30 years. LandSat images were analyzed to record also changes in the delta of Sali River at the reservoir.

Expansion of agricultural lands was observed mainly in lowland areas along the Sali river Valley and in the east region of the basin (piedmont areas of the Sierras de Medina). Changes in river morphology at the delta, sediment deposits and stabilization of deposits with vegetation were observed comparing Landsat 5 TM for different dates. Changes observed could be related to both, natural and anthropical factors. First, change in base level due to the presence of the reservoir and the adaptation of the fluvial system to the new base level, also increased rainfall amount an its consequent raise in sediment yield. In second place mismanagement practices related to land use could have affected the balance of sediment leaving the basin area.

PALEOFLUVIAL SYSTEMS IN THE WESTERN CHACO PLAIN, TUCUMÁN PROVINCE, ARGENTINA

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The aims of the work was study de evolution of the western fluvio-eolian plain in the Tucumán Province. The analysis of the paleofluvial features of the study area, using photointerpretation and field observations, allowed mapping and classifying the geoforms created by past river dynamics. Paleochannels with structural control, migrating paleochannels and paleochannels turned into ravines by human-induced erosion were characterized according to their morphology and/or genesis.

The paleochannels with structural control,

are elongated flat-bottom valleys run down to the plain as shallow, sometimes buried. The morphology of the paleoforms suggests that they were developed by NW-SE running streams with moderate energy and high competence. Although they are presently inactive, subsurface or even surface runoff during heavy rain periods might occur. River behavior seems to be related to paleofluvial conditions, together with fault and fracture control.

The migrating paleochannels are frequent throughout the fluvio-eolian plain, occurring as shallow channeled depressions generally masked by crops or artificial drenaige. Such channels can be attributed to relatively recent overflows from the Tajamar river. They served as local collectors of excess water during heavy rain periods, when the region was still covered by Chaco forest. Nowadays, they behave as local areas of runoff storage on soils having high capacity for moisture retention that plays an important role during drought periods.

The fluvial paleovalleys, are located in the western sector of the study area, large elongated depressions, similar to real fluvial valleys, start in the fluvio-eolian on the west and extend southward over several tens of kilometers and disappear in the saline depressions of Santiago del Estero province. They seem to be related to intensive head-retreat erosion during the moist Holocene periods, with runoff increase from the west, and/or to changes in the eastern base level by neotectonic reactivation. In all cases, ravine heads are located in the plain, not in the piedmont. This could be related to the existence of an area depressed by tectonics that would have diminished river incision, and/or be caused by decrease in water supply from the west due to climatic change. All these channels coincide, in some stretch of their courses, with structural features causing slightly asymmetric margins. Additionally, mass movements might have contributed not only to channel widening but also to channel stabilization through creeps and flows from the hillsides.

THE RIERA DE SOBIRANS (NE, SPAIN) MODEL OF OVERELEVATED TORRENTIAL CHANNELS: SEDIMENTARY CHARACTERISTICS

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In the Quaternary of the Maresme there are a number of natural overelevated straight streams of torrent channels located at a level higher than the surrounding floodplains. These overelevated streams show a distinct morphology and a channelized convex-up sedimentary body where the vertical accretion and the levee growth episodes are coeval. These streams are characterized by episodic water discharges that are interrupted by prolonged dry periods with no superficial water discharge.

The ”Riera” type stream corresponds to a single channel of a sandy braided river. It is short with steep gradient from 3.2% to 3.4% in the Riera d’Arenys (Sobirans). The source area is made up of granitic rocks that supply large amounts of sandy sediments. The “Ramblas”, located in the Barcelonès and Maresme areas, are good examples of overelevated streams.

The term “Sobirans” is proposed for this new model.

ESTIMATION OF SUSPENSION SEDIMENT VOLUME IN TO THE FUTURE DAM OF POTRERO DE LAS TABLAS ON RIO LULES. TUCUMAN PROVINCE. REPUBLICA ARGENTINA

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The application of the methods of USLE, MUSLE, GAVRILOFF and MATHEMATICAL CORRELATION OF LIQUID AND SOLID VOLUMES is made, to estimate expectable future volume of suspension sediment in dam of Potrero de las Tablas, on the Lules River in the Province of Tucumán, Argentine Republic. The necessary parameters for the application of the mentioned methods are determined and the hypotheses of work and the results obtained with each one are compared.

The information to use is included in the topics of morphology, hydrometric, hydrometeorology, land use and fluvial hydraulics.

The results of the comparison are expressed graphically and in percentage.

Conclusions are obtained about the effectiveness of the methods applied in mountain river basins as the one of the Lules River and the consequences of the sediment deposit in the future dams are analyzed.

AN ESTUARINE FOSSIL ASSEMBLAGE FROM THE YACORAITE FORMATION (MAASTRICHTIAN-DANIAN) AND ITS PALEOENVIRONMENTAL SIGNIFICANCE. JUJUY - NORTHWESTERN ARGENTINE

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We describe a brackish water fossil assemblage from Yacoraite Formation (Maastrichtian – Danian), in the localities of Maimará and Jueya, Jujuy - Northwest Argentine. The dominant lithology of the study levels is characterized by a calcareous sandstones succession, with ripplestratified structure, fining-upward. Fine to very fine sandstone lenses occur in this fossiliferous interval. The sandstones are interpreted as storm washover deposits. In these sequences we have found numerous disarticulated remains of fishes (Pycnodontiforms and Siluriforms), fragments of tetrapods? (Tetrapoda), a tooth of crocodile (Crocodylidae), preserved mollusks (Gastropods and Bivalves) of problematic taxonomy, stromatolites (LLHC, LLHS and dome type). Also was identified a set of fossil traces integrated by traces of birds (Avipedidae) and Skolitos ichnofacies , besides a Domichnia trace on an estromatolitic rock, caused by a perforant bivalve, also preserved. The study of the fossils assemblage, traces, sediments, and sedimentary structures indicates a brackish mixed environment, of low depth and high energy, probably estuarine.

GRADUAL LATERAL RIVER MIGRATION INDUCED BY LATERAL FLOODPLAIN TILTING; A 3D NUMERICAL SIMULATION

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Counter-intuitively meandering rivers may migrate laterally upslope (Nanson, 1980; Peakall *et al.*, 2000). Using the Channel Hillslope Integrated Landscape Development Model (CHILD; Tucker et al, 2001; Clevis *et al.*, 2006) the effects of different tilting rates were analysed. During relatively strong tilting (3.10^{-5} rad/1000 yr) river migration was found to be down-slope, and at lower tilting rates (2.10^{-5} rad/1000 yr) upslope migration occurs, while avulsions and crevasses were not considered in the model.

A faster rate of meander expansion on the lower side and the resulting preferential

meander cut-off was identified as one of the mechanisms behind upslope migration (Nanson, 1980). Another potential element in upslope migration suggested by the numerical simulations is the relatively fast overbank accumulation on the lower side floodplain. This may reverse the slope near the locus of the river bed and thus the direction of lateral migration.

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NEOPROTEROZOIC FLUVIAL-DELTAIC DEPOSITS OF THE AMAZON CRATON: THE PROSPERANÇA FORMATION, STATE OF AMAZONAS, BRAZIL

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Neoproterozoic sedimentary rocks represented by the Prosperança Formation, covering the Guianas Shield in the northern part of the Amazon craton, are poorly exposed when compared with the Paleo to Mesoproterozoic sedimentary record of this craton. The Prosperança Formation consists of conglomerates, arkosic sandstones and mudstones, which fill graben structures. This unit is overlain unconformably by carbonate rocks of the Acari Formation (Neoproterozoic) observed only in cores. These formations represent the basement of the oil producing Paleozoic basins of Amazonia and the precise characterization and paleoenvironmental reconstruction is important for their distinction from Paleozoic units. The stratigraphic analysis of the Prosperança Formation was carried out along the margin of the Negro and Jaú rivers at the northern part of State of Amazonas. Three facies associations were recognized and interpreted as products of a fluvial-deltaic system: 1) prodelta/lacustrine, exhibiting laterally extensive sandstones/mudstones rhythmites and mudstones interbedded with decimeter thick lenses of climbing ripple cross-laminated sandstones; 2) delta front, consisting of fine sandstones with complex cross-stratification characterized by sigmoidal strata, low angle to planar and climbing ripple cross-laminations, locally associated with deformational sedimentary structures; and 3) fluvial braided plain, comprised of medium to coarse sandstones with planar and trough-cross bedding. The sigmoidal lobes of the delta front were fed by braided distributaries that migrated mainly to SW, under hyperpycnal flow conditions. Rhythmites and mudstones distributed along several kilometers suggest a widespread sedimentary basin probably of lacustrine origin. Lenticular medium to coarse sandstones are related to migration of subaqueous dunes, associated to fluvial-braided processes. The top of the Prosperança Formation is marked by an expressive erosional surface interpreted as a sequence boundary. This interpretation is reinforced by the occurrence of an iron-rich sandy-pelitic mottled to columnar horizon attributed to a paleosol. The trough cross-bedded sandstones, possibly of Paleozoic age, which overlies unconformably the Prosperança Formation migrated to NE and is in contrast to the SW-directed cross-stratification of the Prosperança sandstones

FLUVIAL RESPONSE TECTONIC FOLDING AND TILTING IN THE EOCENE FORELAND BASIN, NW ARGENTINA

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The Andean foreland basin (Middle Eocene-Present) in northwest of Argentina is characterized by very thick (ca. 8000 meters) and coarsening upwards sequences deposited in fluvial and alluvial fan environments. The Middle Eocene basal deposits are well-recorded in the Puna-Cordillera Oriental transition, where syn-tectonic sedimentation in a complex style basin has been recently documented (Hongn *et al.*, 2007).

These basal orogenic sequences are characterized by thick reddish siltstones and fine- to coarse- grained sandstones and conglomeratic levels deposited in extensive floodplains and moderately sinuous channels and bar- braided alluvial settings. Notwithstanding local tectonic activity produced variations in the fluvial drainage.

Well-exposed tectonic structures at Saladillo (northern Calchaquí valley) permit confidence fluvial architectural reconstructions. A west-vergent growth fold produced progressive unconformity surfaces and cumulative wedge-fan strata geometry. Strata are sandy fluvial channels and are characterized by fined-grained sandstones and very shallow channels in the pre-growth levels to coarse-grained sandstones and narrowing of channels in the sin-growth levels. Once the folding processes ceased the sedimentation re-establish it previous equilibrium with fined-grained sedimentation in the post-growth levels. In this case, the coeval folding aroused local migration, and steepening of the fluvial gradient.

On the other hand, in the Tres Cruces area (Jujuy province), the sin-sedimentary deformation is only evident by the careful observation of channels position up sequence. In this area, basal Andean foreland sequences are characterized by highly lenticular sandy channels interbedded in floodplain siltstones. The channels' position shifted step by step up section suggesting pulsate migration of the thalweg of the valley. This stratigraphic relation is interpreted as consequence of local slow lateral cross-valley tilting.

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INTEGRATED MODELING OF FLUVIAL FAN FRINGE SHEET SANDSTONE: TEN BOER CLAYSTONE MEMBER, SOUTHERN PERMIAN BASIN, NW EUROPE

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The secondary reservoir potential of fluvial sheet sandstone beds in the Ten Boer Claystone Member (TBCM) was investigated, with the aim to boost gas production in declining smaller fields surrounding the giant Dutch Rotliegend Slochteren Gas Field. The TBCM is a 40-110-m-thick shale-prone succession with thin fluvial sheet sandstone beds deposited on a mud flat at the edge of the Silverpit Desert Lake in the Southern Permian Basin of northwest Europe. Sedimentary structures in the 5-50 cm thick, very-fine to medium-grained sandstone beds are wave ripple lamination, climbing-ripple and trough cross-lamination. Sand injection structures are common. Combined core and well-log analysis allowed for the subdivision

of the succession in lithofacies cycles. Each cycle comprises a shaley base, a sandy-silty middle part and a shaley top, interpreted as the result of wet-dry-wet climate cyclicity. Log correlation of the TBCM succession in a 300 by 160 km area resulted in a 3-D static reservoir architecture model of the fluvial sheet sandstone and showed the development in space and time of nested sandstone sheets at the end of widely spaced south-north elongated fluvial pathways.

Challenges were to assess the size, shape, spatial distribution and connectivity of the sheet sandstone. To achieve this, an outcrop analogue study and process-driven forward modeling experiments were carried out. The outcrop study in the distal part of the Huesca Fluvial Fan (Miocene, Spain) provided a depositional model and size and shape data of terminal sheet and crevasse splay and associated meandering river sandstone. The data sets were used as input in forward modeling experiments. Depositional scenarios were performed for two populations of fluvial channels: larger channels representative for the lower floodplain and smaller, distributary channels at the most distal fringes of the fluvial fan. The model results provided insight in plume depositional thickness, area and volumes and distribution of sand deposited at the mouth of these channels.

The results of this study provide scenarios to assess volume and connectivity potential of thin-bedded distal fluvial reservoir sandstone bodies in the TBCM.

GEOMORPHOLOGICAL DEVELOPMENT OF THE ATACAMA PLANATION SURFACE

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The Atacama Planation Surface forms an extensive westerly dipping, planar surface developed between 17°S and 27°S along the Pacific margin of South America. The planation surface is assumed to have formed at a single time and has been used to constrain both the onset of the hyperarid climate regime that currently prevails along western coast of South America and the beginning of Andean uplift. The surface is formed due to alluvial-fluvial processes and is well developed on the western flank of the High Andes where it can be traced westwards from over 3000 m to 1000 m in the Longitudinal Valley of northern Chile and close to sea-level in northernmost Chile and southern Peru. It ranges from 30 to 100 km in width and dips westwards at between 1.5 and 3°. The pediplain comprises 1 to 10 m thick gravels that unconformably overlie a 3 to 8° westerly dipping erosion surface developed on underlying Oligo-Miocene sediments and Paleocene and older igneous rocks. Age constraints based on stratigraphic relationships bracket the age of formation as between 16 and 8.3 Ma.

Analysis of satellite imagery, aerial photographs and field studies reveal the presence of extensive alluvial-fluvial networks developed on the surface. These surfaces were characterised and correlated from Southern Peru through to the Central Depression. By using cross cutting relationships, previous studies of the planation surfaces, cosmogenic isotope exposure ages and the age of supergene enrichment located on each surface the chronostratigraphy of the planation surface can be reconstructed. These observations for planation surface formation indicate that it is a composite feature comprising a number of depositional and erosional events superimposed on each other which predate Andean uplift and formed during a number of 'wetter' phases related to global climatic events dating back to 23 Ma.

A SEDIMENTARY QUANTITATIVE MODEL FOR THE BAJO BARREAL FORMATION (CRETACEOUS): INTEGRATION BETWEEN OUTCROPS AND SUBSURFACE DATA. SAN JORGE BASIN, SANTA CRUZ, ARGENTINA

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The outcrops around the La Sin Nombre Lake belong to the Bajo Barreal Formation (Cretaceous, Chubut Group). These deposits are analogs to the hydrocarbon-bearing reservoirs in the adjacent Cerro Guadal Norte oil field (YPF SA). At the present day, the Bajo Barreal Formation is the major oil unit in the San Jorge Basin (Santa Cruz Province, Argentina). The distance between outcrops and the nearest oil well is about 600m and this one is towards the East-Northeast direction of the outcrops.

In the outcrops, the dip ranges from 45ºE (in the base) to 15ºE (at the top). A vertical stratigraphic profile was measured in the outcrops and 15 fluvial sandstone bodies were recorded. The thicknesses of the sandstone bodies vary from 1.5 to 3 m and the width from tens to hundreds meters. The paleocurrent measurements indicate that the outcrops are normal to oblique to the paleoflow direction and the sinuosities were obtained.

In the other hand, a detailed analysis was performed in the oil-well by using microresistive log images, cuttings and a set of logcurves. The log images allowed defining the synthetic sandstone-bodies; besides, the sedimentary structures, the thickness, and estimations of paleocurrent directions were recorded. By comparing the surface deposits with the images, it was possible to make a facies analysis and define the presence of fluvial bars and channels.

Thus, the stratigraphic correlation between outcrops and the oil well mentioned above is performed by using the seismic sections. A set of seismic horizons were developed, which is considering the amplitude as a seismic attribute and useful tool to define fluvial geoforms (Santangelo *et al.*, 2009).

The integration among data (outcrops, oil-well and 3D seismic) allowed obtaining important fluvial parameters. The width is from 150 to 250 m, while the sinuosity varies from 1.15 to 1.35. The Bridge and Tye's (2000) equation was applied to calculate the channel-width from log images, although these values were 25% higher to those measured in outcrops and seismic horizons.

The data coming from different sources (surface and subsurface) allow optimizing the quantitative sedimentary model for the Bajo Barreal Formation and improve the oil and gas production.

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A FACIES MODEL FOR FLUVIAL SYSTEMS IN THE SEASONAL TROPICS AND SUBTROPICS

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Facies models that summarize the deposits of fluvial systems are well-established for humid climate settings and for desert environments, but the deposits of rivers in the sub-humid and semi-arid seasonal tropics have been largely ignored. Yet, such rivers drain large portions of Australia, Asia, South America, and Africa. These rivers experience strongly seasonal discharge, and drain landscapes where there is a considerable excess of evaporation over precipitation and high surface temperatures. One consequence of this is that trees colonize the beds of rivers to utilize the reliable water source, and are adapted to this unusual ecological niche where they are intermittently inundated by

fast-flowing water. It follows from their abundance today and from the past position of continental landmasses that the deposits of seasonal tropical rivers must be well-represented in the stratigraphic record, but perhaps are under-represented in the literature because they are in some respects transitional between humid and arid end members.

Several major rivers drain large, sub-humid to semi-arid areas of NE Australia including the Burdekin River which drains an area of 129,000 km^2 and discharges onto the Great Barrier Reef shelf. Much of the catchment experiences mean annual rainfall of 500–700 mm. Precipitation is very strongly seasonal, variable from year to year, and controlled by the passage of tropical cyclones and monsoonal depressions. Intense rainfall events cause short-duration, high-magnitude runoff events (20,000 – 30,000 m^{3}s^{-1} discharge events have a 10-16 yr return period). Event hydrographs for this and other rivers of NE Australia rise extremely rapidly to a sharp peak and decline almost as rapidly. During the falling stage, riverbed macroforms and mesoforms formed under Froude-supercritical flow conditions, and large scale dunes formed in deep subcritical flow are frequently preserved as there is insufficient time for them to adapt to falling stage conditions. Whereas the hydrology of these rivers is similar to those in other strongly seasonal climatic settings, the combination of strongly variable discharge and river bed vegetation growth gives rise to distinctive characteristics. Our observations and data from modern streams and recent deposits in NE Australia show how such rivers, with extremely variable discharge, have distinctive deposit characteristics that are substantially different from conventional fluvial facies models. These properties include 1) erosionally-based channel-fill lithosomes that exhibit complex lateral facies changes, with 2) abundant, pedogenically-modified mud partings, 3) complex internal architecture that may lack the macroform elements (lateral/downstream accretion structure) typical of other fluvial sediment bodies, 4) an abundance of sedimentary structures formed under high flow stage, and 5) an abundance of in situ trees that colonize channel floors and are adapted to inundation by fast-flowing water. We illustrate examples of this fluvial style from the rock record, and set out a new facies model. The recognition of such a distinctive fluvial character, and of changes in character through vertical successions, will aid paleoclimate and reservoir analysis.

SHEET-LIKE FLUVIAL ARCHITECTURE ON REGIONAL SCALES: EXAMPLES FROM THE CRETACEOUS WESTERN INTERIOR SEAWAY OF NORTH AMERICA

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Extant sequence stratigraphic models for lowland/coastal plain fluvial successions emphasize vertical changes in stratal stacking patterns through a cycle of relative sea-level change. According to these models, incised valley surfaces form during drawdown and lowstand of relative sea-level, are filled and then pass upward into more isolated fluvial sandstone bodies formed during rising relative sea-level, and in turn become more amalgamated during highstand. It is apparent, however, that not all lowland fluvial successions conform to this pattern, with many showing sequence boundaries of more planar cross-sectional geometry (ie., lacking significant valleys). Here, we draw attention to this under-appreciated stacking pattern by documenting the stratal architecture of three Upper Cretaceous formations, broadly of coastal plain origin, from the Henry Mountains of south-central Utah, USA. The succession as a whole represents a condensed equivalent of the better-known Book Cliffs succession 100 km to the north.

In the Henry Mountains, the Ferron Sandstone comprises a stack of progradational

deltaic bodies, overlain by a series of distributary channel sandstones and coastal floodbasin deposits. The channel bodies in the latter appear to be amalgamated laterally to form single- to locally multi-storey channel complexes of 10's of km extent in a depositional strike orientation. Lateral extent of these composite bodies is at least an order of magnitude greater than the channel belt width predicted from paleohydraulic calculations or channel form dimensions. Accordingly, the stack of sheet-like channel complexes, separated by equally laterally extensive floodbasin intervals, may be interpreted as a series of sequences, forced by relative sea-level fluctuation. The overlying Muley Canyon Sandstone contains two intervals of tidally-influenced fluvial deposits enclosed by shoreface sandstones. Again, these intervals are of regional extent (>20 km) and sheet-like, with modest erosional relief (<10 m) on basal sequence boundaries. The most spectacular example of the sheet-like fluvial stacking pattern occurs in the overlying Masuk Formation, where several cycles of fluvial channel bodies and intervening coastal floodplain facies can be traced over >10 km as continuous sheets, again strongly suggesting an external forcing control on their cross-sectional geometry. The common factors among these three formations are the prevalence of a sheet-like architecture to fluvial units, and their enclosing stratal intervals, the condensed and incomplete nature of sequences, and the lack of significant incisional relief at the base of sequences. These patterns suggest that fluvial channel complexes apparently lacking incised valley fills may in some cases nonetheless be records of external forcing and may be of great lateral extent.

SEDIMENTOLOGY AND STRATIGRAPHIC ARCHITECTURE OF THE UPPER PALEOCENE RÍO CHICO FORMATION, GOLFO SAN JORGE BASIN, PATAGONIA ARGENTINA

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The upper Paleocene Río Chico Formation in the Golfo San Jorge basin (Central Patagonia) is a 150-180m thick fluvial succession. This work consists of a description and interpretation of stratigraphic sections of the North Flank of the basin, from the northern basin margin to the southern depocenters. The palaeoenvironment analysis is primarily based on the identification of lithofacies and lithofacies associations. Spatial and temporal variations in the fluvial dynamic were also analyzed by means of a detailed architectural analysis. Six lithofacies associations were identified in the Río Chico Formation: 1) sheet-flood deposits; 2) braided channels; 3) straight to low-sinuosity channels; 4) meandering channels, 5) proximal floodplain and 6) distal floodplain.

At the northern basin-margin (e.g. Estancia Las Violetas, Estancia Chapital, Meseta del Curioso) the Río Chico Formation consists of a sandstone-rich succession (up to 75%) of sandy-gravelly channels with tabular appearance (W/Th=300-850) and low palaeocurrent dispersion (S<1.3), interpreted as a braided system. Tabular, single-event sandbodies containing high-regime structures were interpreted as sheet-flood deposits, accumulated during high-discharge flood events.

In a basinward direction (e.g. Pto. Visser, Punta Peligro Norte) channel sandbodies represent ~25% of the sections and multi-storey sandbodies are narrow sheets with W/Th ~ 30. Most of the sandbodies show abundance of cut-fill structures and lack of lateral migration, displaying low palaeocurrent dispersion (S<1.5), being interpreted as straight to low-sinuosity channels. Some channels contain lateral accretion surfaces and show high palaeocurrent dispersion, being interpreted as high-sinuosity fluvial channels (5>S>1.7).

Lateral/vertical changes in the alluvial architecture of the Río Chico Formation are

recognized by: 1) spatial and temporal variations in fluvial styles, 2) changes in the geometry of sandbodies and 3) changes in channel/floodplain ratio across the basin. Tabular, braided systems with high channel/floodplain ratio are recognized close to the basin margin, while in a basinward direction the channel/floodplain ratio reduces and sandbodies show meandering and straight to low-sinuosity patterns. These stratigraphic changes are interpreted as spatial/temporal variations in the accommodation rate, controlling the aggradation rate of the alluvial system and fluvial styles.

POST-LGM INCISED VALLEYS IN THE VENETIAN-FRIULIAN PLAIN (NE ITALY)

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Recent geological surveys and cores allowed to identify several incised valleys in the distal sector of the alluvial megafans between Venice Lagoon and the Karst Range. From East to West, at least 2 incisions exist in the Isonzo-Torre River megafan, 5 in the Tagliamento River megafan and 4 in the Piave River megafan.

A major depositional phase occurred in the area during LGM, when sedimentary supply fed by glaciers debouching in to the plain supported a large and widespread aggradation. Along the present coastal plain, LGM deposits are mud-dominated and have an average thickness of 20-30 m. These sediments are cut by valleys which have a depth of 15-30 m and a width of 600-2000 m. The studied incised-valley fills (IVF) display a similar internal architecture, characterized by coarse gravel deposits at bottom and a general fining-upward trend. Several phases of abandonment and re-activation are recorded, but gravels are almost lacking in the upper part of the IVF and their diameter is considerably finer than the basal gravel.

Radiocarbon datings demonstrate that fluvial entrenchment and coarse-gravel transport occurred during Lateglacial and early Holocene and stopped around 8.0-7.0 ka cal. BP. Since 7.0 ka cal. BP some abandoned incisions were drowned by marine transgression; this process led to the formation of 15-km long tidal inlets and to the deposition of lagoon and estuarine sediments inside the incisions. This particular palaeogeographic setting played a major role in constraining the ancient human settlements.

Valley formation has been mainly controlled by the dramatic change of sedimentary supply occurred at the LGM/post-LGM boundary, due to the transition from fluvioglacial to fluvial processes. Also the valley lakes, triggered by the large landslides occurred in the mountain catchments after deglaciation, largely contributed to stop the sedimentary flux towards the plain. The IVFs have been affected by the internal evolution of the fluvial systems and specially by the avulsions, which activated and/or deactivated different sectors of the megafans, and, thus, different incisions. Sea-level rise influenced the filling of the valleys only since 8.0 ka cal. BP, but this factor had a paramount importance in the last millennia. The phase of fluvial ridges formation which interested the Venetian-Friulian coastal plain during late Holocene, specially since 3.0 ka cal BP, brought to silt-up the valleys almost completely.

POROSITY PREDICTION FOR FLUVIAL SAND-GRAVEL MIXTURES

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The porosity, defined as the ratio of pore volume to total volume, is one of the key properties of sediment mixtures. It determines the storage capacity for oil, gas and groundwater, the pressure fluctuations leading to initiation of sediment motion, the oxygen flow into the hyporheic zone, the efficiency of measure-

ment devices and affect many other processes. The porosity of fluvial sediments can be measured with standard well-logging techniques, such as neutron probes, but also be predicted with porosity predictors. The objective of this study was to determine the accuracy of such porosity predictors for modern, fluvial, sand-gravel mixtures.

To obtain an accurate, independent database of porosity data, we collected 52 large, homogeneous sediment samples from the channel bed of the river Rhine. A diving bell was applied to prevent sediment loss by flowing water during sampling. Sediment size ranged from 0.06 mm to 125 mm, with distributions varying from unimodal to bimodal. The porosity was determined in-situ with the water-saturation method and found to vary between 10 and 40 percent. Laboratory analysis included determination of grain size, grain shape and ex-situ porosity.

The capability to reproduce the measured porosity values was tested for six porosity predictors, using the median grain size (*D*), the sediment standard deviation (s) or the full grain size distribution (*GSD*) as input parameter. Whereas the *D*-based predictors were found to be theoretically unsound, the s-based predictors realistically predict a decrease of porosity with mixture bimodality. The sophisticated *GSD*-based predictors, however, perform best. Although these predictors tend to underestimate the porosity slightly, they produce equally good results as empirical predictors based on the Rhine data.

The relatively high error variance of the predictions illustrates that apart from grain size, other parameters have a distinct influence on porosity. Especially the angularity of the grains seems to be important, as it determines the bridging tendency during packing. The mechanism of deposition is thought to play a vital role too, because it governs the magnitude and direction of forces during packing.

Despite their shortcomings, porosity predictors provide valuable insights into the spatial variability of porosity in rivers and river deposits. This is demonstrated by applying the predictors to 4,500 measured GSDs of the river Rhine and by incorporating the predictors into the morphological modelling software Delft3D.

CHARACTERIZATION OF FLUVIAL SANDSTONES IN CERRO GUADAL NORTE OIL FIELD, GOLFO SAN JORGE BASIN, SANTA CRUZ, ARGENTINA

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The extensive Cretaceous fluvial outcrops, around the La Sin Nombre Lake, allow performing stratigraphy, sedimentology and tectonic studies. The outcrops belong to Bajo Barreal Formation and correspond to the sides and the plunge of an asymmetrical anticline oriented North-South. The study area is an active oil field belonging to YPF SA at the north of Santa Cruz Province in the Golfo San Jorge Basin, Argentina.

One hundred fifteen sandstones and twenty mudstones were sampled from three stratigraphic profiles; all the samples were georeferenced with gps and sandstones were oriented to the magnetic north. Petrography and porosity studies were realized from thin section and the mineralogy of mudstones, the cements and matrixes of sandstone were searched using X ray diffractions (Ibañez *et al.* 2009; Vides *et al.* 2009, in this volume).

The structural geology was studied through field works and seismic line analysis, and it shows the interplay between extensive and compressive stresses contempo-

raneous with the sedimentation (Sosa Gómez *et al.* 2008). The faults produced a stacking of sandstone bodies in the western side of the anticline (Gutierrez *et al.* 2009, in this volume).

The stratigraphic profiles were correlated according their lithostratigraphic characteristics and the interpretation is also supported with seismic data. The paleocurrent directions show local orientations toward north (in the southern outcrops) either east or southeast (in the northern outcrops) but all of them converge to the center-east area of the oil field. This dispersion could be related to the activity of the faults during the deposition. The sinuosity of channels is low between 1.1 and 1.3.

The width of sandstone bodies range from some few tens to 200 m or 300 m, only at the top of the sequence and in some few channel belts the width could reach 600 m. The mean thickness varies from 1.6 to almost 3 m.

The fluvial architectural studies indicate lenticular isolated channel belts, mainly monochannel but some multichannel belts were also described. The thicker sandstone bodies represent permanent rivers, while the thinner ones are interpreted as ephemeral crevasse channels with evidences of organic activity onto a mud floodplain.

AN ESTIMATE OF THE PATTERN OF FLUVIAL EROSION FOR THE HIMALAYAS

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The present-day physiography of the Himalayan mountain belt, an active orogen, is an expression of complex interplay between the tectonic and erosional processes. It has been hypothesized that the orographic barrier initially produced by the tectonic uplift was sufficiently large to induce monsoonal circulation leading to enhanced precipitation over the orogen. After the last deglaciation a major part of the orogen is being denuded by fluvial processes aided by monsoonal precipitation and mass wasting. It has been debated if this precipitation-enhanced erosion is also influencing the kinematics of the orogen and a lack of consensus highlights the need for more comprehensive understanding.

As a part of multidisciplinary initiatives to understand the interplay between different earth processes, this study employs terrain analysis techniques to estimate the pattern of erosion across a major part of the Himalayan orogen. The spatial interrelationships between the erosion pattern, precipitation and the disposition of litho-tectonic units are investigated in this study.

The technique when applied to digital elevation datasets identifies three major classes of hinterland catchment basins that supplies sediment and water to the foredeep. These classes are distinct by their size, frequency and "drained-litho-type". These three classes of basins are disposed in three orogen parallel bands. Moreover, the estimates of erosion are found to vary significantly both across and along the orogen. It has been noted that the erosion estimates for the interior parts the catchment basins are larger compared to that for their downstream ends. On the other hand, the central part of the orogen is found to be most intensely denuded compared to its eastern and western extremities. This pattern of denudation show significant spatial correlation with the pattern of precipitation and the disposition of the litho-tectonic units of the Himalayas.

TRANSITION OF THE MIDDLE AMAZON RIVER IN THE CONTEXT OF CLIMATIC CHANGE

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The Amazon River is the main component of a complex ecosystem characterized by

high biodiversity in the Amazon rainforest. The evolution of this system, especially during the Holocene, is still not well understood, with only a few detailed characterizations of small sections of the system reported. In this context we studied the middle Amazon River between Manaus and the mouth of the Madeira. The use of remote sensing tools and geomorphologic and stratigraphic analysis allowed the identification of an anastomosing pattern of the Amazon River, based on a very low gradient, clay dominated, vegetated, rather permanent islands, whose heights roughly correspond to those of the adjacent floodplain, steep-sided channel margin with locally displaced blocks ("terra caída"). Also indicative of this patterns are great water-depth near the bank and outlines of islands and channels that have remained largely unchanged over the period from 1986 to 2001. Beyond classifying this reach of the Amazon River as anastomosing, evidence is provided for its evolution from meandering during the mid Holocene. This evidence is strongly supported by the presence of inclined heterolithic stratification of point bars. Additionally, the point bars exhibit distinctive morphological sets of scroll bars indicating a multistory lateral migration of the Amazon River before evolving into an anastomosing pattern.

We propose that climate change leading to increased humidity as recorded between 6000 and 4000 yr BP, correlated with a relative base-level (sea-level) rise, influenced the development of the fluvial pattern change.

INTERPRETATION AND FLUVIAL PARAMETERS OF SUBSURFACE SANDSTONE BODIES, CASTILLO AND BAJO BARREAL FORMATIONS (CRETACEOUS) IN THE CAÑADÓN VASCO OIL FIELD, GOLFO SAN JORGE BASIN, SANTA CRUZ, ARGENTINA

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The interpretation of resistivity imaging logs allows identifying sedimentary structures, thicknesses, contacts hierarchies, paleocurrent directions and other details (e.g. bioturbation, intraclasts, root fragments and an inference of grain size). These data were compared with cutting samples and outcrops data in order to improve the sedimentological model for Bajo Barreal and Castillo Formations (Cretaceous).

The Cañadón Vasco oil field is located in the southern border of the Golfo San Jorge Basin (Argentina); near to the oil field, the Ballena Hill shows extensive fluvial deposits belonging to Bajo Barreal Formation. Thus, a stratigraphic correlation between them was proposed by using seismic lines. The Ballena Hill and the Cañadón Vasco oil fields show a strong tectonic control produced by a NW-SE normal fault reversed during Late Cretaceous.

The integration of cutting samples (grain size and color) and resistivity imaging log allowed obtaining a stratigraphic log. Twelve sandstone bodies belonging to Bajo Barreal and Castillo Formations were analyzed following this method and ten litho-facies were defined from this study. The litho-facies assemblages were assigned to channel, crevasse channel, channel bar, splay and floodplain deposits. The sandstone bodies thickness (trough cross stratification) and paleocurrent directions were used to apply the Mackey and Bridge's equation (1995) and obtain the channel belt width. The sandstone bodies were also associated with the SP and resistivity wire-logs to define a group of electro-facies. Finally, seismic horizon slices related to the sandstone bodies studied were also analyzed as intent to merge litho– and electro-facies assemblages and seismic geoforms.

As paleocurrent directions coming from imaging log as seismic horizon slices are

coincident in to point out several changes in the channel pattern and sinuosity. Most noticeable change occurs for those strata belonging to the lower section of Bajo Barreal Formation (informally named "tobácea section"). The sinuosity increases from 1.15 to around 2 and the channel belt wide reaches 500m.

The sedimentary model of electro-facies may apply to wells (in the same or another oil field) without assistance of imaging log but with available 3D seismic information.

TECTOSEDIMENTATION AND COMBINED TRAPS IN THE SANDSTONE HYDROCARBON-BEARING OF THE BAJO BARREAL FORMATION (CRETACEOUS) AT LA SIN NOMBRE LAKE, GOLFO SAN JORGE BASIN, SANTA CRUZ, ARGENTINA

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The main purpose of this contributionis to proposes a sedimentary model that explains the syntectonic deposition of fluvial sandstone bodies in the Bajo Barreal Formation in the Golfo San Jorge Basin (Argentina). The study area is located in the western side of La Sin Nombre Lake at the north of the Santa Cruz Province, approximately 46 ° 30 '51.8 "S and 69 ° 25' 48.1" W. The zone was folded and faulted during the Late Cretaceous and mainly during Tertiary. The axis of the anticline is oriented in north-south direction. The deposits crop out on the western side of the anticline. The deposits have been assigned to the Bajo Barreal Formation (Cretaceous) through lithostratigraphic correlation and seismic data (Santangelo *et al.* 2009, in this volume). Along the stratigraphic log it is possible to recognize fourteen sandstone bodies; most of them show both dry and fluid oil impregnations. The sandstone bodies appear isolated in the base of the stratigraphic log and they are stacked at the top of the sequence. The main geometry is lenticular and frequently both margins are exposed, but in few cases the geometry is tabular. The strike of the strata is N10ºW and the dip varies from 6° to 12°W.

The area was recorded by gps, the base and top of all sandstone bodies, major and secondary faults were mapped. The major faults show dextral strike-slip motion, and they are listric faults.

Short lateral logs, measurements of paleocurrent directions and photomosaics were recorded for the fourteen sandstone bodies in order to reconstruct the geometries, orientations and channel patterns of those Cretaceous rivers. The grain size of channel belt deposits is medium to coarse sandstone and fine gravel (mainly clasts of tuff), which are associated to the faults activities. The main sedimentary structure is trough cross strata but planar stratification and ripple marks were also observed at the top of the channel belt deposits. The mean thickness of sandstones bodies is 1.23m and the standard deviation 0.98 but two main modes were obtained: 0.5-1m and 2-2.5 m; the first represent crevasse channels and the second the main channels. The apparent width ranges from 15m to 105 and the mean width is 41.44 m and the standard deviation of 30.3. In order to obtain the paleocurrent directions, fifty five trough cross strata were measured in the stratigraphic profile and from ten channel belts. The mean paleocurrent direction is toward N110º but varies from N320º to N193º. The facies and facies assemblages indicate sandy channel belts flowed onto a silt-clayed floodplain. The channel belts are formed by main and secondary channels, lateral- and mid-bars.

The deposition of the sandstones bodies (high connectivity of channel belts), and the migration patterns were controlled by the main faults, which also behave as seals.

SEDIMENTOLOGICAL AND PALAEOHYDROLOGICAL CONSTRAINTS ON THE DEVELOPMENT OF A LATE SILURIAN TO EARLY DEVONIAN 'SYN-RIFT' FLUVIAL SUCCESSION IN THE MIDLAND VALLEY BASIN, SCOTLAND

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The approximately 9000 m thick Upper Silurian to Lower Devonian fluvial succession in the Midland Valley Basin, Scotland (referred to as the Lower Old Red Sandstone), has been studied extensively over the last 150 years. Deposition is thought to have occurred in an active extensional/transtensional basin and a number of models have been proposed to explain the documented facies and provenance data. Two end-member models have emerged that include either, 1) derivation from a large-scale axial fluvial system that drained a source area located to the east on the Baltic Shield or 2) deposition on alluvial fans that formed along an active fault (the Highland Boundary Fault) along the northern flank of the basin. In order to assess which, if either, of these models may be appropriate we have undertaken a sedimentological study of the lower part of the Lower Old Red Sandstone succession with the aim of identifying the nature of the alluvial system and to apply palaeohydrological techniques to determine possible discharge estimates from which to provide information on the drainage basin.

The Lower Old Red Sandstone succession shows a rapid transition from discrete sandstone bodies that form channel packages 1 to 3 m thick separated by mudstones, into 1 to 10 m thick packages of pebble and boulder conglomerates with sandstone interbeds (the latter comprise < 5% of the total outcrop). The conglomerates are organised into 1 to 5 m thick coarsening or fining upwards packages and display extensive imbrication. Clasts within the conglomerates are well to very well rounded and comprise a range of lithologies including mainly quartzite, andesite, metasediments and granites. Maximum long axis clast sizes range from 5 to 100 cm. Similar clast types and palaeocurrents indicating derivation from the northeast, are present in both the underlying sandstones and the conglomerates indicating no obvious change in source area composition or location across this major grain size transition. Palaeohydrological data derived from Manning's equation, which uses clast dimensions to estimate discharge, suggest that the conglomerates were deposited by high magnitude flood events. A comparison with modern day systems in which similar flood events occur indicates a basinal location immediately adjacent to a high relief catchment. This suggests the presence of a high relief catchment immediately NE of the basin in contrast to previously published models. In addition, whilst this is a preliminary study, it appears that palaeohydrological information can greatly enhance our understanding of ancient fluvial successions.

DISTRIBUTIVE FLUVIAL SYSTEMS (DFS): A RE-EVALUATION OF FLUVIAL FACIES MODELS

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Analysis of ~700 modern continental sedimentary basins from around the world (i.e., those that may be preserved in the rock record) reveals that rivers in these basins are not tributary in nature; rather they form either (1) distributive fluvial systems (DFS), commonly called megafans, fluvial fans, and alluvial fans, or (2) axial stream systems that parallel the basin trend, with the vast

majority of sedimentation in the basin occurring on the DFS (up to 95%). Yet, most fluvial facies models are based on rivers in tributary, degradational settings. In these continental sedimentary basins, we identified ~400 fluvial megafans (defined as DFS > 30 km in length), with numerous smaller DFS filling the basins. Thus, most sedimentary basins undergoing aggradation do not contain tributary fluvial systems except in the axial position.

Characteristic features of DFS that differ from tributary systems include: 1) a radial pattern of channels away from an apex (or intersection point), 2) a downstream decrease in channel width and discharge, 3) floodplains dominated by avulsion deposits, 4) greater preservation of floodplain deposits associated with braided streams.

Studies of modern DFS indicate that general trends and relationships between planform type, length, gradient, tectonic setting, climate (in the catchment and basin) and termination style can be observed in DFS. DFS length is controlled by the available horizontal accommodation space which in turn is strongly related to tectonic setting. The longest DFS occur in peripheral foreland basins and cratonic settings where lateral systems can develop across an extensive basinwards slope. Extensional, strike-slip and intra-thrust belt basins are narrower and have much more limited horizontal accommodation space. Consequently DFS developed in these settings are shorter with radii often less than 30 km. DFS dominate in aggradational settings such as actively subsiding sedimentary basins and will therefore form a significant proportion of alluvial sedimentary successions preserved in the rock record.

FROM RIVER VALLEY TO ESTUARY: EUSTATIC AND GLACIO-TECTONIC CONTROLS ON THE EARLY-MIDDLE HOLOCENE RHINE-MEUSE SYSTEM, THE NETHERLANDS

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This paper focuses on the palaeogeographic development of the Rhine-Meuse river mouth (the Netherlands) in the early-middle Holocene. During the Holocene transgression, an area of 800 km^2 transformed from valley to estuary within 200 years (8.5-8.3 ka BP: sea-level jump; Hijma and Cohen, subm.). Initially, overbank deposition started to increase (fluvial onlap of lowstand system tract) accompanied by widespread peat formation. The transition to the transgressive system tract (transgressive surface) is diachronous, but mainly occurred during the jump. The surface predominantly separates fluvial from fluvial-tidal deposits and is characterized by a gyttjaic deposit. Farther landward, the environment remained fluvial, but with subaqueous deposition within permanently flooded flood basins. After ~6 ka BP retrogradation of the coastline halted and subsequently most tidal inlets closed and extensive peat formation began at the base of the highstand system tract. We will illustrate the changing facies and transition with several photos and detailed maps.

The study area is situated in a long term subsiding basin (North Sea). Towards and during the Last Glacial Maximum it was located just south of a zone of maximum forebulge upwarping and consequently in an area of accelerated subsidence in Late Glacial and early-middle Holocene times (Busschers *et al.*, 2007). Rates of relative sea-level rise were therefore high (> 1 m/100 yr) and between 8.5-8.3 ka BP reached rates of > 2 m/100 yr. In the case of the Rhine-Meuse mouth, this is well reconstructable because of 1) favourable antecedent topography and subsidence setting; 2) long history of coring, mapping, dating, establishing facies models; 3) New 3D-techniques of dealing with the wealth of data and 4) key papers produced in recent years: Busschers *et al.* (2007; last glacial), Hijma *et al.* (2009; last glacial - Holocene) and Hijma and Cohen (subm.; sea-level history). This

research increases our knowledge of the response of fluvial-estuarine systems to rapid sea-level rise and therefore will benefit planning and designing coastal protection works during the expected future sea-level rise.

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SHEET LIKE CHANNEL BODIES, WEATHERING AND CALCRETES. A COMPARISON BETWEEN TWO EXAMPLES OF THE DUERO AND ALMAZÁN BASIN (SPAIN)

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The way external forcing controls large scale fluvial architecture is even today a debate matter. The LAB (Leeder-Allen-Bridge) models interpret high-density channel systems as the result of decreasing accommodation space and qualitative models predict sheet like channel geometries for this stages. However, some experimental models show linkage between development of high density channel belts and increasing basin accommodation space. This study analyzes two field examples with highly connected sheet like channel bodies in two different palaeogeographic contexts and compares the facies in their distal floodplains.

1) The first case is the Gómara Fm. in the Palaeogene succession of the Almazán basin (Spain) which shows a thick (> 3000 m) fluvial record. The Gómara Fm. in the A3 depositional sequence of the basin displays a highly vertical connected sheet like conglomerate bodies. These bodies are 20-30 m thick and 500-3000 m width, and the channel body/floodplain proportion is 50.2 %. Laterally, on the distal floodplain, there is an important development of mature calcretes. Sometimes several (3-5) calcrete profiles occur stacked vertically. 2) The second case is the Plio-Pleistocene (s.l.) fluvial fan deposits of the Duero basin (Rañas), which are sheet like conglomerate bodies with high lateral connectivity that are associated with red muddy sands in the proximal areas These deposits are several (5-20) km width, and commonly 2-5 m thick. The length from the mountain front (spill point) to the most distal conglomerate outcrops ranges from 15 to 70 km. In the most of the cases the distal floodplain deposits has been eroded and evacuated, and only some relics are preserved in karstic depressions within the underlying upper Miocene limestones. The Raña deposits underwent intense weathering and pedogenesis, the most spectacular product being the lateral washing of the finer matrix with subsequent residual gravel accumulations toped by well-developed red soils. The sheet-like conglomerates record the stage of reduced accommodation space preceding the Quaternary fluvial dissection of the Neogene endorheic Duero Basin.

In both cases, tectonic uplift, eventual basin overfilling, stable planation surfaces linked to intense weathering (under different climatic conditions), are linked to the episodes of decreasing accommodation space. In the latter case preceding the eventual fluvial dissection of the ancient sedimentary basin.

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CHANNEL ABANDONMENT PROCESSES IN THE MAHAKAM DELTA, EAST BORNEO, INDONESIA

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The modern Mahakam Delta has been acknowledged as a typical example of a tropical mixed fluvial and tide-dominated delta. Its subaerial delta plain has a fan-shaped morphology and is dissected by numerous distributary and estuary channels. As distributaries branch seaward out from the delta apex, they can be grouped into the northern and southern areas, while the central area is only occupied by estuaries. Some morphological evidences suggest that distributaries can be abandoned and converted into estuaries.

This study investigates the distributary abandonment processes in the northern area which has 3 distributaries and 3 estuaries. Channels morphology was studied by 85 high resolution echo-sounding profiles, bottom sedimentary facies was reconstructed by 143 grab sediment samples and hydrodynamics data were systematically measured at 10 locations for complete spring and neap tidal cycles. Distributaries exhibit relatively straight channels with flaring mouths while estuaries are more sinuous and have deeper and smaller mouths. Sand is more distributed in the bottom of, and thus covered a larger part of, the active distributaries than in the abandoned distributaries and gradually fines seaward but does not extend to the channel mouths while mud dominates the estuaries and the distal reaches of the distributaries. Hydrodynamic data indicates that the interaction of fluvial and tidal processes is dynamically active along the entire length of the distributaries. Fluvial processes dominate the sandy reaches of the distributaries, while tides are the most important process in the lower reaches of active distributaries, the inactive distributaries and estuaries.

This study suggests that the channel abandonment processes in the Mahakam Delta is sequential. As the tidal processes become more dominant, fluvially-supplied sand is being stored onshore in the distributaries and tidal processes are modifying distributary morphology and dominating sedimentary facies progressively further landward. These processes influence the distribution of the potential reservoir in the delta plain.

PETROGRAPHY AND POROSITY IN FLUVIAL HYDROCARBON–BEARING SANDSTONES. BAJO BARREAL FORMATION (CRETACEOUS), SAN JORGE BASIN, ARGENTINA

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Petrography and porosity studies were performed to improve the knowledge about fluid migrations throughout Cretaceous fluvial sandstones in the Cerro Guadal Norte oil field (San Jorge Basin, Santa Cruz Province, Argentina) and the additional hydrocarbon recovery projects.

Upper section of the Bajo Barreal Formation (Turonian) is composed of fine and medium sandstones which show mainly cross trough stratification but also planar, massive and ripple lamination. Occasionally, a silt parallel lamination is observed at the top of sandstone bodies.

The fluvial sandstone bodies are well exposed around La Sin Nombre small Lake, where two stratigraphic logs were described. Besides, architectural descriptions in some

representative sandstones bodies, fully exposed, and additional short detailed logs separated by tens of meters each were recorded.

Forty nine orientated medium sandstones were sampled along the vertical logs and in a laterally described body. Two petrographic slides were prepared from each sample. One is parallel to the plane formed by the stratification surface and the North, and the other perpendicular to the North direction. Thereby ninety six slides were described.

The sandstones are mainly feldspar litharenites and there are some litharenites and feldspar wackes. Almost all of them are submatures. The mean porosity is around 18 % which varies from homogeneous to heterogeneous. Clays, zeolitic, siliceous and carbonatic cements are present in different proportions.

A comparison among petrography, porosity and architectural studies indicates an increase of zeolitic cements at the top of sandstone body; while the clays are predominant in the base of channels. Furthermore, the porosity decrease from main channel to adjacent bars and cross over bar-channel. In the bar deposit, the porosity decreases downstream and upward.

LATE WEICHSELIAN DEGLACIATION, BASE LEVEL CHANGES AND FLUVIAL RESPONSE, AIN RIVER, JURA, FRANCE

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The behaviour of fluvial systems is controlled by changes in climate, sediment supply, tectonics and base level which often operate simultaneously. In the present contribution the effects of base level changes on the Ain river in eastern France during the last glacial-interglacial transition will be evaluated. During the Last Glacial Maximum the river catchment was partially glaciated and blocked by the Jura ice cap leading to development of large proglacial lakes. Rapid aggradation by sanders and Gilbert-type delta's occurred at the margins of the lakes due to local high base levels. The associated glaciolacustrine varves enable to reconstruct the duration of this high base level phase. During deglaciation the ice dams disappeared and the large proglacial lake in the Ain valley drained almost instantaneously. This rapid base level fall resulted in dissection of the deltas and formation of a widespread gravel sheet on the former lake bottom. Further incision by the Ain formed a terrace staircase in the deltaic and glaciolacustrine high-stand deposits. The upper terraces may be related to ice-recessional phases. This case study enlarges our understanding of the impact of base-level changes on the preservation of high-stand deposits (coastal prisms).

WHY LARGE RIVERS HAVE LOW-ANGLE DUNES

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Dunes in flumes are *Classic High-Angle Dunes* (CHADs)dominated by bedload transport andcharacterized by steep (>30º) lee side slope angles and a separation zone with flow reversalBed load is transported up the stoss side of the dune and accumulates at the brinkpoint. Bed load deposited at the brinkpoint periodically avalanches down the lee slope, maintaining a steep angle of repose. Field measurements however have shown that dunes in large, deep rivers are not CHADS, but are *Low-Angle Dunes* (LADs) with low lee side slope angles (often <10º) and a separation zone that is characterized by deceleration in streamwisevelocity rather than flow reversal. LADS are believed to result from deposition of suspended sand on the lee side slope and in the trough, resulting in a lower slope angle.

This study uses reach-averaged data from seven rivers and two flume studies to test the LAD hypothesis. Flumes dunes are CHADs, with lee side slope angles from 38-51º, but

the field dunes are LADs, with lee slopes from 5-23°. Lee slope angle decreases as dune size (height and length) increases, and increases with height/length. Application of an excursion length shows that sand suspended at dune crests in the flume bypasses dune lee slopes, but it is captured on the lee slope in rivers. The deposition of suspended sand on the lee sides of large dunes supports the LAD hypothesis. The critical factor in the capture of suspended sand appears to be the streamwise length of the dune lee slope – greater lengths result in increased sand capture. Large rivers have large dunes with long lee slopes and hence lower lee slope angles.

WASH LOAD IN THE PARANÁ RIVER, ARGENTINA

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The Paraná River has one of the largest watersheds in the world, draining significant portions of Argentina and Brazil. The main tributary of the Paraná is the Paraguay River. Virtually the entire wash load, defined as fine sediment (usually <64 ìm) in permanent suspension, present in the middle and lower reaches of the Paraná originates in the Bermejo River, which is a tributary of the Paraguay.

Surveys in May 2008 were undertaken to determine the discharge and wash load concentrations at three sites in the middle reach of the Paraná: Bermejo River 50 m upstream of the confluence with the Paraguay River, Paraguay River 50 m upstream of the confluence with the Paraná River, and Paraná River 300 m upstream of Corrientes Bridge. Velocity and discharge at each site was determined with an acoustic Doppler current profiler. Surface samples of wash load were taken at each site and analysed for concentration and particle size using a portable laser system.

Discharge increased downstream from about 500 m^3s^{-1} in the Bermejo to nearly 20,000 m^3s^{-1} at Corrientes, due to the increase in watershed area and addition of flow from tributaries. Wash load samples were composed entirely of silt and clay and particle size increased slightly downstream. Wash load concentrations decreased downstream from nearly 8000 mgL^{-1} in the Bermejo to around 140 mgL^{-1} at Corrientes. Wash load flux decreased by 50% between the Bermejo and Paraguay and then remained constant downstream to Corrientes. These preliminary results suggest that wash load is being diluted downstream in response to increasing discharge, but is also being deposited in the Paraguay River between the Bermejo and Paraná.

SEDIMENTATION SETTING AND QUATERNARY DEPOSITION

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The quaternary depositions, as in the other regions, also in Albania, are related to many processes, which are created long time before, but they continue until today (glaciers, sloppy, end sloppy, river net, sea and lagoon processes).

Quaternary depositions in general and so do their sedimentation settings are very represented and developed along the Albanian geological structures, beginning from these continental, marine and their intermediate. The most completed conception for the settings, relates not only to the dimensions of the basin development, but also with the relations which are created between them. So the relation between river-sea-land and the climatic changes of Plio-Quaternary to today gets many values. There are rivers which with their abrasive and conveyer activity furnish the seas with water and sediments, and are these sediments that elaborate, according to circumstances in favour or disfavour, of

forming of the new land. In the dynamic point of view, it is evidently, these settings and processes of the depositions are not closed systems, but they are open systems that develop in neighbour areas, something displacing one to the other some other times extending in disfavour of one of them.

In this aspect, almost all the relief, orogenesis and the new Plio-Quaternary depositions and Quaternary one, in Albania are aggradations of the regressive marine processes.

Almost in up 80 % of the surface in Albanian territories, these settings and depositions in them are consolidated under a dilatory elevator process, associated with considerable erosion. Just in lower flows of the rivers, in their embouchures and along all the shore, the processes are very dynamic and are distinctly, minimally during two yearly cycles.

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DETERMINATION OF RELATIONS BETWEEN THE TRANSPORT OF BOTTOM MATERIAL AND SUSPENDED MATERIAL IN A LARGE RIVER, BASING ON GRAIN SIZE ANALYSIS OF DEPOSITS IN ARTIFICIAL WATER RESERVOIRS (THE VISTULA CATCHMENT BASIN, POLAND)

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The results of grain size analysis of deposits accumulated in most of artificial water reservoirs of different size in Poland indicate a considerable predominance of transport of material suspended over the bottom. Only some reservoirs (in the mountains and lowlands) lose their capacity as a result of the supply of bottom accumulation. With the river course, the grain size in both forms of transport increases, however, the increase of bottom material transport occurs faster. The increase of the share of bottom material in total transport of clastic material with the river course results for example from increasing in this direction size of sand fraction transport, which in upper sections of rivers is rather transported as a suspension. This trend increases with the course of Carpathian tributaries of the Vistula river, and further, with the course of this river, which drains susceptible to erosion flysch areas, areas covered by loess deposits, moraines and fluvioglacial deposits. As a result, in the lower course of the Vistula river (central and northern Poland) transport of bottom material considerably exceeds transport of suspended material.

The results of investigations complete the gap in the knowledge of the relations between the transport of bottom material and suspended material in the whole course of the Vistula river and its Carpathian tributaries. The suspended material represents over 95% of clastic material transported in the upper sections of Carpathian rivers, about 90% in the middle sections, about 70% in the Vistula at the Carpathian foreland, 50% in the middle section of the Vistula, and

about 25% in the lower section of this river. These proportions between the transport of bottom material and suspended material are different than the generally accepted model of fluvial transport in the longitudinal profile of a large river draining mountain, upland and lowland areas.

CHANNEL BED ADJUSTMENTS FOLLOWING A MAJOR DEBRIS FLOW IN A MOUNTAIN STREAM

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In the absence of consensus on a bedload sediment transport conceptual model and predictive equations in mountain streams, particles tagging may appear an obvious approach to determine transport rates and grain displacement lengths. It gives unique information on the processes involved in sediment transfer within the channel. This study presents a unique dataset on sediment transport in a mountain stream after a high-magnitude flood, a rapid release of bed material, and bed degradation.

The experiment was carried out in a mountain stream located in the French Alps. The 100-m selected reach has a slope 43%. Bed material is heterometric essentially coming from hillslopes and travelling in the channel through gravitational and nival processes under conditions of moderate discharges. Topographic measurements were used to quantify channel bed adjustments over a three-year period following a debris flow event. We also used passive integrated transponders inserted into clasts to track particles and follow the reorganization of the grains into bed morphological features. The tracers were inserted in the upstream section of the reach, in both bars and local scour pools after the debris flow in 2005. They were tracked in 2006 and 2008.

The results show that three years after the debris flow, preferred deposition areas were located along the margins of the channel. Sediment movements are limited considering that the slope of the channel could have initiated, by itself, gravitational movements. Average displacements are short (12 m) and decrease with an increase in median grain size until the grain size reaches 800 mm. Clasts that moved longer distances are deposited on the channel margins, a pattern of deposition that fits the results obtained from topographic maps. As bed elevations increase at the insertion point, the displacement distances are longer, suggesting that clasts initially located on bars are more mobile. This is not surprising considering their lack of imbrication and their exposition to the flow after the flood. The stability observed in the reach suggests that the availability of sediment is limited, thus insufficient to observe bed sediment reorganization into structured morphological features on a short time-scale.

FLOW VELOCITY FIELDS OVER A 15-KM LONG DUNEBED IN THE LOWER MISSISSIPPI RIVER DURING SPRING HIGH DISCHARGES

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Recent results on large-river morphodynamics revealed that these rivers do not behave exactly like smaller systems. Yet to this day, data are still sparse on bedform and flow dynamics of large rivers. Surveys were conducted over a 15-km long line in a stretch of the Mississippi River, which comprises a straight reach and a meander bend located at

about 370-385 km from the river mouth.

This paper reports data from three surveys conducted during the falling limb of one of the Spring hydrograph peaks, when discharge decreased from 22,750 m^3/s, to 17,900 m^3/s, to 13 470 m^3/s (respectively 1.7, 1.3, and 0.98 of mean annual discharge at the closest upstream river gage station). Bed elevation was measured with a 1 MHz, single, narrow (1.7°) beam transducer and a high-resolution echosounder coupled with a DGPS and a motion-sensor compensating for roll, pitch and heave. A RDI 1200 kHz ADCP was installed on the same mount as the other instruments, providing data for estimating sediment transport parameters.

Results show that the largest dunes are not systematically observed in the deepest part of the channel. The straight reach is shallower and often covered with larger dunes than the bend scour. ADCP 2-D results show that although large dunes (up to 4-5 m high) affect the entire column of the flow over their migrating path, there are channel-scale flow structures -alternate faster or slower flow-velocity zones that may affect their development. Signal intensity from the instruments show ejections over dune crests and related spatial variability of the flow velocity field.

The present study is embedded in a research that aims at linking morphodynamic to stratigraphic models (e.g. Paola & Borgman, 1991; Leclair & Bridge, 2001), and hence at improving our understanding of modern systems as well as ancient fluvial records.

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NORTH ATLANTIC TRIASSIC RIFT BASIN FILLS: CONTROLS ON THE EVOLUTION FROM FLUVIAL TO PLAYA STAGE

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The continental deposits of Triassic rift basins developed along the Central and North Atlantic margins display a similar sedimentological evolution. Classically, two phases of sedimentation can be recognised: 1) a lower sand-prone phase characterised by fluvial deposits including alluvial fan and fluvio-aeolian deposits and 2) an upper fine-grained phase which is a mud-prone unit and may include evaporites which record deposition in playa/ lacustrine dominated environments. Triassic basins that display this sedimentological evolution include those of the UK, Ireland, Portugal, Morocco and North America. Although the sedimentological evolution of these basins is similar, the timing and duration of the phases of fluvial and playa deposition vary from one to another. Characterising the transition between the fluvial and playa dominated episodes of basin development is important in terms of understanding what the controls are on this widespread architectural signal within Triassic continental basins.

This work presents a section from the Minas Sub-Basin (Fundy Basin, Nova Scotia) where the transition from the fluvial to the playa/ lacustrine stage is exposed. The fluvial phase is represented by the Wolfville Formation beneath the lacustrine/playa phase of the Blomidon Formation. The Wolfville Formation presents three fluvial units which show well organized and repetitive cycles developed at different scales. In the upper part of the succession an increase in ephemeral fluvial/playa-lacustrine deposits and preservation of aeolian sediments prior to playa deposition of the Blomidon Formation is present. Overall the Wolfville Formation records retrogradation of a fluvial system within which cycles are considered to be climatically driven. Despite a possible climatic

control on the retrogradation of the sedimentary succession, the diachronous nature of the transition in different north Atlantic basins suggests that additional controls are important in defining continental Triassic Atlantic basin evolution, such as drainage basin evolution or fault array development related to internal rift basin re-organisation.

CHANNEL CROSS-PROFILE CHANGE AT TOUDAOGUAI STATION AND ITS RESPONSE TO THE OPERATION OF UPSTREAM RESERVOIRS IN THE UPPER YELLOW RIVER

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The application of dams built upstream will change the input conditions, including water and sediment, of downstream fluvial system, and destroy previous dynamic quasi-equilibrium reached by channel streamflow, so indispensable adjustments are necessary for downstream channel to adapt to the new water and sediment supply, leading the fluvial system to restore its previous equilibrium or reach a new equilibrium. Using about 50-year-long hydrological, sediment and cross-sectional data, temporal response process of Toudaoguai cross-section located in the upper Yellow River to the operation of reservoirs built upstream was analyzed. The results showed that the Toudaoguai cross-section change was influenced strongly by the operation of upstream reservoirs and downstream channel armoring thereafter occurred gradually and extended to the reach below Sanhuhekou cross-section. Besides, median diameter of suspended sediment load experienced a three-stage change that was characterized by an increase at first, then a decrease and an increase again finally, which reflects the process of channel armoring that began at Qingtongxia reservoir and then gradually developed downstream to the reach below Sanhuhekou cross-section. Since the joint operation of Longyangxia, Qingtongxia and Liujiaxia reservoirs in 1986, the three-stage change trend has become less evident than that in the time period between 1969 and 1986 when only Qingtongxia and Liujiaxia reservoirs were put into operation alone. In addition, since 1987, the extent of lateral migration and talweg elevation change at Toudaoguai cross-section has reduced dramatically, cross-sectional profile and location tended to be stable, which is beneficial to the normal living for local people.

Key words: cross-sectional profile; median diameter; reservoir; Toudaoguai cross-section; the upper Yellow River.

LATE QUATERNARY ALLUVIAL SEQUENCES IN THE ARID PIEDMONT OF CORDILLERA FRONTAL (33º-34º S) MENDOZA, ARGENTINA

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The piedmont of Cordillera Frontal, between 33°-34° S, is located within the domain of the South American Arid Diagonal (AD), an area climatically sensitive to the Late Pleistocene-Holocene climate changes. Within this setting, nearly 600 metres of Late Quaternary deposits are deposited in the Tunuyán tectonic basin from which only the uppermost 30 metres crop out, mainly along the bankfulls of *arroyo* La Estacada basin and its tributary *arroyo* Anchayuyo. The exposed deposits, including four main facies and two facies associations, make up three geomorphological units, an aggradational plain (Late Pleistocene- Early Holocene), a cut and fill terrace (Middle to Late Holocene) and the present floodplain environment (last 400 yrs. BP). Facies A represents channel deposits, it includes lag deposits (lithofacies Gmm) and channel bars (lithofa-

cies Gh). Its participation in the alluvial sequences is secondary, being present at the lower stratigraphic section of both the aggradational plain and the cut and fill terrace. Facies D is composed of stacked layers (0.4 to 2.5 m) of medium to fine sand and silty sand (lithofacies Sm, Sr y Src) making up several meter high sets. It is best represented at the aggradational plain, suggesting an overbank environment affected by hyperconcentrated overflows proximal to the main stream. Facies E includes horizontal layers of sandy silts laterally continuous (lithofacies Fl and Fsm), as well as lithofacies Sm. Facies E, which represents overflows reaching distal sectors of the floodplain, is the dominant facies at the cut and fill terrace and secondarily at the aggradational plain. Overbank areas (Facies E and D) register several alluvial buried soils (lithofacies Pa) that represent intervals of stability during the aggradation process; limnic levels (lithofacies c) are also present, being very common in the cut and fill terrace deposits. The aggradational plain and the cut and fill terrace units are covered by a blanket of eolian sand (lithofacies Sme) that set up Facies J. Massive silty fine sands (*circa* 1 meter thick) of eolian origin accumulated by the end the Late Glacial are also present at the lower stratigraphic section of the aggradational plain.

The facies association (Facies A, D and J) of the aggradational plain is interpreted as a distal alluvial fan dominated by overflows and secondarily sinuous streams. The cut and fill terrace facies association (Facies A, E and J) corresponds to a fining upward sequence of a sinuous to meandering stream. Preliminary results obtained point to a climatic control of the degradation episodes that gave way to the formation of the cut and fill terrace and the present floodplain, sometimes during the Middle and the Late Holocene respectively.

RESERVOIR ARCHITECTURE MODELING OF FLUVIAL POINT BARS: LORANCA BASIN, SPAIN

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Hydrocarbon and water recovery in fluvial sandstone reservoirs are complex due to low net-to-gross ratios and internal lithological and permeability heterogeneity. Modeling of subsurface fluvial architecture is hampered by the sparse data of wide-spaced wells and therefore has an inherent uncertainty. Outcrop analogue studies with focus on the size, shape and spatial distribution of the fluvial elements and their internal permeability distribution may yield the quantitative data sets needed to reduce the modeling uncertainty.

The aim of the present study is to gain a better insight in the complex reservoir architecture of fluvial point-bar sandstones and its implications for fluid flow. To this end three-dimensional static grain size and permeability models were created, based on an outcrop study of composite point bars in the distal area of the Tórtola fluvial system in the Loranca Basin (U. Oligocene – L. Miocene, central Spain). Lithofacies characteristics of the outcrops were compared with earlier-recorded outcrop permeability measurements. Qualitative microscopic sample analysis was carried out to study the relation between permeability values and diagenetic processes.

The study yielded that the composite point bars consist of various units of fining up sequences of sandstone and siltstone beds. The point-bar architecture and associated grain-size distributions were created by lateral migration of a meandering river and vertical stacking of its deposits. Gradual aggradational phases were interrupted by abrupt channel migration, meander loop cutoff and channel fill. Subsequent aggradation partly eroded such channel fills to varying extents. Finer grained and/or better cemented point-bar sections do not compartmentalize the studied composite point-bar

sediment bodies but form baffles to flow. These baffles do not compromise fluid flow completely, but force it to follow a tortuous pathway. Late-diagenetic dissolution of gypsum grains as a result of uplift and subsequent surface water percolation has largely increased the permeability.

Hydrocarbon recovery from subsurface reservoirs may be less than expected from reservoir dimensions only, due to the occurrence of permeability baffles that force hydrocarbons to follow a tortuous flow path.

The studied point-bar outcrop can serve as an analog for fluvial point bar reservoirs and can thus enhance 3-D reservoir architecture modeling of these structures.

VARIABILITY OF CHANNEL MORPHOLOGY OF LARGE FLUVIAL FAN SYSTEMS IN ACTIVE FORELAND TECTONIC SETTINGS: VARIABILITY OF CHANNEL MORPHOLOGY OF LARGE FLUVIAL FAN SYSTEMS IN ACTIVE FORELAND TECTONIC SETTINGS: IMPACT ON RESERVOIR ARCHITECTURE AND CONNECTIVITY

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Large fluvial fans accumulations resulting from dispersive sediment deposition generally from a single main individual river stream, represent ideal natural laboratories to observe and describe the variability of fluvial channel morphology and assess the effects that external factors such as i.e. tectonic, preexisting topography, relative base level changes, etc., can have on channel downstream evolution.

In the South American Andean foreland region, where contiguous fans occupy an area up to 750000 km^2, it is not uncommon to observe coeval development of different types of channel style (e.g. Paranetí, Pilocomayo fans). This can be related to a variety of reasons such as range of different depositional processes, downstream and lateral changes in slope and channel con?guration, variability of sediment source, etc.

As an example, the morphology and sedimentation style of the main active channel of the Pilocomayo ?uvial fan covering over 210000 km^2, has been studied using high-resolution satellite images and detailed DEM. A detailed geomorphological analysis of the downstream channel evolution from apex to toe (ca. 680 km), indicates a strong variability of channel pattern, type of incision, occurrence of levees and aggrading and distribution of flood plains. Specifically, the latter associated with high sinuosity channels occurs in the upper third of the fan, a fluvial style that is commonly considered to be associated with the lower gradients occurring at the toe of the fan. In this case, the unexpected changes in channel patterns occur in correspondence of the active forebulge which most likely caused a decrease in gradient inducing the generation of a 'mini ponded basin' in the upstream direction.

Ultimately, this study highlights that the fluvial pattern of the Pilcomayo fluvial fan does not follow the classic proximal-to-distal channel style schemes commonly described and accepted in the literature for fluvial systems. Grain-size distribution, facies, facies associations, sand body geometry, internal architecture and sand connectivity are instead dependent on local external factors such as, in this case, the tectonic evolution of the deeply seated forebulge underneath the fluvial fan accumulation.

THE FLOODPLAIN SEDIMENTOLOGY OF COOPER CREEK. WHY BILLABONGS (WATERHOLES) IN THE CHANNEL COUNTRY START AND STOP

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The Channel Country of western Queensland consists of a low gradient anastomosing channels inset in muddy floodplains in a desert climate. Annual transmission losses are large, averaging 75-80% of total volume along a ~400 km reach of Cooper Creek. Billabongs (waterholes) are common and consist of local channel expansions in the

mud-lined anastomosing network, as well as isolated scour-channels on a floodplain that is formed of 2-3m of clay-rich mud. Both the primary anabranching and overbank flood channels carry water during large floods but only the billabongs store water for long periods of drought, making them vital to the ecology and agriculture of the region. Despite penetrating a very extensive underlying Pleistocene-age sand body, they are impermeable much of the time. However, transects away from several billabongs reveal marked increases in salinity and provide compelling evidence that they act as fresh-water 'entry valves' through an otherwise impermeable muddy floodplain. The base of each billabong is scoured during floods, enabling large volumes of surface water to be dumped into the 10 m deep saline aquifer. As flows decline the billabongs self-seal with mud such that fresh water can be stored for a year or more. Transmission losses along Cooper Creek were initially believed to be due to evaporation, however, the lack of any solute concentration between gauging stations along the ~400 study reach, suggests that of the ~1.8 km3 of surface flow lost from the ~3.0 km3 entering the upper end of the study reach, most leaks through the base of the billabongs. Such massive losses also account for why the billabongs in the form of large and efficient channels, terminate after just a few kilometres. They reform repeatedly at locations where conditions are suitable, but their numbers decline downstream in accordance with the loss of total flow-volume.

HYDRAULIC GEOMETRY OF NARROW DEEP CHANNELS IN PEATLAND FLOODPLAINS; EVIDENCE FOR OPTIMISATION

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At-a-station and bankfull hydraulic geometry analyses of peatland channels at Barrington Tops, New South Wales, Australia, reveal adjustments in self-forming channels in the absence of sediment load. Using Rhodes ternary diagram, comparisons are made with hydraulic geometry data from self-forming channels carrying bedload in alluvial settings elsewhere. Despite constraints on channel depths caused at some locations by the restricted depth of peat, most stations have cohesive, near-vertical, well-vegetated banks and optimal w/d ratios of ~2. Because both depth and width are to some extent constrained, adjustments to discharge are accommodated largely by changes in velocity. These findings for the movement of sediment free water are consistent with the model of maximum flow efficiency and the overarching least action principle in open channels. Importantly, the depth of peat in these swamps rarely exceeds that required to form a bankfull channel of optimum w/d ratio. The bankfull depth of freely adjusting laterally-active channels in clastic alluvium is well known to be related to the thickness of floodplain alluvium. A similar condition appears to apply to these swamps that grow in situ and are formed almost entirely of organic matter. Swamp vegetation is highly dependent on proximity to the watertable. To maintain a swamp-channel and floodplain system, the channels need to flow with abundant water much of the time; they not only offer an efficient morphology for flow but do so in a way that enables bankfull conditions to occur many times a year. They also prevent the swamp from growing above a level linked to the depth of the channel. Once the channel attains the most efficent cross-section, further growth of the swamp vertically is restricted by enhanced flow velocities and limited flow depths: the volume of peat in such swamps is determined by the hydraulic efficiency of their self-forming channels. The development and maintenance of the hydraulic geometry of these swamp channels is bio-geomorphic and bio-hydraulic in nature and yet accords to the same optimising principles that govern the formation of self-adjusting channels and floodplains in clastic alluvium.

FLOOD RISK ON FLUVIAL MARGINS AND URBAN AREAS. TUCUMÁN. ARGENTINA

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San Miguel de Tucumán city, capital of the Province of Tucumán, belongs to the subtropical Northwestern region of Argentina. The city is located on the eastern foothill of San Javier range towards a north-south river, Salí River, which is the main fluvial collector of the province. The urban growth since 1950 was accelerated yielding an urban agglomerate joining several nearby towns and represents a metropolitan area that settled almost the entire foothill from the apical to distal zones.

The Salí River, which is the main source of fresh water and irrigation supplying, splits two districts, one is the San Miguel de Tucumán city westwardly and the other is Banda del Río Salí eastwardly, where a great urban expansion took place on the river flood plain, through poor neighbourhoods and illegal settlements for low income people.

The aims of the current research focus on establishing flood risk categories on the fluvial margins of the Salí River, mainly on the urban areas affected by channel overflowing under extraordinary pluvial conditions, modeling the water level onto the urban sectors. The lack of territorial planning, multiannual climatic variations, intraurban paleochannel (masked by urbanization), insufficient collecting draining without preservation and the increasing impermeable and paved areas with high rates of runoff over infiltration, have contributed that some zones were more affected by periodic floodings.

The applied methodology was based on aerial photointerpretation, satellite images analysis and topographic maps. The yielded data were manipulated using the ILWIS software and the hydrological and flood risk and soil use cartography were obtained through this GIS. North-South and West-East cross sections were mapped using GPS.

Flood areas, due to rain excess on the Gran San Miguel de Tucumán, are located a few meters from the North and West-South collector channels, which were affected by flood processes during the extreme rains, such as the ones occurred in January of 2007 and 2008.

MAIN CONTROLS ON THE EVOLUTION OF DISTAL VOLCANICLASTIC SUCCESSIONS IN CONTINENTAL ENVIRONMENTS: CASTILLO FORMATION (ALBIAN) OF THE GOLFO SAN JORGE BASIN, ARGENTINA

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Volcaniclastic successions in distal positions in relation to the source of pyroclastic detritus are controlled by the interplay among intermittent-variable volume of fine ash transported by atmospheric winds during syn-eruptive stages, contemporary subsidence of the basin and superficial processes of reworking of ash and sediments during intereruptive stages. Those controls were evaluated in the Castillo Formation (Albian) in the N-S trending San Bernardo Fold Belt, located 170-190 km eastward of the source of pyroclastic detritus, the Andean Volcanic Chain. The unit represents the reworking of pyroclastic ash-fall beds in fluvial, playa-lake and lacustrine environments, and can be divided in sixteen lithofacies, grouped in three lithofacies associations: 1) fluvial channel, with five sub-types, 2) proximal floodplain and 3)

distal floodplain. Four major Regions with distinctive features of the fluvial deposits were recognized, named Regions 1 to 4. At basin margin locations (e.g. Region 1) the unit is a 30m thick succession of deeply bioturbated ash-fall strata, which records bypassing and condensation of the sedimentary record in a subaerial floodplain. In areas proximal to the northern basin margin (e.g. Region 2) the unit is less than 300m thick, it consists of small-scale, massive sandbodies and sheetflow (or flash-flood) deposits encased in a subaerial or subaqueous floodplain. The fluvial system evidences a poorly integrated network of channels and large variation in discharge. In southern areas (e.g. Region 3) the unit is 300-500m thick and consists of thicker fluvial channels and floodplain deposits. Fluvial channels show alternation of massive, plane-parallel and straight to low-sinuosity sandbodies, reflecting a highly variable fluvial dynamic. In areas of high-subsidence, at southern San Bernardo Fold Belt (e.g. Region 4), the unit is ~ 1000m thick. Fluvial channels are straight to low-sinuosity, mostly single or multi-storey, being part of a well-integrated drainage network in which large variations in discharge are evidenced by plane-laminated sandbodies with W/Th>100. Spatial changes in thickness, scale and proportion of different fluvial channels of the Castillo Fm. suggest that in spite of the widely recognized control of volcanism on the characteristics of volcaniclastic deposits, the reworking of ash-fall deposits in large basins located in a distal position to the source of volcaniclastics are mainly controlled by intrabasinal processes.

MORPHOLOGY, FORM ROUGHNESS AND THE ABSENCE OF CHANNEL SCALE SECONDARY FLOWS AT BIFURCATIONS IN A LARGE RIVER

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Bifurcations around mid-channel bars are key elements within braided river sytems, having a major impact upon the routing of flow and sediment, upon channel change and bar sedimentology. Although much progress has been made in understanding a range of fluvial processes, increasing attention is being paid to bifurcations and the important role of bifurcation asymmetry and flow and sediment routing at these sites. Most studies have been conducted in laboratory flumes or within small rivers with low width:depth (aspect) ratios. This paper presents results of a field-based study that details the bed morphology and 3D flow structure around two large bifurcations in the Río Paraná, Argentina, with a width:depth ratio of approaching 200. Flow within both bifurcations is dominated largely by the bed roughness, in the form of sand dunes; coherent, channel-scale, secondary flow cells, that have been identified as important aspects of the flow field within smaller channels, and assumed to be present within large rivers, are found to be generally absent in these reaches. This paper discusses these findings and outlines how this has profound implications for flow mixing rates, sediment transport rates and pathways, and thus the interpretation of large river morphology and sedimentology.

COHERENT FLOW STRUCTURES OVER ALLUVIAL SAND DUNES REVEALED BY MULTIBEAM ECHO SOUNDING

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The topology, magnitude and sediment transport capabilities of large-scale turbulence generated over alluvial sand dunes is

influential in creating and maintaining dune morphology, and in dominating the transport of suspended sediment above dune beds. Much past laboratory and numerical research has illustrated the origin and structure of such dune-related macro turbulence, and this turbulence has also been measured using both at-a-point and multipoint (aDcp) measurements within natural channels. However, all of these past field techniques have been unable to examine the holistic structure of such turbulence and examine how this may related to smaller-scale laboratory studies and numerical simulations. This paper examines the novel application of multibeam echo sounding (MBES) to examine flow and sediment flux above a series of sand dunes in the Mississippi and Missouri rivers, USA. A RESON 7125 MBES system was deployed from a small survey boat and used to map the detailed three-dimensional topography of sand dunes. Once this bathymetric surveying had been completed, the boat was then moored at-a-point and the MBES head aligned so that is captured a flow parallel swath. The backscatter signal from the multibeam swath was then utilized to visualize the structure of turbulence as picked out by the clouds of suspended sediment. Image sequences were taken in the trough and near the crests of a large sand dune and reveal the presence and advection of large coherent flow structures, with superimposed smaller vortices, that translate through the measurement volume. These images are the first such whole flow field visualizations of dune-related macroturbulence ever collected from a natural alluvial channel and reveal a complex flow structure, which bears many similarities to that modelled in past laboratory and numerical experiments. This paper will present images and animations of the flow structure and compare this to past modeling of coherent vorticity within both smooth and dune-covered beds.

FLOOD DOMINATED FAN DELTA – CASE STUDY FROM EASTERN SLOVAKIA (MARKUŠOVCE)

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Inner Carpathian Paleogene Basin, situated in the western part of the Carpathian Mts., has almost 2 km thick sedimentary fill consisting of terrestrial, shallow-marine and deep-marine deposits. Several ancient incised valleys with well-exposed fluvial deposits occur along the southern margin of the basin.

Unique exposures along the southern margin of the basin in the Eastern Slovakia (Markušovce area) show transition between fluvial deposits and wave-reworked fan-deltaic deposits. The common feature of both systems is a prevalence of coarse-grained conglomerates alternating with sandstone facies suggesting dominancy of flooding during the deposition.

Terrestrial fluvial deposits are represented by channel fill complex consisting of conglomerates filling shallow and broad channels alternating with flood plain fine-grained and silty deposits. A striking feature of the channel complex is several metres thick interval of clast-supported cobbles and boulders arranged in several dm shallow and few metres wide channels interpreted as debris flow deposits. These are thought to be deposited by catastrophic floods transporting the sediments from distant source areas as suggested by their petrographical composition. Debris flow facies are at several places interbedded by laterally pinching carbonate conglomerates representing the entry of alluvial fans into the river paleovalley.

Fan-deltaic and shallow-water sediments are characteristic by conglomerates alternating with fine-grained sandstones with varied internal structures (horizontal lamination, through-cross stratification). Hummocky cross stratification is also observed occasionally and is probably a result of the increas-

ing oscillatory component when unidirectional current enter the shallow water (shelf). Remarkable is thin layer of coarse-grained subrounded and rounded paleozoic cobbles and boulders transported from a distant source area and probably representing lateral subaquous analog of thick interval described from the fluvial part of the system.

Fan deltaic deposits were wave-reworked as suggested by through cross stratification, ripple cross stratifications, thin conglomerate beds alternating with sandstones and by bioturbated sandstones. The entire vertical succession is capped by notable large-scale through-cross stratified and horizontally laminated sandstone with sharp base (know as „Markušovce mushroom"), representing the fan deltaic deposit reworked by waves in shallow water environment.

DISTINGUISHING CROSS STRATA FORMED BY DUNES AND UNIT BARS

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The stratification formed by fluvial unit bars can be readily distinguished from that formed by dunes when observed in extensive 2-D exposures. However, angle-of-repose cross strata can occur in both unit bars and dunes, and it is difficult to distinguish them in small outcrops and cores. Angle-of-repose cross strata formed by unit bars can be distinguished in cores by the presence of relatively thick and fine-grained bottomsets, and, to a certain extent, by the relatively large set thickness. Additional information can be obtained from the cross strata themselves. These criteria are required for correct interpretation of channel deposits and for parameterization of hydrological or reservoir models. Cores through two modern channel belts indicate that only 1-3% of the channel deposits are composed of angle-of-repose cross strata formed by angle-of-repose unit bars, which is much less than commonly believed. Most unit bars are internally composed of down-climbing stratasets formed by dunes migrating down low-angle, unit-bar lee slopes. Hence, channel deposits are dominated by angle-of-repose cross strata formed by dunes.

DOES LARGE-SCALE ALLUVIAL MORPHOLOGY CONTROL DUNE-SET PRESERVATION?

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The thickness distributions of cross-strata sets underlie paleo-hydraulic interpretations and predictions of permeability heterogeneity. Previous work on the proportion of a bedform that is preserved as a set stresses the importance of the variation in bedform height and the deposition rate relative to the migration rate. Although no real consensus exists on the relative importance of the factors controlling set preservation, it is generally accepted that sets scale to their formative bedforms, and that both follow log-normal distributions. This paper compares the thicknesses distributions of cross-strata sets with ground-penetrating radar (GPR) surveys. Cross stratatified sets are classified into three groups based on radar facies, and these three groups are interpreted as: near-horizontal dune sets, inclined dune sets, and angle-of-repose unit-bar sets.

The distributions of medium- and large-scale set thicknesses were measured from 28,

~4 m long suction-cores taken in mid-channel bars in the Paraná River, Argentina, and 36 ~ 3m long cores taken in the South Saskatchewan River, Canada. Results show that the total distribution of thicknesses of sets formed by dunes and bars does not follow a log-normal distribution. Instead, the total distribution is better described by three separate log-normal distributions: [1] dune sets associated with near-horizontal (<4 º) GPR reflections, formed by dunes on near-horizontal surfaces, and; [2] dune sets associated with inclined (>4º) GPR reflections, formed by dunes on slopes; [3] unit-bar sets, identified by their large lateral extent, large thickness compared to bankfull levels, and association with fine-grained bottomsets. No clear relationship was found between set thickness and vertical position in the deposit. Dune sets associated with inclined GPR reflections [2] are 2-2.5 times thicker on average than dune sets associated with near-horizontal surfaces [1]. This increase in set thickness can be explained by increased preservation of sets on slopes, which is attributed to the decrease in migration rate, height and length of dunes migrating down large-scale lee slopes, and the locally increased deposition rates caused by flow expansion over the lee slope. Inclined dune sets made up 10-20% of the investigated river channel deposits which equals roughly 40% of all dune sets. It is therefore suggested here that large-scale alluvial morphology forms a dominant control on the preservation of dune sets.

STRATIGRAPHY AND FLUVIAL ARCHITECTURE OF THE CASTILLO AND BAJO BARREAL FORMATIONS (CRETACEOUS) IN THE SOUTHERN END OF SAN BERNARDO RANGE AND BARRANCA YANKOWSKI, GOLFO SAN JORGE BASIN, CHUBUT AND SANTA CRUZ PROVINCES, ARGENTINA

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The sedimentary record along the margins of Senguerr River shows fluvial and volcaniclastic deposits belong to Castillo and Bajo Barreal Formations (Chubut Group, Lesta, 1968; in Uliana and Legarreta, 1999). These outcrops form an asymmetrical anticline in the southern end of the San Bernardo Range. The plunge of this fold continues to the south in the subsurface.

The field work consisted in the description of three stratigraphic profiles (818m of thickness) and twenty short lateral profiles, and the drawing of each sandstone bodies from a color photomosaic (Wizevich, 1991), which covered all the outcrop, 4km of length and 60 to 100m of height.

The major stratigraphic profiles were used in the facies analysis, stratigraphic correlation and to record the vertical distribution of sandstone, mudstone and volcaniclastic deposits. The photomosaic allowed to identify thirty eight channel belts; the descriptions of additional short lateral profiles permitted the quantitative reconstructions of five channel belts.

The width of all sandstone bodies varies from 12m to 523m but the average width for Castillo Formation is 127m and only 73m for the Bajo Barreal Formation because the margins of these sandstone bodies are eroded or covered.

The thickness of sandstone bodies is higher for Castillo Formation than Bajo Barreal Formation: 3m and 2.15, respectively.

The paleocurrent directions were measured in the trough cross strata and in the imbricated pebbles. The average paleocurrent direction for Castillo Formation is toward N148º but ranging from N60º to 210º and the sinuosity is 1.35. Bajo Barreal Formation shows a mean paleocurrent direction toward N107º, varying from N0º to N180º and the sinuosity is 1.57.

The sinuosity and average thickness of sandstone bodies in Castillo Formation indi-

cate low lateral migration and deep channels; while Bajo Barreal Formation shows higher sinuosity and shallower channel belts.

A stratigraphic correlation between the outcrops and the near Barranca Yankowski oil field was performed by using seismic lines. Due to the paleocurrent directions is possible to correlate channel belts between outcrops and wells. The correlation indicates a control in the direction of the channel belts, which is assumed as a syntectonic control.

QUANTIFYING THE DYNAMICS OF FLOW WITHIN A PERMEABLE GRAVEL BED USING HIGH-RESOLUTION ENDOSCOPIC PARTICLE IMAGING VELOCIMETRY (PIV)

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Flow within permeable river beds plays a significant role in both the channel morphodynamics and in important environmental processes such as dissolved oxygen exchange, nutrient availability and contaminant transport. However, current knowledge of this critical 'hyporheic' zone remains largely unquantified, principally due to the technical difficulties involved in collecting velocity data within the pore spaces. Although numerical models are being developed to predict flow pathways within permeable river beds, their validation also demands accurate experimental data at the grain/pore scale.

Direct investigations using quantitative visualization techniques are inherently challenging due to practical difficulties in imaging through the opaque solid matrix of a permeable bed. In the present study, a fully endoscopic PIV system is described that has been developed and employed to collect velocity data on the scale of the individual pore space. A pulsed Nd:YAG laser has been used to fully illuminate the interstitial measurement plane, whilst a 4Mpxl, image-intensified camera, coupled with a high-sensitivity rod-based borescope, allows capture of high-resolution images of seed particles within the flow. This experimental configuration will be described to demonstrate the great potential of the technique for studying flow within porous beds.

The experimental investigation presented herein details experiments in a laboratory flume in which spheres were used, in a simple geometrical packing, to simulate a porous natural gravel river bed. The boundary conditions of flow depth and mean flow velocity were varied to examine the changing flow fields within the first four pore spaces. Additionally, the impact of the bed topography, in the form of a simple particle cluster, was also examined to detail its effect on the local subsurface flow. This paper will present details of the instantaneous and time-averaged flow fields within a representative pore volume that quantify the complex nature of the interstitial flow structure.

LINKING SURFACE MORPHODYNAMICS AND SUBSURFACE ARCHITECTURE IN BRAIDED RIVERS: NEW INSIGHTS FROM THE SOUTH SASKATCHEWAN RIVER PROJECT 1999-2009

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This paper presents results from research that has been quantifying the morphological and sedimentological evolution of the sandy braided South Saskatchewan River, Canada, over the last decade. The project has used a novel approach that links Digital Elevation Models, derived from specially-commissioned annual aerial photographs, with repeat surveys of the subsurface using Ground Penetrating Radar. By integrating the two datasets, not only can the morphological evolution of the river be quantified, but the expression of this evolution in the subsurface can also be identified unambiguously. Thus, the sedimentary architecture can be matched explicitly with the formative bedforms. Furthermore, these datasets can be compared on

an annual basis to establish how the deposits have been reworked and preserved over time as the braidplain has evolved through bar migration, avulsion and channel fill. Finally, the relative impact of different flood magnitudes on sediment preservation can be assessed, as the study reach has experienced a wide range of flows over the past decade, including a 1-in-40 year event. Highlights of this unique data demonstrate: 1) the importance of unit bars in both the morphological and sedimentological evolution of the braidplain; 2) the similarity between the alluvial architecture of compound bars and channel fills, 3) that larger floods may increase the rate of morphological evolution, but not the scale of the subsurface structures, such that the deposits of large floods can be difficult to discriminate from those of smaller floods, and, 4) the deposits of older bars that have been reworked provide a better geometrical analogue to the rock record than those of recently formed bars that have undergone only limited modification.

FACIES AND ARCHITECTURAL ANALYSIS OF LOWER CRETACEOUS FLUVIAL DEPOSITS IN WEST-CENTRAL ARGENTINA

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In Agrio del Medio locality (Neuquén Basin) crops out the Pichi Neuquén Member of the Rayoso Formation. This unit is 200 meters thick and is conformed by continental clastic deposits of Aptian and Albian age.

Sedimentological detailed logs (1:100 scale) were made on the oriental flank of the Agrio Anticlinal on the right margin of the Agrio river. With this data along with photomosaics of the area, facies were defined, bidimentional panels were made, and lithosomes were identified.

Lithosome characteristics allowed distinguishing between channel units and non-channelized units. The first group includes complex sheets, large-scale complex ribbons (about 100 m long and up to 5 m thick) and small scale ribbons (a few tens of meters long and up to 3 m thick). The second group includes sheets, lobes and fine grained background sedimentation.

Although some authors have described these deposits as hyperpicnites, the presence of dissecation cracks is an unequivocal evidence of sub-aereal exposure during the accumulation of this unit. Thus, the idea of subacueous deposition in a water body should be revised. In that manner, the current analysis interpret the unit as a fluvial system dominated by sandy bed load (channel units), with episodic flooding events on the alluvial plain area (non-channelized units).

CHARACTERIZATION OF FLUVIAL GEOFORMS FROM 3D SEISMIC: EXAMPLES FOR CERRO GUADAL NORTE OIL FIELD, CHUBUT GROUP (CRETACEOUS), GOLFO SAN JORGE BASIN, ARGENTINA

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The strata of the Chubut Group (Cretaceous, Golfo San Jorge Basin, Argentina) are mainly fluvial and lacustrine deposits. The fluvial architecture and poro-permeability characteristics of the hydrocarbon-bearing reservoirs were controlled by tectonic, volcanic and volcaniclastic processes contemporaneous to the epiclastic sedimentation. Additionally, the connectivity of sandstone bodies was modified according to their location in relation to the faults. Hence, lateral and vertical changes in the fluvial architecture are observed in different areas of the same oil field.

230 Km2 of 3D seismic registration were performed in the Cerro Guadal Norte oil field (YPF SA) at the end of 2008.

The use of amplitude anomalies allowed us to identify several distinctive geoforms, such as channel belts, crevasse channels, splays or lobes. Horizon sections made possible to determine the shape of channel and channel belts (wide, orientation, sinuosity and connectivity) and in vertical sections these are interpreted by means of slight amplitude anomalies as well as changes on the shape of the wavelet.

The analysis of the 3D seismic information is a fundamental tool for the study of oil fields, throughout the integration of stratigraphic, sedimentologic and tectonic data, allowing the optimization on the oil wells location, aiming to generate an efficient and reliable development of the field.

SEDIMENTOLOGICAL CHARACTERISTICS OF SUBTROPICAL PLAIN RIVERS IN RELATION WITH THE HYDROLOGICAL CYCLE (CHACO, ARGENTINA)

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The Chaco-Pampa plain is a large morphological unit located in the northeastern region of Argentina. A series of local fluvial networks were developed in the Eastern region that presents two important fluvial subsystems named “Amores” and “Oro” differentiated by its genesis and morphologic evolution. The studied region, including these small rivers, presents particular characteristics related to the small slope and subtropical climate. This contribution presents a hydrosedimentologic characterization of each subsystem in order to generate information about general features of the region and its relation to the annual variations of the rainfall.

One river from each subsystem was selected: Salado River (from Amores subsystem) and Tragadero River (from Oro subsystem). Bed material load and suspended sediment samples were taken from both river channels, as well as sediment samples from the levee and alluvial plain to evaluate differences in the dynamic of the sediments, the dominant grain size and the influence of the pluviometric variation on the suspended solids.

In order to determinate the grain size, the sieving and pipette techniques were used. The graphic method was employed in the calculation of some textural parameters. The Visher method was used to evaluate different mechanisms of bed sediment transport (Visher, 1969). Sediment concentrations were calculated by filtering using membrane disks size of pores 0.45 μm.

The Salado River is characterized by high concentration of suspended solids, linked with the low rain offer and the high development of vegetation.

The grain size of bed sediments was relatively homogeneous along all the hydrological cycle, where coarse and medium silt were the dominant fractions.

The Tragadero River bed sediment was more heterogeneous in grain size. The mean size is primarily within the very find sand in the central area of river channel. The suspended sediment concentration was lower than the Salado River. The concentration of suspended solid in both streams was increased during the high water periods. Distribution curves of accumulative frequencies demonstrated that the suspension is the dominant mechanism of transport.

All sediment analysis reflected the particularities of the area of contribution and the intrinsic characteristics of the transport agent. The results improved the available information about fluvial environments located subtropical plains.

SOLID LOAD DYNAMICS IN THE DON AND KUBAN RIVERS, SOUTH RUSSIA: INFLUENCE OF ANTHROPOGENIC AND CLIMATE FACTORS

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Don and Kuban are the largest rivers of South Russia, both terminating in the Azov Sea. The watersheds of the rivers comprise almost 500 000 km2, therefore analysis of dynamics discharge and solid load here is important task. We analysed dynamics of discharge and solid load in the Don and Kuban Rivers for the period 1940-2000 years, using systematic annual observations. We found for both rivers that there is a strong variation of the discharge driven mainly by climate. On the contrary, solid load strongly depends on the river's regulation. The load decreased with implementation of large hydrological projects in 1952 for the Don River and in 1972 for the Kuban River. Positive correlation between river run-off and solid load is seen for both cases, however, solid load of Don is decrease slightly in the last decade of XX century, despite of approximately constant river run-off. We analyse decrease in the seasonal peak of solid load and river run-off for both rivers after construction of reservoirs in 1952 and 1972.

Anthropogenic changes of river run-off in the Kuban River (minimum 5.7 km3 in 1986) were highest 1970 -1986 period, and for the Don River (minimum 9.5 êì3 in 1972) similar changes took part in 1972-1975. Increase in the Kuban River run-off is observed from 1987 mainly due change in the precipitation in the region.

Solid load in the Don River has dropped from 4.0 to 2.8 million tons per year in the period 1953-1972 after the construction of Zimla Reservoir. For the Kuban River the decrease in solid load was more radical from 8.2 to 0.86 million tons per year in the period 1973-2004 after the construction of Krasnodar Reservoir. This can be explained by mountainous type of the Kuban watershed.

THE ASYMMETRICAL CHANNEL DEVELOPMENT IN MODERN ALLUVIAL DEPOSITS: NEOTECTONIC EVIDENCES. CUMBRES CALCHAQUÍES RANGES, ARGENTINA

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At the foot of the Cumbres Calchaquíes Ranges (CCR, Tucumán Province), more precisely the area where this range structurally approaches the Aconquija System (AS) in the Tucumán Province, several alluvial fans have originated, mainly coming from the CCR slopes. However, these sedimentary deposits look very heterogeneous in their morphology.

One of these alluvial fans is located in an area between El Castillo de las Brujas and Los Cardones an unusual channel pattern is observed in the satellite images. The alluvial fan radius is 6 km; the length from the apex is 6.8 km and the alluvial fan channels flow towards Amaicha River. The amount of channels is highly variable, from the apex to the central fan 4 alluvial channels can be observe; while, from the central towards the Amaicha River the number increase to 13 and the change in degree of incisions, sinuosity etc is noticeably abrupt.

This difference between apical and distal areas is also emphasized by the channel incisions observed sharply in the central zone. The deepest channels are observed from the central to the distal alluvial fan area, whereas in the apex area the channels are shallower. A topographic step in the central area of the alluvial fan has been recorded in both field studies and satellite images analysis. Further, this step or escarpment form a belt, around 150 m width, normal to the drainage direction and coincides with the zone where the amount of channels changes. The belt has been interpreted as a neotectonic reactivation of the Amaicha Fault, which also marks the main border between CCR and

AS. No deflation on the channels has been observed, which would indicates only a vertical compressive reactivation of the underlying structural block to the river basin.

EVOLUTION OF THE SAN IGNACIO RIVER: AN EXAMPLE OF THE TECTONIC, CLIMATIC AND BASE LEVEL CONTROLS IN THE RIVER DYNAMIC, TUCUMÁN, ARGENTINA

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The orogenic belt of the northern Sierras Pampeanas in the provinces of Tucumán and Catamarca, Argentina, has developed an important drainage network towards the east, which flows to the Mar Chiquita's endorheic system. The San Ignacio River (SIR, Tucumán Province) is a tributary to that system with a reduced to moderate discharge (0.09 – 18.4 cumecs). The SIR flows towards northwest across Potrerillo, Balcosna, Los Pinos and Los Llanos Ranges. The river is controlled by a NNW-SSE fault system and forms a deeply incised valley in the basement rocks. Besides, the igneous-metamorphic massif defines an uncommon pattern of high sinuosity. However, when the river reaches the plain, the modifications in the channel pattern allow also identifying unusual changes in the river sinuosity across to the plain.

The most noticeable modification in the sinuosity of SIR is observed in the confluence with Marapa River, which is manifested as systematic channel belt migration towards the north and a continuous increment in the sinuosity. In the past century, the SIR formed splays deposits onto the plains, generating widely-distributed lobes of important dimensions as an arheic system. The La Posta and El Sueño Streams located to the south show an analog behavior to the SIR. The El Sueño Stream shows a straight pattern at the foothills and 10 km in downstream direction forms a splay deposit of 1.5 km^2. At the present day, this area is mainly covered by plantations, but there are also areas without cultivations, possibly due to the seasonal stream regime and low quality of soil.

Multiple mechanisms are considered to be responsible for the modifications of the SIR and other streams at the south of Tucumán Province: tectonic (the slope changes caused by tilting of the blocks in the subsurface), climate (transition area of rainfall, from 800 mm to 600 mm per year), base level (the migration of Marapa River to the south produced an early upstream join with SIR), and finally, and less apparent, anthropic activity.

COMPARISON OF DEPOSITIONAL DYNAMICS AMONG THE BRAIDED, MEANDERING AND STRAIGHT CHANNEL REACHES IN THE LOWER YELLOW RIVER

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There are braided, meandering and straight channel reaches along the lower Yellow River. The difference in channel planform certainly is influenced by different depositional dynamics. In this work, according to a series of data collected from the yearbook of the water and sediment of the Yellow River, the different indexes representative channel depositional dynamics has analyzed. The results show that, there are evident differences in depositional dynamics among the braided, meandering and straight channel reaches in the lower Yellow River. The channel gradient is the maximum for the braided reach, which ranges 0.2‰ ~ 0.14‰, is moderate for the meandering reach, which ranges 0.14‰~0.10‰, and the minimum for the straight reach, which less than 0.10%. The flow velocity of the bankfull discharge is also larger for the braided, moderate for the meandering and least for the straight reaches. Its

variational extent decreases downwards along the three channel patterns. The gross power of stream flow is decreases from the braiding via meandering to straight reaches and its ratio is 2.31:1.35:1. The specific power of stream flow is minimum for the braided, maximum for the meandering and moderate for the straight reaches and its ratio is 0.52: 1.18:1. The channel bed sediment is relative fine and generally lacks the roll component. The median grain size is 3.0Ö, 3.2Ö and 3.67Ö for the braided, meandering and straight reaches, respectively, further more, the sediment sorting is also enhanced along the different channel reaches downwords. The sedimentation rate on the channel beds is different among the three channel pattern reaches under the influence of the different depositional dynamics. It is the minimum for the braided, maximum for the meandering and moderate for the straight reaches when discharge is moderate to large, and it is approximative among the three channel pattern reaches, but a decrease tendency downwards, when discharge is small. In addition, the sedimentation rate on braided channel bed evidently depends on the variation of discharge, and decreases with increasing discharge.

Key Words: Depositional dynamics; Sedimentation rate; Braided chnnel; Meandering channel; Straight channel; Lower Yellow River.

MULTIDISCIPLINARY STUDY OF RÍO QUEQUÉN GRANDE BASIN, ARGENTINA

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In Argentina, rivers are managed from a political and an engineering point of view and the associated specific environmental problems (e.g. floods, pollution) are solved with local measures leading to the collapse of living riverine systems. In Europe and other developed countries, integration of geological, hydrological and geomorphological data with biological monitoring tools is considered fundamental in water legislation and management activities. In the last decades a new paradigm in the evaluation of surface waters quality was identified and concepts like biotic integrity or ecological status were defined to adequately manage water resources. In Argentina these concepts only concerns research and there are no standardized methodologies to be applied in water management.

The Río Quequén Grande watershed has a surface of about 9,940 km2 and is located in the southeast of Buenos Aires province, Argentina. It outflows into the Atlantic Ocean. The aims of this ongoing research are: to integrate abiotic and biotic information, to recognize natural and anthropogenic spatial heterogeneity and to test methodologies for the assessment of ecological status of the Río Quequén Grande watershed. A multidisciplinary approach is being developed.

The watershed was characterized, using an integrated informative system of the geological, geomorphological, sedimentological, hydrological, geochemical, land uses and biological information. Textural and geochemical bed sediments analysis and chemical water characterization of the main tributaries and the main course are also available. Bankfull channel and caliche outcrops that crossed the Río Quequén Grande channel were mapped. These data together with fluvial cross sections were used for the hydraulic analysis.

As a first approach, a biological monitoring campaign was defined for integrating ecological information with preexistent data. Samples for principal nutrients analyses were collected. General habitat quality was also evaluated and benthic algal communities, aquatic and riparian vegetation were sampled. In general the preliminary biological results indicate that the monitored rivers have an insufficient water quality possibly related to the diffused pollution

due to intensive agricultural activities. Further research is necessary. In particular biomonitoring will need to be continued, and the number of monitoring sites will need to be increased.

MORPHOLOGICAL AND SEDIMENTARY DYNAMICS OF A SOUTH AFRICAN FLOODPLAIN WETLAND: FROM CHANNELLED TO UNCHANNELLED AND BACK TO CHANNELLED?

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Understanding the allogenic and autogenic controls on wetland dynamics is essential for improving interpretations of wetland sedimentary successions and for informing wetland conservation and remediation schemes. We focus on the ~15 km^2 upper Blood River floodplain wetlands, KwaZulu-Natal, South Africa, where aerial photographs, field investigations, and Optically Stimulated Luminescence (OSL) ages provide evidence for marked channel-floodplain changes during the very late Holocene. Between ~600 and 150 years ago, the wetlands were characterised by a through-going, meandering channel set within a 2.5-km-wide floodplain. Wetland sedimentation resulted primarily from lateral point-bar accretion of thin (<4 m), fining-upwards successions of gravelly sand to mud, and from oxbow infilling by organic-rich mud. A sinuous channel flanked by oxbows remains in the lowermost wetlands but during the last 100-150 years, major morphological and sedimentary changes have occurred upstream, leading to dramatic changes in the spatial distribution and style of wetland sedimentation. The former through-going, meandering channel has been replaced by a straighter channel that decreases in size downstream and terminates in a 'floodout', characterised here by an unchannelled reedswamp. In the past ~60 years, at least four avulsions have occurred in the channel reach immediately upstream of the floodout, forming abandoned channel-levee complexes and altering the distribution of water and sediment supply. Small tributaries surrounding the wetland also supply water and sediment to this floodout and another floodout located farther downvalley. Augering reveals that organoclastic sediments >3 m thick have accumulated in the floodouts as broad lobes that in places have buried the former meander belt sediments. On the steepened, downvalley sides of these lobes, small headcutting channels receive water that filters through the floodouts. If headcutting through the lobes continues, a through-going channel will reestablish upstream, and will eventually link with the sinuous but now essentially moribund channel still present in the lowermost wetlands. Along the Blood River, the relative roles of allogenic and autogenic factors in initiating this sequence of channel-floodplain changes remain unclear, but the resulting adjustments are partially analogous to the system-scale, morphological and sedimentary dynamics of those dryland fluvial systems that are also characterised by a combination of channelled and unchannelled landforms (e.g. discontinuous ephemeral streams, erosion cells). From a management perspective, knowledge of these dynamics can help to anticipate and mitigate undesirable future wetland changes.

FLUVIAL REWORKING OF PYROCLASTIC DEPOSITS: THE CRETACEOUS LOWER MEMBER OF THE BAJO BARREAL FORMATION, SAN JORGE BASIN, PATAGONIA, ARGENTINA

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The lower member of the Bajo Barreal Formation (Cretaceous of Patagonia) records fluvial sedimentation affected by explosive volcanism produced in the Patagonian Andes. Five sections were studied along a N-S transect in the San Bernardo Range. This member is composed of sandstone-conglomerate lenses interbedded with thicker and finer-grained tuffaceous sheets. Facies associations (Fa) defined include sub-aerial primary pyroclastic deposits (Fa1 and Fa2) and epiclastic deposits partially originated by reworking of the formers (Fa3 to Fa7). Fa1 (pyroclastic ash-falls) is composed of massive or laminated, fine-grained vitric tuffs showing mantle bedding and pedogenized tops. Fa2 (pyroclastic flows) consists of stratified lapilli tuffs with reverse grading of pumice that pass upward to cross-bedded tuffs, which are capped by massive tuffs. Fa3 (fluvial channel belts) includes fining-upward bodies with channel or ribbon geometry, increasing their thickness and width from N to S. Fa3 deposits begin with through cross-bedded conglomerates or horizontal stratified breccias with vertical transition to through cross-bedded or massive sandstones. Rarely, pause-planes were detected in the lower part of channel deposits suggesting intermittent sedimentation. Paleocurrents indicate paleoflow towards E-SE in all localities. Architectural analysis mostly suggests multi-channelled and subordinately single-channelled rivers with point bars. Fa4 (crevasse-splays) is characterized by massive and cross-bedded lobe-shaped sandstone bodies with subtle fining-upward trend, participation of mudstone drapes is rare. Fa5 (sheet-floods) comprises sheet-like strata of fine-grained tuffs with scoured bases; commonly they are massive in the basal part and laminated in the upper sector. Rarely, there are intercalations of tuffs and sandstones with different cross-beddings or pedogenic features. Paleodrainage was near orthogonal to those recorded in Fa3 deposits. Fa6 (debris-flows) is characterized by sheets to plano-convex bodies dominated by massive, matrix-supported and intraclastic conglomerates. Intercalations of tuff levels with through cross-bedding or paleosols are scarce. Fa7 (ponds) includes sheet-like to channel-like tuffaceous mudstone bodies with plane parallel lamination, asymmetrical ripples or massive structure arranged in coarsening-upward cycles. Facies relationship suggests fluvial systems constituted by different types of fluvial channel belts (Fa3) and floodplains where accumulation of primary pyroclastic detritus occurred (Fa1 and Fa2), although the remobilization of these by different fluvial processes was common (Fa4 to Fa7).

MULTIPLE-POINT SIMULATION OF CHANNELIZED AND UNCONFINED FLUVIAL DEPOSITS: AN EXPLORATORY MODEL FOR CRETACEOUS OIL-BEARING SANDSTONES OF CENTRAL PATAGONIA

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The results of a multiple-point simulation of the lower member of the Bajo Barreal Formation (San Jorge Basin) are shown using outcrop data from the San Bernardo Range. Five localities were studied defining a 68 km length N-S transect. This member is equivalent to the main hydrocarbon producing unit of the basin. Multiple-point stochastic sequence simulation is a statistical procedure that allows to simulate categorical variables, particularly curvilinear facies structures, from relative frequencies observed in training images (numerical representation of a sedimentary model that includes facies patterns). According to facies interpretation, the training volume corresponds to a fluvial model with channel-belts showing moderate sinuosity (adapted from Pyrcz *et al.*, 2008);

with the following size x=256 y= 256 and z=128 nodes. Five main facies associations are distinguished from outcrop data: fluvial ribbon-shaped channel-belt sandbodies, tuffaceous sheet-floods with scoured bases, ashfall deposits, lacustrine mudstones and pyroclastic flows (ignimbrites). Maximum thickness is 350 m in the Southern region, and the area is 46000 km^2. Alluvial architecture of the succession is characterized by the absence of discontinuity surfaces or truncations, so the model possesses a constant number of layers. The used algorithm is SNESIM (Single Normal Equation) defined by Strebelle (2002), and conditioning data come from five outcrop profiles. Observed orientation of sandbodies was used in training images to guide simulation. The cell size is x=300 m, y=300 m, z=1.75 m. General facies proportion (72% sheet-floods, 22% channels, 6% the remaining facies) from original logs is respected in the resulting simulated model, where proportion of channels varies between 9-45%, 5-29% and 17-28% respectively in the lower, middle and upper sections. The model predicts that channel sandbodies would be more frequent in the Central area; and upward in the upper section, which also displays the lower variation. Lacustrine facies would only occur in middle and upper sections, while ignimbrites and ashfalls in the upper section. This model can be improved with more information from outcrops and wells.

THE EFFECT OF PEAT COMPACTION ON THE EVOLUTION OF ALLUVIAL PLAIN

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Alluvial plains like deltas often contain thick peat layers. Peat has several distinctive properties compared to inorganic sediments, which affect processes and the geometry of alluvial rivers. One of these properties is the high compressibility of peat, which potentially leads to high amounts of land subsidence. Peat compaction likely plays an important role in the evolution of alluvial plains, for example by providing extra accommodation space, which affects temporal and spatial fluvial sedimentation patterns. It has also been suggested that differential peat compaction affects floodplain gradients, and hence may affect the occurrence of avulsion. In such ways, peat compaction influences the alluvial architecture of both modern and ancient alluvial sequences, which is important knowledge for e.g. the exploration of natural resources such as oil and gas.

Still, there is a lack of field data to test such hypothesis. Therefore, field research, using new methods to quantify peat compaction, was carried out in the Cumberland Marshes (Canada) and the Rhine-Meuse delta (The Netherlands), where processes occurring on respectively decades and millennia timescales were studied. Most important factors controlling the amount of subsidence due to peat compaction are 1) the organic matter content of peat, 2) stress imposed on a peat layer by loading, 3) thickness of the compressible substrate, 4) relative vertical position in a peat layer, and 5) peat composition. Much compaction (=thickness reduction / original thickness) occurs shortly after loading; within decades up to 43% compaction might occur. In the Rhine-Meuse delta, where peat layers are up to ~8 m thick, peat compaction has led to subsidence of up to 3 m.

On short timescales (10^1-10^2 years), high amounts of peat compaction locally occur due to loading by crevasse splay or natural levee deposits. As the created additional accommodation space is rapidly filled by increased fluvial sedimentation or by peat accumulation, no gradient advantages are created which could drive avulsion. Peat compaction below channel deposits rather leads to vertical aggradation and fixation of river channels. In addition, lateral migration is inhibited by river banks consisting of mainly peat, which is highly resistant to fluvial erosion. On longer timescales, when the maximum compaction potential of peat layers in an area has largely been reached, delta

lobes become prone to switch to another part of the alluvial plain.

ACCOMMODATION / SEDIMENT SUPPLY FLUVIAL DEPOSITION CONTROLLED BY BASE LEVEL CHANGES AND RELATIVE SEA LEVEL FLUCTUATIONS IN THE MATA AMARILLA FORMATION (EARLY UPPER CRETACEOUS), SOUTHERN PATAGONIA, ARGENTINA

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The aim of this contribution is to study the tectonic, eustatic and climatic controls over the Mata Amarilla Formation sedimentation. The area selected for the current study is situated along the southern margin of the Viedma Lake, where the unit has its maximum outcropping thickness, reaching about 350 metres.

The Mata Amarilla Formation (Feruglio in Fossa Mancini, 1938) is composed of an alternation of grey, green greyish and dark mudstones with whitish sandstones deposited under continental to litoral environmental conditions. This unit date back to the Early Upper Cretaceous and is a key element for understanding the passage from the extensional Rocas Verdes basin to the foreland Austral Basin. The Mata Amarilla Formation is deposited over the deltaic Piedra Clavada Formation and is overlained by the shoreface facies of the Anita Formation.

Detailed sedimentological logs, facies analysis and architectural parametres were useful to define three sedimentary units. These sections are different in their accommodation/sediment supply rates. Paleosol horizons appear interbedding within the channel belt along the geological column.

The lower section of Mata Amarilla Formation cropping out to the west shows distal fluvial mudstones with subordinated fine and medium sandstones. While at the eastern side, the deposits form a coarsening upward sequence consisting of estuarine mudstones, flaser and wavy heterolithic and herringbone sandstones, and bayhead delta sandstones. The medium section is mainly fluvial and shows, from west to east, a definite transition from conglomerate braided systems to sandy meandering and anastomosing systems at the farther end. The upper section shows fine grained distal fluvial deposits in the west and littoral setting in the east. In this manner, the lower and upper section should represent higher accommodation / sediment supply conditions, whereas the medium section should correspond to a lower accommodation / sediment supply stage.

The three sections show evidence of consistent paleoclimatic conditions, so the variations in accommodation / sediment supply registered for the Mata Amarilla Formation are inferred to be promoted by base level changes related to relative sea level oscillations. The strong west to east evolution of the fluvial systems is in correspondence to the direction of propagation of the Austral Basin fold and thrust belt. In this way, the relative sea level changes of the Mata Amarilla Formation respond to a tectonic control over a pure eustatic fluctuation.

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3D COMPUTER-MODELLING OF FLUVIAL DEPOSITS: OUTCROPS STUDIES OF THE LOWER TRONCOSO MEMBER (NEUQUÉN BASIN, ARGENTINA) AND IMPLICATIONS FOR THE CHARACTERISATION OF SUBSURFACE RESERVOIRS

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Computer-based modelling of fluvial deposits has become a crucial tool for understanding and predicting the variability of hydrocarbon reservoirs in the subsurface. The precise definition of their key parameters requires quantitative geometric data that can be only obtained through the direct observation of the rocks. Therefore, outcrop analysis of potential targets or the study of suitable analogues is important as a means of constructing quantitative models that can be directly applied to subsurface exploration.

In order to evaluate the relative importance of some of these variables, a detailed study of the distal fluvial deposits of the Lower Troncoso Member of the Huitrín Formation in the central Neuquén Basin (west-central Argentina) was performed. The aim of the study was, while building robust models that could be applied to the subsurface in neighbouring areas, evaluate how key elements that can be only assessed through the 3D observation of the sedimentary bodies influence the outcome of dynamic flow simulations.

Models were built considering the distribution of potential reservoir units (three types of channels and sandstone lobes) and its contrast with low permeability units (floodplains) at a complete unit scale (~80 m thick) in a 56 km^2 area. Reservoir units were modelled stochastically and populated with petrophysical properties from analogue units in the North Sea. Alternative models were built changing some of the modelling parameters (channel-belt width, sinuosity, detailed channel-belt vertical distribution) in order to compare the results of flow simulations and evaluate their influence in the final results.

Of all the parameters analysed the main differences raised in the analysis of the vertical distribution of sandstone bodies. The stochastic distribution of channel bodies considering only ten vertical logs gave a more uniform channel distribution and more optimistic results, in contrast with the observed architecture where channels are more constrained to a restricted vertical zone. Results derived from changes in the channel-belt width proved more significant than changes in the channel-belt sinuosity (this one calculated empirically through palaeocurrent distribution within a channel body). Finally, slight changes in the petrophysical characteristics of floodplain deposits changed the results of the flow simulations significantly, suggesting that a detailed study of fine-grained facies is also of great importance in the characterisation of distal fluvial successions.

EPHEMERAL ALLUVIAL SYSTEMS OF THE TERUEL BASIN (MIOCENE, SPAIN): BASINAL AND CLIMATIC CONTROLS

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The classic stratigraphic record of fluvial systems, with protracted discharge through time, is characterized by highly structured and organized deposits both at facies and architectural element scales. Relatively less attention has been paid to deposits of short-range, ephemeral alluvial systems in high-gradient, tectonically active areas, which may often be confused with alluvial fans.

The Tertiary Teruel Basin (Spain) is an association of half-grabens developed under semi-arid climate. Proximal coarse-clastic systems developed at basin margins, interfingering with deposits of low-energy (mudflat to lacustrine) distal settings. On a large-scale distinction between overbank and channel-fill elements allows to characterize such alluvial successions as products of channelized drainage pathways. On the other hand, facies analysis reveals high volumes of poorly organized deposits resulting from non-newtonian hyperconcentrated flows and possible in-channel debris flows.

Active tectonics at basin margins and a semi-arid climate conducive to flash-floods probably favored high-gradients, proximity to sediment sources and ephemeral- discharge events, which in most cases resulted in poor ability to effectively reorganize the abundant sediment supply during transport.

An additional role could have been played by high volumes of Triassic claystones in the basement. In particular, elevated concentrations of suspended fines in channel flows would have significantly contributed to dampen turbulence and raise flow viscosity, inhibiting sorting and full development of bedforms or tractive fabrics.

This latter hypothesis can be tested by comparing deposits of two such ephemeral alluvial systems dating respectively from the Late Miocene of the central basin sector and the Quaternary of the northern sector. Striking facies differences for the two successions reveal a prevalence of hyperconcentrated flows in channel-fills of the older one, exposed to much higher sediment supply from Triassic sources.

At basin scale, despite the distinctiveness of fine, basinal and overbank deposits and high-energy, coarse-clastic alluvial facies, the overwhelming volume of clay present in most preserved alluvial units might significantly lower their potential as pathways for subsurface fluid flow.

THE ORIGIN OF THE INCISED CHANNELS IN THE UPPER SECTION OF THE PLAYA DEL ZORRO ALLOFORMATION (NEOGENE), EL CAJÓN VALLEY, CATAMARCA – ARGENTINA

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The Neogene succession of the Santa María Basin at El Cajón Valley (NW-Pampean Ranges, NW Argentina) is divided in three alloformations, from base to top: Peñas Azules, Playa del Zorro and Totoral. Lithology of the fillings indicates sandy fluvial systems changing up into alluvial fans. Paleocurrent directions indicate a changing paleodrainage headed to the East in the lower alloformation and to SE in the two upper units. The change of drainage orientation indicates a growing influence of the southern half of Quilmes Ranges that started to emerge above the basin surface at 5 My, along with the tectonic inversion stage.

Playa del Zorro Alloformation is the better exposed and present the maximum thickness (1,280 m in the type stratigraphic profile of Puesto Molle Grande). The unit lays disconformably over the Peñas Azules and is covered in turn by the Totoral Alloformation through a low angle irregular unconformity.

The sandy succession of Playa del Zorro Alloformation changes in the middle part to lacustrine deposits formed by green to yellow-green shales rich in freshwater ostracods, pelecipods, gastropods and fish scales. The 40 m thick of the lacustrine deposit decreases gradually toward the North. In the equivalent strata of the Ovejeria Chica stratigraphic profile the lacustrine facies are absent. In this particular profile, the uppermost succession of Playa del Zorro Alloformation shows a succession of very well developed incised channels, with a complex architecture of multiple incisions (deep crevassing).

According to the paleocurrents measured in Playa del Zorro Alloformation, the predominant drainage was to the southeast, coming from a north-south oriented source area that formed the western basin border. The lacustrine facies are extended in the north-south direction from a place near the Ovejeria Chica to the north, down to the Agua de la Paloma River in the south, by a continuous extension of 70 km or more (in subsurface). The existence of such a lacustrine persistent environment is related to the extensional tectonic stage of the basin evolution. At the top of the lacustrine horizon there is a tuff level dated in 5,7 My by Ar-Ar, very close to the initiation time of the tectonic inversion in the Santa María Basin (circa 5 My). The upper section of Playa del Zorro Alloformation over the lacustrine facies, is a coarsening-up succession with an increase participation of conglomerates, that indicates an increment of tectonic activity and progressive grow of the relief, due to the uplift of the surrounding mountain blocks. As a consequence of the mountain uplift, a

climatic barrier grew up in the eastern border of the basin, creating arid conditions in the Basin climate.

The incised channels occurrence is related in part to the aridification of the climate (multiple crevassing) but also to the influence of tectonic changes. Several causes could be associated to the lacustrine filling end and the starting of the incised channels developing. Considering the size and location of the lacustrine facies, the changes in the tectonic environment conducted first to the disappearance of the paleolake and there after to a general change of the local base level of the associated fluvial system.

ARID CLIMATE FLUVIAL SYSTEMS IN THE SALICAS FORMATION (PLIOCENE), BOLSÓN DE PIPANACO, LA RIOJA, ARGENTINA

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The Pliocene sedimentary succession of the Salicas Formation outcropping around the Bolsón de Pipanaco is laying over the Pampean Peneplain, a paleogeomorphic surface build during a Mesozoic and Early Cenozoic extensive erosive period. The Salicas Formation consists in sandstones channel bodies interstratified with subordinate tabular fine sandstones and shales, of the floodplain.The unit yields fossil mammals related with small herbivorous forms of Huayquerian-Montehermosean ages (Pliocene). Shales form massive isolated tabular bodies and show rhyzoconcretions and calcretes horizons, which are interbedded with floodplain sandstones. At the west of Mazán Village, a thick siltstone bed, around 1.10 m, is interbedded with flood plain deposit formed by decimeter tabular ill-laminated beds, which could be compared with similar silty bed accumulated in the present day Señor de la Peña playa lake ("barreal") a nearby endorheic pampean valley ("bolsón").

The fluvial channel facies are normally composed of lenticular sandy small channels with smooth erosive bases crowded of irregular paraclasts of cohesive siltstone. Interstratified with the water laid sandstones, there are sandy beds with erosive tops formed by well sorted fine grained sands with a very well preserved thin lamination. This association of fluvial poor sorted medium to coarse sands with silty paraclast, associated with fine well sorted sandstones is typical of many dry rivers of the area. The fine sands are reworked aeoilan material taken mainly from the river floor.

A second well preserved feature of the channel facies is the presence of high (2 to 5 m) river banks("barrancas") with chaotic concentration of angular blocks and rounded pebbles. The Salicas Formation facies presents remarkably similarities with the present day fluvial environment developed under an arid climate with moderate wind activity at the end of the winter, and rains concentrated in the summer (200-400 mm a year). Arid climate, in this case, could be considered a latitudinal effect of the southern convergence of the Hadley and Ferrell cells in a moment of much lower altitude of the Andean Cordillera.

CLAY MINERALS RELATED TO FLUVIAL DYNAMIC. BAJO BARREAL FORMATION. SAN JORGE BASIN, SANTA CRUZ, ARGENTINA

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Bajo Barreal Formation, Upper Cretaceous of San Jorge Basin, Argentina, is an

important hydrocarbon reservoir. It is composed of fluvial channel sandstones and flood plain deposits. It involves south of Chubut and north of Santa Cruz provinces. The seals are both stratigraphic and structural. The former are represented by mudrocks laminated beds.This job aims to point out the relationships between the clay mineralogy and the fluvial dynamic. Moreover, it tries to set up the possible use of the mudrocks levels as correlation markers.

Twenty mudstone samples were taken from two logs described in the outcrops around La Sin Nombre small Lake, in Cerro Guadal play. X ray analyses were performed in order to determine the clay mineralogy. Montmorillonite, as the main clay mineral, kaolinite and illite are present in the log described at the east side of the small lake. Smectite-illite mixed layered is present in one of the samples and two others levels bear no differenced smectites. Feldespars and zeolites are the accessory minerals. The log located to the north of the small lake has beidellita as the main clay mineral. Some beds contain montmorillonite but never both of them. Zeolites are present in the base and in the top of the stratigraphic log. Feldespars and smectite-illite and smectite-chlorite mixed layered are present in three samples located towards the top. Quartz, kaolinite and illite can be found all along two logs in the clay size class.

The great abundance of smectites allows us to classify these mudrocks as belonging to Clayzone A (Gainza et all, 1984), although these authors call all the smectites as montmorillonites.

The reasons of the predominance of smectites over other clay minerals could be in: 1) alteration of pyroclastic materials (Moore and Reynolds, 1989); 2) weathering in ill dreinaged environments, swamps or flood plains in fluvial systems (Berner, 1971); 3) warm climates with a very dry season (Singer, 1984 and Galán, 1986).

In this case, the abundance of smectites could be caused by the weathering of pyroclastic underlying beds as well as the location of the outcrops respect to the wet winds which could had induced the montmorillonite formation on the lee and the beidellita formation on the humid exposed slope (Paquet and Clauer, 1997) in the flood plains of fluvial systems.

RECONSTRUCTION OF FLOOD EVENTS OVER THE LAST 150 YEARS IN THE LOWER CHANGJIANG VALLEY

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The reconstruction of paleo-floods in the Holocene has attracted many research attentions for the present global change study. The core sediments from one newly-emerged bar in the lower Changjiang (Yangtze River) mainstream were collected for grain size and organic elemental measurements, with the aim to reconstruct the flood events over the past 150 years. Major grain size parameters such as mean grain size, probability cumulative curve and C-M diagram of the core sediments clearly indicate the flood event deposition. Furthermore, the TOC/TN ratios in the sediments can indicate flood events considering that during the flash floods, strong surface erosion in the upper and lower valley of the Changjiang could transport a large amount of undecomposed plant debris and organic components with relatively low C/N ratios into the lower mainstream. Based on 210Pb dating and sedimentary geochemical results, the research profile recorded several large floods happened from 1850 to 1954, which completely agrees with the historical documents and hydrological observations. It is interesting to note that the flood events since 1960s cannot be distinctly recognized on the basis of sediment grain size and organic elemental compositions of the profile, which mainly reflects the intense human activities over the last fifty years, especially condense dam construction, which have significantly changed the characters of suspended sediment into the lower mainstream.

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