Jurassic pelagic deposits of the Tatra Mountains: facies, depositional environments, integrated stratigraphy

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Middle–Upper Jurassic deposits were studied in the Krížna Nappe of the Tatra Mountains (Central Western Carpathians), southern Poland and Slovakia. They comprise radiolarites and associated pelagic limestones. A carbon isotope stratigraphy of these deposits was combined with biostratigraphy based on radiolarians, calcareous dinoflagellates and calpionellids.

Middle Jurassic deep-water deposits show distinct facies variations laterally and vertically. Basin succession is represented by thick, spotted limestones of the Bajocian age, followed by uppermost Bajocian–Middle Bathonian grey nodular limestones. Simultaneously, condensed *Bositra*-crinoidal limestones were laid down on the submarine highs and their slopes. Uniform radiolarite sedimentation started in the Late Bathonian (UAZ 7) or somewhat earlier in the latest Middle Bathonian, but intermittent radiolarian-bearing sedimentation occurred already in the Bajocian. This kind of sedimentation persisted to the early Late Kimmeridgian (UAZ 11). Recovery of carbonate sedimentation took place in the latest Kimmeridgian–Early Tithonian (Moluccana, Borza, Pulla, Malmica, Semiradiata and Chitinoidella zones), when red nodular limestones and platy limestones were laid down. These two carbonate facies interfinger with each other.

Bulk-carbonate isotope composition of carbonate-siliceous deposits shows delta13C excursions in the Early Bajocian, Late Bajocian, Early Bathonian, Late Bathonian, Late Callovian, Middle Oxfordian and Late Kimmeridgian (Moluccana Zone). Additionally, the distinctive features of the studied $\delta^{13}C$ curve are a pronounced increasing trend in the Callovian and a steadily decreasing trend from the Middle Oxfordian to the Early Tithonian. These trends correlate with the trends known from other areas of the Tethyan region. Increased delta13C values in the Middle Callovian–Middle Oxfordian and Late Kimmeridgian (Moluccana Zone) correspond to enhanced radiolarian production. In contrast, the onset of Late Bathonian radiolarite sedimentation coincides with a decreasing trend of delta13C. A distinct increase in calcium carbonate content is recorded just below the Middle Oxfordian delta13C excursion, which coincides with transition from green to variegated radiolarites. The study additionally suggests that delta13C of bulk-samples of micritic carbonates from carbonate-biosiliceous deposits containing only small amount of carbonate admixture (up to 12 wt% of calcium carbonate) can be effectively used in chemostratigraphic studies.

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Geometry and evolution of fault-controlled syn-rift carbonate platform margins: the Upper Triassic Dolomia Principale depositional system (Western Southern Alps, Italy)

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Extensional tectonic plays a relevant role on the accommodation rates, geometry and facies character of carbonate platforms, frequently promoting the development of intraplatform basins bordered by fault-controlled escarpment. Along the southern side of the westernmost Tethys, the Dolomia Principale (Val Taleggio Basin, Bergamasc Alps, N Italy) carbonate platform was dissected, at different regional and local scales during the Norian (Late Triassic) by extensional faults, generating several intraplatform basins. The restricted character of these basins promoted the development of a carbonate factory consisting of microbialites, frequently associated with serpulid-bivalve bioconstructions, which conquered the margin and slope environments. Fault activity along unstable, poorly-cemented platform margins triggered talus proximal slope polygenic breccia deposits, dominated by clasts of dolomitized microbial mounds associated with intraformational slope carbonates and minor platform-top peritidal and subtidal lithofacies. More distally into the basin, decimetre-thick debris flow breccia beds alternated with dolomitized calci-turbidites and calci-mudstone.

The asymmetry of the half-graben extensional basin (5-20 km wide) is reflected in the geometry, lithofacies character, evolution and different thickness of the adjacent platform early dolomitized successions (from 800 up to 2000 m). In the studied Val Taleggio Basin, the steeper western margin corresponded to the master fault footwall characterized by a downward stepping profile, whereas the eastern hanging wall margin was lower angle.

The western margin retrograded with a multistep retreat (at least 1.5 km) of the fault-controlled escarpment. Microbialites consisted of dolomicrite laminae (a few millimetres thick) alternating with trapped silt-sized peloidal intraclastic packstone (up to 2 cm thick). A few metres thick, planar to hemispheroidal mounds accreted on the top of the upper slope breccias and sub-horizontal terraces of the stepped escarpment morphology, commonly resedimented in breccia beds.

In contrast, the ramp-type eastern margin was characterized by a thicker cyclic succession (up to 700 m thick), with microbialites preserved in place, alternating with finer grained and less common breccias, characterized by two major progradational/aggradational pulses, with clinoforms up to 10-15°, and a retrogradational phase at the top. In the upper slope succession, *in situ*, up to 6 m thick and hundreds of metres wide, microbial tabular and domal bioherms alternated with decametre-thick, lenticular breccia beds rich in microbialite debris. Microbialites were favoured by periods of tectonic quiescence, during which they played a key role in stabilizing the upper slope and in buffering the abundant lime mud exported from the non rimmed, subtidal dasyclad-rich platform interior.

The different stratigraphic evolution of the studied Dolomia Principale succession demonstrates the role of syn-sedimentary extensional tectonic strongly controlling the development of carbonate platform margins, in terms of geometry, carbonate factory, lithofacies types and their vertical stacking and spatial distribution.

Microbial Carbonate System at Shark Bay, Western Australia

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Shark Bay World Heritage area is located 800 kilometers north of Perth on Australia's westernmost coast. The region is recognized for its natural beauty and scientific significance, particularly the conspicuous stromatolites and thrombolitic structures, produced mainly by bacterial communities.

The microbial carbonate system has developed in response to a progressive change in environmental conditions transforming a near open marine system into a restricted embayment with abnormal salinity, high alkalinity and high evaporation. Microbial limestone started depositing at about 2000 years ago long after the Holocene maximum flooding of the sea level in response to sea level fall of about 2.5 meters, as a minor variation within the Holocene stratigraphic highstand system tract.

The occurrence, external morphologies, internal fabrics, constructional mechanisms, cyanobacteria taxonomy, growth rates and sediment associations were investigated in the intertidal and previously little researched subtidal zone.

Oldest dated heads are near 2000 years and the overall system was deposited in two stages; the first between 2000-1200 and the last from 900 years BP to the present. Slow growth rates vary from less than 0.1 mm/year to 0.5 mm/year.

Different internal fabrics were constructed according to their position in relation to the littoral zone by distinct microbial communities, and known fabric relations have been expanded into the subtidal zone. Evidence of shallowing-upward fabric sequences of microbial origin reflects falling sea levels during the late Holocene and is likely useful in ancient environmental interpretation. A sequence of events and mechanisms were described emphasizing differences between the stromatolitic, thrombolitic and cryptomicrobial deposits in Shark Bay.

Despite the very gentle morphologic gradient, the bacterial communities live in very specific positions showing definite zonation related to different water depth conditions in the tidal environment, as characterized in the new substrate map. Parameters like salinity, water depth, turbulence, luminosity and accommodation space, associated with shore morphology, waves, wind direction and sediment influx are responsible for the occurrence and distribution of the microbial communities and their resultant organo-sedimentary deposits. Substrate morphology in Hamelin Pool displays an important role in controlling the presence of microbial sediments growing as mats or build-up structures with conical, domical, elongate/ellipsoidal or club shaped morphologies dominant in places with steep gradient contrasting with mats that cover extensive areas with gentle substrate gradient.

Based on the improved knowledge of the nature and distribution of Shark Bay microbial deposits a revised facies model has been constructed. Peritidal zones at Shark Bay are characterized by a relatively extensive and prolific activity of bacteria producing microbialites that are exposed in the supratidal zone and are progressively colonizing the subtidal zone as a consequence of sea level fall, although evidence of recolonization observed on the intertidal zone points to a recent short marine transgression.

Tectonostratigraphy of Cretaceous Carbonate Platform and Slope in the Santaren Channel, Bahamas

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In the GOM/Caribbean area, aggrading to prograding Albian platforms are well known whereas Cenomanian platforms have not been widely recognized below the well-known Mid Cretaceous Unconformity (MCU) followed by a global flooding event. Based on an extensive 3D seismic dataset in the Santaren Channel area of the Bahamas, we investigate the development and demise of an Albian and a Cenomanian Platform in an active compressional tectonic setting. The initiation and development of an Albian platform corresponds to the onset of breakup of the Early Cretaceous Megabank with clear shelf-to-basin differentiation with in Late Albian. The top of the aggrading Albian platform is characterized by an heavily karsted exposure that produce extensive post-Albian karst collapse structure rooted in this Albian karst surface. Following the Albian exposure event, drowning of the Albian platform initiated the growth of keep-up pinnacles and subsequently results in the backstepping of the carbonate platform margin 15 to 25 km back from the Albian margin. The continuing post Albian overall relative sea-level increase leads to the development of an approximately 1000 m high aggrading Early Cenomanian platform. This steep-sided platform has spectacular margin faulting, collapse and rotation during Cenomanian time along margin parallel faults (or slides) plane that can clearly be seen in the coherency data. The steep sided Cenomanian platform has a by-pass slope with a thick sediment wedge onlaping the steep slope that contain high amplitude and slightly incoherent seismic reflection that are interpreted as a debris flow related to margin collapse. By the end of the Cenomanian platform growth, a 150 m rimmed-margin developed before the terminal exposure of the Mid Cenomanian platform. High amplitude, wavy and contorted reflections mark the top of the platform corresponds to the regionally recognized MCU exposure event. The subsequent drowning of the MCU platform is characterized by the development of numerous up to 800m wide and 200m high pinnacles. Tectonic loading and tilting of the platform produces normal faults and large slumps in the platform interior area. This slide can be recognized in the semblance volume by a rectangular shaped large slump scar up to 12 km wide and up to 100m high. The Cenomanian Platform morphology has lasting influence on the Tertiary deposits, potentially up to the sea floor. Tertiary pelagic sediment onlap that topography and differential compaction between the area of the Cenomanian platform and the more basinal area creates a margin parallel fault, which almost reaches the seafloor. The effect of the MCU platform on compaction can also be seen on the modern sea floor topography. The massive Cenomanian Platform seems to have a strong control on the shape of the folds associate with the Cuban orogeny. , Compression caused preferential deformation of the Albian and post-Albian pelagic sediment but seems to just have tilted the MCU platform while leaving it unfolded. As the deformation front propagated eastward, detachment occurs and thrust faults initiated on a deep ductile layer, a decollement potentially mediated by salt.

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3D Seismic Geomorphology of the Neogene to recent leeward slope of the Great Bahama Bank in the Santaren Channel area

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The Tertiary to modern slopes of the Bahamas are by far the most studied carbonate slope system. The leeward slope of the Great Bahamas Bank (GBB) has been the focus of several seismic and drilling campaigns in the last 25 years. This leeward slope system has become the type system for muddy carbonate slopes. In the last 5 years, several studies have acquired high resolution multi-beam bathymetry, AUV bathymetry and high resolution 2D seismic data that has changed drastically our understanding of this slope system. In particular, previously unrecognized erosive canyon, channel levee complexes, gully systems, and large platform collapse scars and slumps have been spectacularly imaged in what was used to be thought as a rather homogeneous muddy leeward slope.

In the Santaren Channel area, the shallow portion of BPC Pearl 3D seismic dataset provides unique insight into the geomorphology of the toe-of-slope part of this slope system, perhaps at a lower resolution than the recent studies mentioned above albeit in full 3D. This project uses stratal slicing through the semblance volume to extract the morphological features of the toe-of-slope to basin area of the GBB.

A Mid-to-Late Miocene system of narrow, sinuous, and avulsing channels changes upward into wide straight channels. The sinuous channels have a width of approximately 100 to 200 m and are up to 20 m deep. The wider straight channels are up to 200 to 600 m wide and 40 m deep. The sinuous channels have very similar geometries and dimensions to the modern channels and gullies illustrated previous work. The resolution of the 3D seismic is not enough to image the levee complex in detail but enough to identify it for a few channels. As the slope steepens, the channel complex change into a more debris and slump dominated slopes. In particular, a large Plio-Pleistocene mass transport complex is well imaged on the semblance slice. These MTCs contain cemented blocks up to 2 km wide, likely composed of muddy slope deposits. The rectangular shape of the blocks, their pattern, and distribution point to a slope origin rather than a margin collapse. The slump and debris interval starts occurring around 3.6 MA, which is similar timing shown by previous study for the same interval further north.

The Change from Channelized slope to Debris dominated slope coincides with the increase of slope angle after the Miocene. The steepening is probably related to the increase in the amplitude of sea level change resulting from the onset of Northern Hemisphere glaciation during the Pliocene.

Deeper in the section, The Tertiary folding associated with the Cuban orogeny triggers MTCs made of pelagic sediment on their flank. We can also observe in the semblance data, deep water channel complexes that terminate on and are deviated by the topography created by the folds.

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Sedimentary facies of beach sediments on an uninhabited reef island in the Spermonde Archipelago, SW Sulawesi, Indonesia

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Pulau Panambungan is an uninhabited reef island in the Spermonde Archipelago, southwest Sulawesi, Indonesia. Similar to other tropical islands, its elevation does not exceed a few meters above mean sea level. This landform is strongly affected by changing boundary conditions such as reversing monsoon wind directions. These influences control their morphological and sedimentary characteristics. However, detailed sedimentological studies on reef islands in Indonesia are still rare.

During field campaigns in 2012 and 2013, we collected surface and subsurface sediment samples from Pulau Panambungan in order to analyze the facies distribution of this island. Additionally the topography of the island was surveyed along multiple transects, thus allowing a comparison of sedimentary characteristics with respect to their relative elevation within the island core. Preliminary results show that the island sediments contain coralline red algae, coral fragments, gastroprod shells, *Halimeda* segments, bivalves and echnioderm fragments. The lateral and vertical grain size distribution comprises particles from fine sand to gravel. Particles within individual samples are bimodal, trimodal and polymodal distributed and accordingly, the sediments analyzed range from very fine gravelly sand to sandy fine gravel with well to poor sorting.

In combination with *in-situ* observations, this indicates that the geomorphology of the study island is largely affected by event-dominated sedimentation processes that resulted in successive accumulations of sand- to gravel-sized material on top of the islet. Such high-energy events mainly occur during the northwest monsoon and therefore indicate that the geomorphological evolution of reef islands in the Spermonde Archipelago is strongly influenced by seasonal climate variations.

Tight interaction between marine and non-marine carbonate deposition in the Danakil Depression (Northern Afar, Ethiopia): Preliminary results from a first reconnaissance survey

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The Danakil Depression, situated in the northern part of the Afar triple junction (up to 120 m below sea level), is part of an active rift associated to the break-up of the Afro-Arabian plateau, that started during Oligocene-Miocene times. In the center of the depression deposits are characterized by an evaporitic succession with a total thickness of more than 1000 m. Deposition at the basin margins was controlled by the interaction between tectonics and global eustatic sea-level changes that led to several episodes of marine transgression during the Quaternary. The last connection with the Red Sea, witnessing open marine conditions, took place during the Late Pleistocene.

Episodes of marine flooding and desiccation resulted in the deposition of diverse carbonate units, ranging from open marine coralgal reefs to hypersaline microbial build-ups deposited in lacustrine environments. During a first field campaign in October 2013 a sedimentological and stratigraphic study was performed on six marine and two lacustrine localities of Pleistocene age on the western and southern side of the Danakil Depression. Samples of specific intervals were collected in order to date carbonate units and to characterize the sedimentary facies.

The studied marine deposits consist of at least three superimposed coralgal units evidencing successive episodes of fringing reef formation around the Danakil depression (geographic extension of approximate 190 km x 70 km). These coralgal units are separated by erosional unconformities suggesting episodes of non-deposition and/or subaerial exposure. Monospecific bivalve- and gastropod shell accumulations occur between the coralgal units, evidencing alternating periods of restricted and open marine conditions. During earlier studies ^{230}Th /^{234}U and ^{14}C datings have been performed on corals and bivalves, suggesting ages between 230 kyr and 32 kyr. In these studies, however, no detailed stratigraphic context was presented, making it impossible to differentiate between single coralgal units and their relation to eustatic sea-level changes. Moreover, older units have been probably undersampled due to scarceness and/or poor preservation of corals. Our observations show that younger units are dominated by corals, while older units are more lithified and dominated by red algae making absolute dating more difficult.

Microbial deposits are found (1) in coralgal reef cavities, (2) as small stromatolites in reef slope environments and (3) at the margin of hypersaline lakes. The latter are witnessing restricted environmental conditions in a closed and arid basin. Detailed studies of these exceptionally well exposed marine and lacustrine microbial deposits will allow the better understanding of processes leading to microbial mediated carbonate precipitation in alternating marine and continental settings.

The primary goal at the onset of this long-term project is to establish a well-constrained stratigraphic framework of the Quaternary succession supported by radiometric datings. This framework will provide the base for detailed sedimentological, palaeoecological and biogeochemical studies of these exceptionally well-exposed deposits. The combined study of marine and non-marine carbonate units at basin-scale will lead to the better understanding of (1) the younger flooding history of the Danakil depression, (2) the timing of final closure of the connection to the Red Sea and (3) the temporal and spatial relation between the different shallow marine and microbial carbonate units deposited at the rift margins, and the evaporites deposited in the central part of the rift basin. This will contribute to the better understanding of sedimentary facies evolution in an active rift setting.

Depositional Models, Controlling Factors and Hydrocarbon Potential of the Daxing Conglomerates in the Paleogene Langgu Sag of the Bohai Bay Basin, North China

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1. Introduction - The Daxing Conglomerates developed in the 3rd member of the Paleogene Shahejie Formation (Es3) have become important exploration targets in the half-graben Langgu Sag of the Bohai Bay Basin. The conglomerates are distributed along the Gu'an-Jiuzhou structural belt and the NE-trending Daxing fault. The conglomerate reservoirs exhibit strong anisotropy with low porosity and permeability. Therefore, study of the Daxing Conglomerates will contribute significantly to our understanding of the conglomerate reservoirs and is key to further exploration and development.
2. Methods - This study utilized a comprehensive approach that integrated seismic, logging, core and well testing data. First, the sedimentary features of the Daxing Conglomerates were analyzed to develop depositional models and then palaeogeomorphology reconstruction and provenance analysis were carried out to find out the controlling factors of the depositional models. Finally, the reservoir quality of the three types of conglomerates and were discussed to compare their hydrocarbon potential.
3. Results - The Es3 member is characterized by interbedding of dark organic-rich mudstones and coarse conglomerates.

The major lithofacies of the Daxing Conglomerates include matrix- and clast-supported conglomerates and the gravel-sized clasts are mainly of carbonate fragments. The conglomerates are texturally immature to submature. Sedimentary structures like load casts and flame structures have been found, indicating the conglomerates were of gravity flow origin. Therefore, the Daxing Conglomerates were deposited in a semi-deep to deep lacustrine environment and represents a series of proximal deep water gravity flows.

Two types of depositional geometries are recognized using 3D seismic data: the banded conglomerates and fan-shaped conglomerates.

Based on the depositional features and geometries, three depositional models were developed, including faulted-trough gravity flow deposits, subaqueous debris flow fans and subaqueous mud flow fans. The gravity flow faulted-trough deposits are characterized by primarily matrix- or clast-supported conglomerates. The subaqueous debris flow fan deposits are mainly clast-supported conglomerates while the subaqueous mud flow fan deposits are mainly matrix-supported conglomerates with higher mud content.

4. Conclusions - The palaeogeomorphology and provenance are major controlling factors of the formation of the Daxing Conglomerates. The palaeogeomorphology controls the conglomerate distribution and results in the difference of depositional geometry between faulted-trough gravity flow deposits and the subaqueous fan deposits. The provenance controls the composition of the conglomerates, and as a result the subaqueous fans developed under similar palaeogeomorphic conditions are further divided into the debris flow fan and the mud flow fan.

The major pore types of faulted-trough gravity flow deposits are dissolution pores. The subaqueous debris flow fan conglomerates are characterized by intragravel dissolution pores and intercrystal pores while the subaqueous mud flow fan deposits are characterized mainly by intragravel dissolution pores.

The subaqueous debris flow fan conglomerates have better reservoir quality and have shown higher hydrocarbon productivity compared with the other two types of deposits. Therefore, the braided channel conglomerates of the debris flow fan have greater potential for oil and gas exploration and development.

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Permian Laminated Hydrothermal Exhalative Microbial Dolostones, Santanghu Basin, NW China

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The Santanghu basin is an intermontane, superimposed and reformed basin, located in north-eastern Xinjiang, NW China. During the Late Carboniferous, a series of normal fault-bounded rift basins formed by intracontinental rifting. Based on recent research, the Permian Lucaogou Formation shows that the basin was a starved and deep lacustrine intracontinental rift basin containing mainly hydroclastic deposits. These hydroclastites and hydrothermal exhalites, a distinctive newly discovered rock in the Lucaogou Formation, are a suite of mantle-originated magmatic- hydrothermal exhalative sedimentary rocks in the Santanghu basin, termed magmatic and hydrothermal exhalites (MHE). We focus on the laminated dolostones, one main type of MHE, to explore their mechanisms of formation and geological significance.
Core-samples were studied using transmitted-light, CL, and SEM microscopy, microprobe and XRD analyses. Elemental composition, Sr and inorganic C and O isotopic compositions, were analyzed to interpret the formation of the dolostones and diagenetic fluids.

The dolostones occur as fine mm-laminae, interlaminated with fine tuffaceous shale and composed mainly of dolomite (ranging from 51.2% to 83.2% and 70% on average), quartz (19.4%), alkaline feldspars (5.1%) and small amounts of analcime and pyrite. The dolomites have a uniform grain size, mostly less than 5μm, mainly anhedral, occasionally irregular elliptic and filiform, and a low degree of order. Carbon isotope values ($\delta^{13}C_{PDB}$), ranging from 5.2‰ to 9.9‰, and 6.9‰ on average, may suggest that the formation of the dolomites is related to the bacterial methane generation. Oxygen isotope values ($\delta^{13}O_{PDB}$), range from -1‰ to -17.4‰, and are -7.5‰ on average. The values of the dolostones dominated by rhombic dolomite are more negative than the irregular ones, which indicates recrystallization generated by hydrothermal activities. Whole-rock strontium isotope analysis of the dolostone samples produced a $^{87}Sr/^{86}Sr$ ratio of 0.70466 to 0.70538, and 0.70514 on average. This is lower than that of the 0.7067-0.7085 values for global Permian marine carbonate rocks and much lower than the average ratio of 0.720±0.005 for crustal sialic rocks, but similar to the global average of 0.70350 for mantle-sourced rocks, and indicates that the diagenetic fluids may be derived from the mantle.

Repetitive occurrences of magmatic-volcanic and volcanic-hydrothermal activity unevenly increased the temperature of the lake-floors in the Lucaogou Formation, exceeding the dynamic barrier temperature (about 50°C) for precipitating dolomite. Mantle-originated fluids provided abundant Mg^{2+}, Ca^{2+} and CO^{2-} for dolomite formation. In this extreme environment, thermophilic bacteria near hydrothermal vents can multiply rapidly, creating suitable chemical conditions for dolomite precipitation. Summarily, the dolostones studied represent a rare type of mantle-originated hydrothermal exhalative microbial dolostone. This offers important insights into the origins of dolomite and dolostones, and also provides important clues to the nature of late Paleozoic regional tectonics and sedimentary environments in northern Xinjiang.

Sedimentation in Liushagang Formation of Paleogene and its response to regional tectonics in the Fushan Sag, Beibuwan Basin, South China Sea

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It is widely accepted that the tectonic activities control the syndepositional processes and significantly contribute to the sedimentation style in the continental basins. Under the isochronous constraint of sequence stratigraphic framework, the deposits preserve various sedimentary structures. The sediment infill and its response to the tectonic movements in Liushagang Formation of the Fushan Sag are recognized and described in this paper.

The Fushan Sag has experienced four major tectonic episodes from Mesozoic to Cenozoic with complicated regimes of both extension and strike-slip characteristics, which generated complex palaeomorphology and hydrocarbon play fairways.

Three third order sequences, namely SQEls3, SQEls2 and SQEls1 are identified in the Liushagang Formation based on sequence boundaries and maximum flooding surfaces delineated in seismic profiles. Four sedimentary facies associations are identified: a fan delta system, turbidite deposits, braided river delta system and a lake system. The sandstone percentages in three delta areas decreased from SQEls3 to SQEls2, which indicates a continuously transgressive process showing the transition from proximal to distal sites in most statistic wells and an obvious decrease of fan delta scales. The northeast-southwest strike faults controlled the lakeward distributions of delta fronts and turbidite fans.

The tectonic activities are the main controlling factors of the sedimentary infill in the Fushan Sag. Meanwhile, the sedimentary spatial-temporal distributions response to the syn-rifting tectonic subsidence. The more active western part of the Lingao Fault has an important influence on the northeastward migration of depocenters in the Liushagang Formation. The fault activities of eastern boundary faults in the Fushan Sag decreased first and then increased, which influences the fan delta system in the Bailian Sub-sag. The activity of Meitai Fault obviously increased since Els2, which controls the turbidite system in Els2, the delta plain and delta front distributions in Els1. The topography developed continuously from Els3 to Els1, the diminished subsidence rate indicates the dominant geological process varying from intense fault rifting in an early stage to relatively gentle and overall subsidence in a later stage during the Paleogene.

Rain Triggered Lahars at Tungurahua Volcano: Probabilistic Analysis of Initiation Thresholds and Antecedent Rainfall Impacts

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The current eruptive phase of Volcán Tungurahua (Lat. 01°28'S; Long. 78°27'W) began in October 1999 and has featured intermittent strombolian, vulcanian and sub-plinian eruptions that have repeatedly deposited pyroclastic material on the steep upper slopes of the 5,023 m high stratovolcano. Situated in the Eastern Cordillera of the Ecuadorian Andes, the 3,200 m tall steep-sided edifice experiences high annual rainfall due to the condensation of warm, moist, westward moving Amazonian air masses. The combination of this abundant rainfall, consistently replenished easily erodible deposits and steep relief has created a persistent rain-triggered lahar hazard at Tungurahua. Lahars are commonly defined as "rapidly flowing mixtures of rock debris and water (other than normal stream flow) from a volcano" and pose a significant hazard due to their potential for widespread inundation and impact damage. Tungurahua lahars threaten the popular tourist town of Baños (permanent population c. 18,000), which lies approximately 8 km from the crater, as well as other villages and vital infrastructure situated in close proximity to the dense drainage network of the volcano. The Vazcun Valley, which drains through Baños, and the La Pampa quebrada are two lahar-prone northern drainages of Tungurahua which are both crossed by the main road linking Baños to the Pan-American Highway. Acoustic Flow Monitor (AFM) records and rainfall data have been analysed from these two drainages in order to identify lahar-triggering rainfall thresholds and resulting flow magnitudes during the period March 2012-June 2013. Results indicate a power-law relationship between lahar-triggering rainfall intensity and duration, in common with previous studies of rain-triggered mass-flow events in disturbed earth systems, such as other active volcanoes and wild-fire impacted watersheds. The probability of an arbitrarily defined lahar "alert" flow magnitude being exceeded is also shown to be amplified by high levels of antecedent rainfall; predominantly when peak rainfall intensity is also high. Heightened antecedent rainfall acts to increase surface runoff via the reduction of deposit infiltration rates, whilst also amplifying the efficiency of flow bulking due to the associated high water content in channel floor sediments. This behaviour is displayed using a variety of antecedent rainfall timescales (24 hour, 3 day, 5 day and 7 day) and peak rainfall intensity timescales (10 minute, 30 minute and 1 hour). Ultimately, this analysis could be used to construct probabilistic rain-triggered lahar forecasts as an aid to hazard mitigation.

A 13,500-years tephrostratigraphic framework for the Jura Mountains and French Massif Central, France

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Tephrostratigraphy has been considerably developed for 30 years, mainly in palaeo-environmental studies. In such studies, distal tephra layers are important chronological markers, but they are also tools to establish or specify record of past eruptions of a volcanic field. Many tephra layers have been recorded in Central Europe. The Laacher See tephra (ca. 12.9 ka) and Vedde Ash (ca. 12.1 ka) are very famous chronological markers related to two major volcanic eruptions in Germany and Iceland, recorded in Eastern France (Vosges and Jura mountains) and Swiss Plateau sequences. The Vasset-Kilian and Nugère tephras, attributed to the Chaîne des Puys volcanic field (French Massif Central), have also been detected in several sites in Eastern France and Switzerland, but there is not enough sites between Eastern France and the Chaîne des Puys to allow a strong correlation between them.

We propose new tephrostratigraphical data from the Forez Mountains (Eastern French Massif Central) which allow to build a bridge between the Chaîne des Puys and Eastern France. These tephrostratigraphic studies have been carried out using a new detection method for tephra layers with, for the first time, a 3D resolution: the Computed Tomography Scan (CT- Scan). This method, regularly used in medicine, allows there to obtain pictures of materials density on 3D with inframillimetric measurement ranges. The CT-Scan enables to detect more tephra layers, quicker than usual methods do (magnetic susceptibility, X-Ray Fluorescence).

Analyses of several tephra layers in sites situated in the Forez Mountains have highlighted Nugère and Vasset-Kilian tephras, and allow us to correlate sequences from the Forez Mountains with others sequences from Central Europe. We also present new chemical data which characterize the chronological history of volcanic activity for 13 500 years, and a new and young volcanic eruption in the Chaîne des Puys.

These results confirm the interest in the study of tephra layers in central Europe and the need to grow tephrostratigraphy studies in order to correlate all the sites between themselves and with volcanic provinces.

Characterization of syn-diapiric Jurassic sedimentation in the Taghia and Tazoult areas, Central High-Atlas, Morocco

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In the central part of the High-Atlas (Morocco), the Amezrai syncline preserves several thousand metres (<6000 m) of Early to Middle Jurassic deposits. The syncline is developed between two diapiric ridges; the ENE-WSW oriented Taghia Ridge to the south, and the NE-SW oriented Tazoult Ridge to the north. At depth, the ridges are thought to be controlled by synsedimentary faults, that localized the diapiric rise of Triassic shales, basalts and locally of Dogger magmatic rocks.

Regionally, the Early to Middle Liassic sequences are formed by carbonate platform facies (<1000m thick), whereas the Late Liassic to Early Dogger sequences correspond to mixed carbonate/siliciclastic deposits (2500m thick or more). Carbonate platform sedimentation was re-established from Late Aalenian times.

The structures, depositional geometries and facies distribution in both the carbonate and mixed systems attest to the synsedimentary nature of diapiric processes along the ridges. The response of these two types of sedimentary systems presents distinctive features. In carbonate systems, diapiric movements have a major role on the location and morphology of bioconstructed (lithiotis) carbonate platform margins and associated mini-basins, dominated by either hemipelagic or gravity-flow deposits. Localized periodic exposure of the carbonate platforms on the crest of the diapiric ridges is marked by carbonate breccia deposits. In mixed systems, synsedimentary halokinetic deformation (progressive unconformities with wedge/hook geometries) occurs only very close to the diapirs (>100 m). Significant variations of sedimentary facies (development of reefs, conglomerates, etc…) are very localized by the diapiric activity.

Reactive diapirism initiated during a phase of extensional tectonic deformation in the Atlas Basin, and the development of Middle Liassic carbonate platform sedimentation. Subsequently, passive diapirs occurred during Late Liassic mixed carbonate-siliciclastic systems. The main phase of diapiric movements is sealed by Dogger (Late Aalenian-Bajocian) carbonate platform deposits in the study area.

An integrated seismic and static modelling workflow for Fault-Related Dolomite (FRD): Example from Trenton-Black River hydrocarbon reservoirs, USA

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Faults and fractures often dominate the permeability architecture of carbonate reservoirs. During burial fault and fracture systems can act as fluid flow pathways for diagenetic fluids, which can result in the modification the host-rock limestone by dissolution or cementation. This is particularly true for fault-related dolomite reservoirs of North America, such as the Trenton-Black River in Michigan, New York State. The main hydrocarbon bearing interval (Trenton and Black River Formations) developed during the Ordovician, when the North East US was subject compression during the Taconic Orogeny. Transtension with localised areas of extension enabled dolomite saturated fluids to migrate along faults onto the Trenton Platform. Subsequent dolomitisation of the shallow to deep water ramp carbonates led to the development of fault-related dolomite in close proximity to the main feeder faults and at intersections with secondary, cross-cutting faults.

This study uses an integrated seismic and static modelling workflow, implementing Shell in-house tools and process based approach to (A) construct a robust structural framework and (B) predict and model the geometry and distribution of fault-related dolomite geobodies within the Trenton-Black River of New York and Michigan State, USA. Four (11km x 11km) models were built within Petrel. Each run incorporated increasingly more data and complexity, taking the modelling from an exploration scale to more of a production scale. This enabled us to compare with production data for the fields and determine the optimum workflow and combination of techniques in order to produce a robust and geologically realistic set of models with realistic volumes.

The models successfully reproduce the facies patterns and dolomite geobodies as constrained by seismic, well and published analogue data. The models suggest that for the Trenton-Black River of eastern US the development and distribution of fault related dolomite reservoirs follows NW-SE and E-W structural trends. Results also suggest that where possible an integrated seismic and static modelling workflow should be applied. However, even with limited data, robust analogue data and a process based modelling approach can be successfully implemented to create geologically realistic scenarios for fault-related dolomite reservoirs.

Coring disturbances in IODP hydraulic piston cores

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Piston cores collected from IODP drilling platforms provide the best long-term geological and climatic record of marine sediments worldwide. Since the early 1980s, IODP (and its predecessors) has collected numerous hydraulic piston cores. Coring disturbances affect the original structure and texture of the cores, and include deformation resulting from shear of sediment against core barrel, basal flow-in due to partial stroke or stuck bottom hole assembly, loss of stratigraphy, fall-in, sediment loss through core catchers, and structures formed during core recovery and on-deck transport. The most severe disturbances occur in non-cohesive (granular) facies, which are particularly common in volcanogenic environments and submarine fans. Consequently, coring disturbances can be significant, and their detection a challenge. Here, we give examples of coring disturbances from the IODP Expedition 340 (Lesser Antilles) and ODP Leg 126 (Sumisu rift, Izu Bonin arc) and propose possible technical alternatives to remediates to major coring disturbances. We re-evaluate facies from previous studies, and provide alternative interpretation for a very thick sandy succession in the Escabana trough (ODP 169; East Pacific).

On the formation of marine ash beds from pumice rafts: satellite imagery, oceanic current modelling and abrasion experiments

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Ash and pumice clasts deposited on the sea floor are derived from various processes, the most recognized being pyroclastic fall over the ocean. Ash beds derived from abrasion in pumice rafts remain poorly defined, and no marine examples have been clearly defined. Here, we compare MODIS satellite imagery to an eddy-resolving ocean model hindcast for the dispersal of pumice rafts generated during the deep submarine 2012 Havre eruption (Kermadec arc). Ash produced during rafting of pumice clasts create wide domains of discolored water that can be detected on satellite images, and is confirmed by wave-tank abrasion experiments. Abrasion experiments show that moderate wave action in open water can substantially abrade pumice clasts over a few days. Unlike atmospheric wind, ocean surface currents are multi-directional, and disperse pumice rafts over various directions, producing complex ash isopachs on the seafloor. Therefore, eruption intensity and source vent cannot be based on seafloor ash isopachs only. For future eruptions that produce potentially hazardous pumice rafts, our model allows real-time forecasts of dispersal routes, in addition to inference of ash/pumice deposit distribution in the deep ocean.