Short-term eustatic sea-level changes during greenhouse climate

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The term "eustatic movements" was introduced by the Austrian geologist Eduard Suess in the year 1888 referring to the phenomenon of displaced shorelines and the worldwide synchronicity of marine events. Eustasy now describes global sea-level changes that play a major role in controlling marine sedimentary sequences and sequence stratigraphy.

Relative (regional and local) and global (eustatic) sea-level fluctuations are controlled by a variety of processes. Mantle convection and resulting gravity anomalies, tectonic movements creating subsidence and uplift, and climate are the main drivers, and apply for different temporal and spatial scales. The long-term sea-level record, i.e. 1st to 2nd order cycles and stratigraphic sequences, occurring over millions to tens of millions of years, is mainly controlled by the internal dynamic history of the Earth, e.g., the changing rates of ocean crust production. Short-term eustatic sea-level changes during icehouse phases of Earth's climate are clearly controlled by waxing and waning of continental ice sheets. However, significant short-term, i.e. 10s kyr to a few myr (3rd to 4th order cycles), sea-level changes during greenhouse episodes of Earth history, are still enigmatic. Such cycles are often explained by the presence of ephemeral ice sheets even during the hottest greenhouse phases of the Phanerozoic climate history such as the mid-Cretaceous. The possible effect of groundwater storage and release on sea-level change, as particularly important during ice-free greenhouse-phases, has been widely underestimated in its order of magnitude. It is considered to constitute a water volume that is approximately equivalent to today's ice volume, thus corresponding to a potential sea-level change of up to ca. 50 m applying isostatic adjustment. Groundwater storage, including both freshwater and saline pore waters, strongly exceeds lake and river storage capacities. Changes in continental groundwater storage may have a profound effect on sea-level fluctuations and cycles during major greenhouse phases of Earth history.

This hypothesis may be testable given high-resolution stratigraphic correlations between marine sea-level and continental lake-level archives during supposed ice-free periods of Earth history. Lake-level and sea-level fluctuations should be out of phase with each other, i.e. a major marine sea-level lowstand should correspond to a lake-level highstand, and vice versa. Preliminary tests using selected stratigraphic levels of the Late Cretaceous record of the long-lived lacustrine Songliao basin in China indicate such an out-of-phase relation and, thus, support the groundwater and lake storage hypothesis as a fundamental, but overlooked mechanism to explain significant short-term sea-level fluctuations during greenhouse climate phases.

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Rock weathering during hyperthermal events in the early Eocene Bighorn Basin: Evidence from clay mineralogy

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A series of transient greenhouse warming periods are recorded in the early Eocene fluvial Willwood Formation of the Bighorn Basin, Wyoming, USA. Here we investigate if we find evidence for enhanced rock weathering during the ETM2 (Elmo) and H2 events which were recently located in stratigraphy. For this, the bulk and clay mineralogical content of 148 fine-grained rock samples from the 130 meter thick Upper Deer Creek section were analyzed. Sample spacing is estimated to be 2-3 kyr in time. Air-dried (AD) and ethylene-glycol (EG) measurements were used to identify clay minerals by X-ray diffraction (XRD) using a PW 1830 diffractometer with Ni-filtered Cu–Ka radiation (45 kV, 30 mA) at Leuven University, Belgium. The program SYBILLA (©Chevron) was used to quantify the proportion of clay minerals.

The clay minerals are composed of smectite (Sme), mixed-layer illite- smectite (IS), kaolinite (Kao), illite (Ill) and chlorite (Chl). Smectite is the most abundant compound and varies from 49.9 to 83.0% with an average of 63.7%. The proportion of smectite increases by 5-10 % within the hyperthermal events. Also, the clay indices (Sme+Kao+IS)/(Ill+Chl) and Smectite/Kaolinite, indicate relative warm and wet environment increase across the hyperthermals. Petrographical evidence revealed that the sources of these early Eocene sediments are widely variably from post-Precambrian sedimentary rocks to Precambrian igneous-metamorphic rock assemblages. Changing source areas across the hyperthermals due to climate change might have occurred. Nevertheless, a simpler explanation could be that global warming during ETM2 and H2 lead to enhanced chemical rock weathering.

Growth characteristics and controlling factors of carbonate platform marginal reef in western deep-water region of South China Sea

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Marginal reefs have been confirmed as important deep-water oil-gas reservoirs due to its high porosity and permeability. Western deep-water region of South China Sea is located on the south of Qiongdongnan Basin. Based on the suitable growth environment including temperature, salinity, water depth and palaeogeomorphology, a large scale of marginal reef developed in the shallow water platform far from continent in mid-Miocene Meishan Formation. Newly acquired data from several boreholes, 2-D seismic profiles and 3-D seismic volume allow improved understanding of the evolution and distribution of marginal reefs in research area.

Seismic data and boreholes were applied to establish high-resolution sequence stratigraphy framework through well-seismic calibration. Marginal reefs, external morphology and internal sedimentary structure were recognized through seismic reflection features and post-stack seismic inversion, which were also applied to determine reef spatial distribution. Back-stripping technique was utilized to calculate the tectonic subsidence history of each structural unit and to reconstruct the synsedimentary palaeogeomorphology in the stage of marginal reef development. Estimation of paleo-water depths was inferred from wells data and sedimentation rates were calculated using 2Dmove software.

The research results indicate that marginal reefs mainly have superimposed development characteristics and two types of marginal reef growth model（fault-controlling and carbonate ramp）are proposed in terms of combined impact of syngenetic fault and structure of carbonate platform margin. Reef growth of the former type is closely related to platform affected by synsedimentary faults. Marginal reef, presenting poor spatial migration, mainly develops in the flat terrain upon the break, with symmetric moundy shape of external morphology and aggradational characteristics within reef. However, the latter one concentrates on slope as retrograding to the southern paleo-uplift. Its external feature is distinct and asymmetric hummocky.

Further research reveals the relationship between reef growth and controlling factors (tectonic movement, palaeogeomorphology, sea-level changes and ocean currents). Palaeogeomorphology and structural framework are important factors in the spatial distribution of marginal reef. Four terraces, separated by break, are distributed from southern paleo-uplift to northern deep depression in Meishan Formation, which make fault-controlling marginal reefs develop in the flat terrains of terraces. The internal sedimentary structure of aggradational and progradational characteristics is mainly influenced by the combined effect of high structural subsidence and low growth rate. As marginal reef is sensitive to sea-level changes in gentle slope, sea-level fluctuation leads to high spatial migration of carbonate ramp marginal reef, developing toward uplift along slope with rising sea-level. Ocean current not only influences the scale of reef development but also controls its external morphology, leading steep upstream face and slow downstream face.

In conclusion, two types of marginal reef growth model, fault-controlling and carbonate ramp, are proposed through comprehensive analysis of four controlling factors, which impact the marginal reef growth characteristics, sedimentary structure, external morphology and spatial distribution.

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Late Cretaceous climate changes recorded in eastern Asian lacustrine deposits and North American epeiric sea strata

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Climate data of the long-lived Cretaceous Songliao Basin (SB) in eastern Asia are correlated and compared with the Western Interior Seaway (WIS) on the northern American plate, in order to better understand the dynamics of the Earth's past "greenhouse" climates. Nearly continuous Late Cretaceous terrestrial deposition in the Songliao Basin is represented by two cores totaling 2431 m in length. The Turonian–Maastrichtian age of the section is based on integrated stratigraphy, and is comparable in age with Upper Cretaceous strata in the WIS. Being consistent with global trends, the dynamic Late Cretaceous climates of both the SB and WIS gradually cooled from the warmest Albian–Cenomanian time to the end of the Maastrichtian with several intervening warm periods as did the global climate. However regional differences existed, the Songliao Basin climate was humid to semi-humid, warm temperate–subtropical and the Western Interior Seaway was in the humid, warm temperate zone and experienced only moderate climatic changes. The shifts of oxygen isotope data in the Songliao Basin were frequent and abrupt, whereas WIS records more gradual change affected mainly by fresh-water runoff mixing with southern Tethyan and northern Arctic waters. Sedimentary cycles of eccentricity, obliquity and precession bands are recorded in both the SB and WIS basins. The sedimentary cycles in the WIS and SB are interpreted to be related to variations of the wet/dry runoff cycles, which indicate that orbital forcing played an important role in global climate change in Late Cretaceous. The most favorable condition for organic carbon burial in both the SB and WIS basin was bottom water anoxia regardless of the cause of the anoxia. But the organic carbon burial rate was usually much higher in the Songliao Lake than in the WI epeiric sea suggesting that giant lakes may serve as important sinks of atmospheric CO_2. In both basins organic-rich deposits formed during a rise in water level and incursion of saline waters. The integration of paleoclimate data from Cretaceous marine deposits and terrestrial sedimentary record will promote our understanding of the Cretaceous "greenhouse" climate change and may provide insights for a future greenhouse world.

Estimating Deposition Rates Using C4 Plant Organic Carbon Contribution in Coastal Saltmarsh

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It is not easy to establish the correspondence between the sediment stratum and time series on coastal saltmarshes which are undergoing environmental change. Apart from daily tidal springs and ebbs, sediments are also interfered with by organisms all the time, which makes the usual isotopic dating methods used in stable environments, such as the 210Pb and 137Cs methods, less reliable. A new exploration in stratum dating method, which is quite similar to event deposition, is documented in this work.

In the past 30 years, large areas of Chinese tidal flats have been occupied by *Spartina alterniflora*, a C4 plant that was introduced to Chinese coasts in 1980s. Comparing with the local C3 plants such as *Suaeda salsa* and *Phragmites australis*, *Spartina alterniflora* have living and competing advantages, therefore, its contribution to coastal ecosystems are growing larger with time. Due to the different photosynthetic pathways, *Spartina alterniflora* has dramatically modified the Carbon pool in the above-mentioned area. In this condition, the different type of carbon sequestration characteristic would surely cause a significant difference in the content of organic isotopic Carbon in sediment layers. What caused our attention is that the difference provides the potential to become a measure of dating the special deposit stratum. Meanwhile, we can obtain the accurate interannual variation of *Spartina alterniflora* expanding edges from the remote sensing images. This research is based on the Carbon sequestration characteristic which influences the organic isotopic Carbon in stratum, and interannual variation of *Spartina alterniflora* expanding front edge retrieved from images, and provides a new direction for exploring the determination of deposition rate using the characteristic stratum.

In the Jiangsu Yancheng Wetland National Nature Reserve, rare Birds have been protected to maintain the natural environment, thus making this place an ideal study site. In 2007, we drilled a sediment columnar sample in the central area of *Spartina alterniflora* saltmarsh. We assume *Spartina alterniflora* is the only C4 plant living here and then determined the planting time of C4 plant here was 1994 by using annual plant expanding data retrieved from remote sense images. The length of columnar sample is 1.35m and vertical variations in lithological characterization, sediment grain size and $\delta^{13}C$ value of the sediment sample were obtained. Furthermore, the rhizome length of *Spartina alterniflora* in the patches of expanding front edge was measured.

The rhizome length of initial colonized plants is 41.83 ± 8.02 cm. Sediment grain size shows that from the top to the bottom, there is a dividing layer. Fine sediment in the upper part and coarse sediment in the lower part reveals the upper part is caused by fine sediment trapping effect resulted from *Spartina alterniflora* plants, and the lower part is the original bare tidal flat that preceded the first planting. The $\delta^{13}C$ profile shows that values abruptly increased at a depth of 118cm, from -23‰ to -18‰. This reveals that C4 plant organic carbon can influence the Carbon pool as deep as 118cm, and that is the deepest level to which *Spartina alterniflora* rhizome can reach. Deducting the rhizome length（41.83±8.02cm）from the 118cm, we estimate the original bare tidal flat was around 76.17±8.02cm below the ground in 2007, and the average sediment deposition from 1994-2007 is 5.24-6.48 $cm \cdot a^{-1}$.

Key words: deposition rate, carbon sink, C4 plant, *Spartina alterniflora* saltmarsh

The geological record of Holocene climate and environment changes in Lake Barkol and surrounding archeological sites

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The Dongheigou-Hongshankou is the best historical site of the group of Hun nomads located at the southern bank of Lake Barkol, eastern Tianshan Mountains, in Xinjiang Uygur Autonomous Region, China.

The north slope of the Barkol mountains contains the Hongshankou-Dongheigou sites encompasses Last Glacial sediments and Holocene alluvial materials. During the Last Glacial mountain and piedmont glaciers developed in the Barkol mountains and actually some of them still remain in the Tianshan region. Glaciers disappeared during the Holocene leaving moraines in the valley triggering the development of small rivers or intermittent flooding.

Seven sections were studied from the shore to the center of Lake Barkol to reconstruct the lake evolution, shoreline changes and regional environment. The methodology included geomorphology, MAPGS, sedimentology, magnetic susceptibility , grain size analysis, OSL dating, and environmental archeology. The last glacial moraine landforms and alluvial fan landforms from the northern foothills of Barkol mountains were also studied as well as the impact of environmental change in the lakes and on the human nomadic settlements of Dongheigou-Hongshankou.

A total of 14 OSL samples were measured to establish a good chronological framework. OSL analyses were accomplished at the Chinese Academy of Sciences, Xining, using a standard protokol. Magnetic susceptibility profiles allowed to compare the different sedimentary facies. The results show very different values for the lacustrine and alluvial fan sediments and, thus, they can be used to reconstruct the lake area. Grain size analyses were performed in selected samples using a Mastersizer 2000 particle analyzer. The distribution of the sedimentary facies in the eight profiles allowed identifying different periods of lake sediments and/or the position of alluvial fans using MAPGS to outline the evolution of the lake basin. Our results show that during the Holocene the Barkol lakes have been very important for the evolution of the nomadic tribes.

At 11000 a BP the glaciers of the East Tianshan Mountain area deposited a moraine ridge at the Barkol northern foothills. The advance of the glaciers during this time produced the shrinking of the Lake Barkol to the north. During the Holocene Optimum (8000 to 4000 a BP) the Barry Kunshan glaciers melt triggering the largest expansion of Lake Barkol since the beginning of the Holocene. After 4000 a BP the lake is gradually shrinking and about 1500 a BP lakes dry and mud flat deposits occupied the current lake zone. Subsequently Lake Barkol went through wide fluctuations either expanding or or drying.

This climatic evolution can be correlated with the ruins of ancient nomadic tribes and different archeological sites.

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The Mechanism of Transport Process of Subaqueous mud-poor Debris Flow — A Case Study of Deep-Water Sandstone in Yanchang Formation, Ordos Basin, China

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Subaqueous debris flow which is formed by mass-transport in deep-marine and deep-lacustrine environments has been taken more and more seriously, which is different from the subaerial debris flow. Through the summary of the current research status on the gravity flow transportation and sedimentation of the deep-water sediments, the concept, main distinction and controlling factors of mass transportation and fluid transportation become clear. Taking the deep-water sandstone (mud poor sands) in Yanchang Formation of Ordos Basin as an example, the paper presents the identification criteria of the mass transportation and fluid transportation, and explores the mechanism of transport process of subaqueous mud-poor debris flow. It is thought that lubrication of a little of clay matrix and adhesion of clay membrane of equal thickness are the root reason why subaqueous mud-poor debris flow of Yangchang Formation can be mass-transport and isn't shattered by the water body underwater. In the deep-lacustrine of the Yangchang Formation, Ordos Basin, thick layer sandstone which is formed by the mass transport has most favorable reservoir configuration, and is the most beneficial oil and gas exploration target.

Keywords：mud-poor debris flow; deep-water sandstone; mass transport; Yanchang Formation; Ordos Basin

Distribution and deposition of mudstone facieses in the Qingshankou formation, Songliao Basin, China

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Songliao Basin is the largest basin in northeast China. The Qingshankou formation mudstone is not only a significant source and seal of hydrocarbons, but it is conside to be reservoir in Songliao Basin. The thicknesses of Qingshankou formation mudstone is about 550m. The TOC content is range between 0.5% and 8%, with a general proximal to distal decrease in TOC content. Application of electron microscope and SEM, the textural and petrographic features can be examined. Four mudstone faciecies are distinguished, each characterized by different sedimentary structures and TOC content. These comprise: 1) sand and silt-bearing clay-rich mudstone; 2) macrofossil debrits-bearing clay-rich mudstone; 3) caly-dominated mudstone; 4) oolitic limestone. The detrital sand- and sile-sized components are mainly composed of quartz and minor feldspar. The macrofossil debrits are mainly ostracoda. The clay-sized materials are mainly illite, illite-smectite and carbon cement. The sand and silt content and TOC variations are paralleled by changes in burrowing and tracefossil abundance.

From the bottom to the top of Qingshankou formation, the pristine/phytane ration increase with TOC decrease. It indicates the paleoenvironmental redox is change. There are a lot of sedimentary structures, wave-enhanced sediment gravity flows of fluid mud, continous parallel, ripples and gutter casts. Initially thought to represent mudstone deposition in a completely anoxic environment, Qingshankou black-shale sedimentation may actually have occurred in at least dysoxic conditions.

Provenance and Its Depositional Response for Multiple Rifting Cycles: One Example from the Palaeogene of Huizhou Depression, Pearl River Mouth Basin, China

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Paleogene sediments are mainly derived from both southern and northern provenance areas, in Huizhou Depression, Pearl River Mouth Basin, China. The southern provenance areas, Dongsha Massif and the internal uplifts of the basin, are predominantly composed of Mesozoic igneous rocks, while northern provenance areas, South China Block, are characterized by complicated lithology and geochronology due to the Precambrian-Mesozoic magmatism and metamorphism. In this study, the detrital zircon ages of sandstones from the Paleogene Lower Wenchang, Upper Wenchang and Enping Formation respectively, are measured through LA-ICP-MS (Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry) method to analyze sediment provenance of study area.

According to zircon dating results and similar tectonic settings of most rift basins in east of China, the evolution of Huizhou Depression in Paleogene can be divided into three rifted stages: period I (I_A, I_B) and Ⅱ. During period I_A (Lower Wenchang Formation), the southern faults of depression suffer strong activities. All of total zircon grains are derived from Mesozoic age, indicating sediments derived from the southern provenance areas (Dongsha Massif and the internal uplifts of the basin). The related sedimentary facies are characterized by fan delta and middle-deep lake under the conditions of southern steep slope of Huizhou depression. During period I_B, corresponding to Upper Wenchang Formation, the tectonic activities are characterized by high subsidence rates in the northern faults zone and low subsidence rated in the southern faults zone. The content of Mesozoic age grains decreases from 100% (Lower Wenchang Formation) to 68%, whereas the content of Precambrian-Paleozoic zircon grains is up to 32%. The more complicated and ancient grains are a record of complex magmatic and metamorphic events, matching with the north provenance areas. This indicates that sediments are derived from both northern and southern provenance areas. The related sedimentary facies have the characteristics of fan delta, braided river delta, and middle-deep lake. During period Ⅱ (Enping Formation), the northern faults continue acting. The content of Mesozoic age grains decreases to 36%, while that of Precambrian-Paleozoic zircon grains increases to 64%. This indicates northern provenance areas play a dominate role in this stage. In addition, the related sedimentary facies are characterized by shallower braided river delta, beach and thin coal seam.

In summary, the provenance switches from proximal provenance in the basin (southern provenance areas) to distant provenance out of the basin (northern provenance areas). Correspondingly, at the early stage of rifting, sedimentation is mainly influenced by flash stream and flood while stable water flow plays an increasingly important role at the late stage. Tectonic activities not only directly play a dominant role in the sediment provenance of continental rift basins but also control the paleogeography and depositional process.

Tight reservoir mechanism and seepage features of turbidite deposit sandbody in HuangLing area of Ordos basin

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Turbidite sand bodies are among major reservoirs of deep sea and lake depositional systems. The Yangchang Formation of the Ordos Basin in Middle Western China, subjet of the present paper, is a typical land lake basin.

This paper reports on the turbiditic system in the area using core observation and provenance analysis. The dataset consists of 260 samples from 6 oil-bearing layers and 14 drilling wells in Huang Ling exploration field. Methods include petrography, grain-size analysis, scanning electron microscopy, mercury injection, phase permeability, porosity and permeability under overburden pressure, nuclear magnetic resonance, and rate-controlled mercury penetration. The reservoir is tight; the growth of pore is middle-low. The average porosity is 8.4%. The matrix permeability average number is $0.23\times10^{-3}\mu m^2$, belonging to tight reservoir.

The main diagenetic minerals of the sandstones include fine-grained lithic feldspathic, time ribbed particles, and separation is middle-low, average particle size is low, porosity is separated from 2.0-5.3, with an important content of silt, mainly pore film thermal and substrate cementation. Interstitial material accounts for the largest percentage, and the minerals are various, mainly chlorite as authigenic clay minerals, carbonate rock and zeolite. The types of pore-filling minerals are various, including pellet pyrite filling indicative of a deep reducing environment. During the sediments, dissolution is lacking. The siliceous, calcite, strontianite, dolomite and so some carbonate cementation are key elements for the reservoir getting tighter.

On the other hand, productive practice indicated that Huang Ling exploration area having outstanding reservoir of the lake-bottom turbidite sand body that has good physical character in the deep underwater environment. Combine sediments with porosity evolution research, the cause is related to rapidly sedimentary compaction (Rapid sedimentary→ Decompaction→ Abnormal high pressure→ Storage of primary porosity→ Porosity and permeability of storage layer→ High productive test output). Furthermore, outcrop investigation, core observation and imaging logging date indicate that reservoir development is controlled by multiple factors including tectonics and diagenesis.

Rate-controlled mercury penetration and nmr experimental indicate that the throat radius of the top class storage layer grown by this crack is mainly from 0.4 to 2.0μm, average radius is 0.76μm, and average pore-throat ratio is 179, and the movable fluid saturation is more than 45%, which have high storage percolation ability. The second class reservoirs which lack of growth cracks but grown pores, their throat radius are mainly from 0.25 to 0.65μm, average radius is 0.44μm, average pore-throat ratio is 336, and the movable fluid saturation is more than 30%, which have middle percolation ability. The third class of Huang Ling exploration area is best grown, because throat radius is low with only 0.38μm, but the pore-throat ratio is high, having low percolation ability, and the lowest movable fluid saturation of 20.5% in average. The particle size of tight storage layer is small, surface roughness is high, specific surface is significant, resulting in fluids trapped.

A Lacustrine Subaqueous Fan Depositional Model; Dongying Rift Basin, East China

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Subaqueous fans in lacustrine rift basins are important exploration targets in China. The deep burial depth (>3000 m) and uncertainties about the depositional conditions make exploration of this type of reservoir risky. This study focuses on a Paleogene subaqueous fan in the Dongying rift basin in East China. A genetic model of a subaqueous fan along the high-angle boundary fault was established based on core observations, sedimentary setting and flume experiments. Fan deposits along the boundary fault occur in transgressive system tracts and highstand system tracts. The boundary faults' episodic activity and ancient climate controlled the fan evolution. In the faults' active stage, debris flow deposits developed, while in the intermittent stages regular supply by turbidites was dominant. Close to the faults massive matrix-supported conglomerates and debris flow deposits occur. Periods in which the lake level was low show a supply of large amounts of coarse clastics into the deep lake while during periods with a high lake level discharge was lower and sediments spread in a tongue shape over a large area with limited channel development. Multiple tongue-shaped fan bodies are superimposed and form thick deposits. They mainly consist of grain-supported sandy conglomerates and traction current deposits. The subaqueous fan shows a fan body and fan-side marginal subfacies. The fan body can further be divided into root, middle and front facies. From the main fan body to the fan side marginal subfacies grain size gradually becomes finer and single sand layers become thinner. Moreover, lacustrine mudstones, which usually do not occur in central fan body, thickens laterally.

A passive margin created by the combined action of down-slope and along-slope: Processes, products and implications for exploration and paleoceanography

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Processes and products associated with the interaction of down-slope and along-slope processes are geographically widespread and yet poorly documented. Using a high-quality 2D database, six major depositional systems are recognized along the northeastern South China Sea margin, and from the upper slope to abyssal plain, they are: the erosional features, the mass-flow system, the sediment gravity-flow (SGF) system, the mixed contourite-SGF system, the contourite system andthe hemipelagic system.

Sedimentary processes on the studied margin show considerable spatial complexity, leading to a depositional model that must incorporate the interplay of down-slope and along-slope processes. The erosional features and mass-flow system are common on the upper and middle slopes, respectively where high mass flows dominate over bottom currents. In the lower slope and continental rise where mass flows transform into sediment gravity-flows such as turbidity currents (SGFs), forming SGF system. In the lower segment of the Taiwan canyon, there is strong interplay of sediment SGFs and bottom currents, resulting in the mixed contourite-SGF system. On the abyssal plain where SGFs are volumetrically overwhelmed by contour currents, the contourite depositional system occurs. Our results highlight the complex interaction between down-slope and along-slope processes on continental margins, thus helping to better understand the deep-water sedimentation on continental margins.

Bottom-current reworked sands lacking 'typical turbidite signatures' are recognized, and are interpreted to be created by the interplay of SGF and bottom currents, which could potentially yield excellent hydrocarbon reservoirs after burial, affording an alternative for interpreting deep-marine non-turbidite reservoirs. Fine-grained bottom-current sediment waves, interpreted to be created by contour currents resulting from the North Pacific Deep Water (NPDW–CCs), providing solid evidence for the intrusion of NPDW in the abyssal plain of the South China Sea. Preliminary bedform-velocity analysis suggests that NPDW–CCs have a maximum velocity up to 3～7 cm/s.

Keywords: Passive margins; depositional processes; the northeastern South China Sea margin; bottom-current reworked sands; paleoceanography

Quantitative reconstruction of precipitation changes on the NE Tibetan Plateau since the Last Glacial Maximum – extending the concept of pollen source area to pollen-based climate reconstructions from large lakes

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Pollen records from large lakes have been used for quantitative palaeoclimate reconstruction but the influences that lake-size (as a result of species-specific variations in pollen dispersal patterns that smaller pollen grains are more easily transported to lake center) and taphonomy have on these climatic signals have not previously been systematically investigated. We introduce the concept of pollen source-area to pollen-based climate calibration using the climate history of the north-eastern Tibetan Plateau as our study area. We present a pollen data-set collected from large lakes in the arid to semi-arid region of Central Asia. The influences that lake size and the inferred pollen source-areas have on pollen compositions have been investigated through comparisons with pollen assemblages in neighbouring lakes of various sizes. Modern pollen samples collected from different parts of Lake Donggi Cona (in the north-eastern part of the Tibetan Plateau) reveal variations in pollen assemblages within this large lake, which are interpreted in terms of the species-specific dispersal and depositional patterns for different types of pollen, and in terms of fluvial input components. We have estimated the pollen source-area for each lake individually and used this information to infer modern climate data with which to then develop a modern calibration data-set, using both the Multivariate Regression Tree (MRT) and Weighted-Averaging Partial Least Squares (WA-PLS) approaches. Fossil pollen data from Lake Donggi Cona have been used to reconstruct the climate history of the north-eastern part of the Tibetan Plateau since the Last Glacial Maximum (LGM). The mean annual precipitation was quantitatively reconstructed using WA-PLS: extremely dry conditions are found to have dominated the LGM, with annual precipitation of around 100 mm, which is only 32% of present-day precipitation. A gradually increasing trend in moisture conditions during the Late Glacial is terminated by an abrupt reversion to a dry phase that lasts for about 1000 years and coincides with “Heinrich Event 1” in the northern Atlantic region. Subsequent periods corresponding to the Bølling/Allerød interstadial, with annual precipitation (Pann) of about 350 mm, and the Younger Dryas event (about 270 mm Pann) are followed by moist conditions in the early Holocene, with annual precipitation of up to 400 mm. A drier trend after 9 cal. ka BP is followed by a second wet phase in the middle Holocene, lasting until 4.5 cal. ka BP. Relatively steady conditions with only slight fluctuations then dominate the late Holocene, resulting in the present climatic conditions. The climate changes since the LGM have been primarily driven by deglaciation and fluctuations in the intensity of the Asian Summer Monsoon that resulted from changes in the Northern Hemisphere summer solar insolation, as well as from changes in the northern Atlantic climate through variations in the circulation patterns and intensity of the westerlies.

Late Triassic Carnian Pluvial Event in Northwestern Sichuan, China : lithological change, paleontological evidence and carbon-oxygen isotopic record

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Most researchers now favour a global climatic interpretation for the Late Triassic Carnian Pluvial Event (or Carnian Carbonate Productivity Crisis) which was initially proposed by the European geologists, based on the research on the Carnian in Austria and Italy. The similar lithological change from carbonate rocks to black shale, terrigenous clasolite is widely seen in the Western and Eastern Tethysic Region (e.g. in Calcareous Alps and SW China). Several distinct Carnian sections are studied in detail in the Northwestern Sichuan, SW China. The Carnian carbonate deposition (e.g. oolites, sponge limestone, crinoid limestone and bioclastic limestone) in these sections is overlied by grayish black shale and then gray siltstone, showing the termination of the carbonate production and the sudden death of sponge reefs. The thickness of the grayish black shale beds vary from several meters to more 10m and the shales are commonly interbeded with bioclastic limestone in Middle Carnian. A transgression cycle is showed from the Lower to Middle Carnian lithological change of Maantang Formation from oolites, bioclastic limestone to black shale in the Northwestern Sichuan Area. Abundant plant leaf and ammonoid fossils are found in the shales and the overlying siltstones, indicating the input of fresh water together with terrigenous material into the paleo-ocean.

The Carnian conodonts as *Paragondolella* sp., *Paragondolella polygnathiformis* and *P. navicula* are found in the oolites and bioclastic limestone of Lower-Middle Maantang Fm., and plentiful Carnian ammonoids are seen in the black shale and sponge reef limestone at Jushui, Anxian, one of the major Canian sections in NW Sichuan. The stable oxygen and carbon isotopic compositions of Carnian fossils foraminifer, bivalve and brachiopodous shells and plant leaves are analyzed using laser micro-sampling technique. The analysis results indicate the slightly lower$\delta^{18}O$ values and the remarkable lower$\delta^{13}C$ values of the Upper Carnian than that of the Lower Carian. It's believed that the isotopic compositions reflect the fresh water input into the Paleotethys Ocean. It is suggested that the Carnian Pluvial Event severely affected the deposits in East Tethys Region. The damp weather is one of the causes that triggered the periodic deaths and finally disappearing of the sponge reefs in the research area.

Key Words: Carnian Pluvial Event, isotopic, sponge reef, Upper Triassic, Eastern Tethys

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The Research of Deepwater Gravity Flow Depositional System of Miocene in Lower Congo Basin, West Africa

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The Lower Congo Basin, one of the most important rift basins of the passive continental margin in West Africa, lies off the west coast of Africa. The stratigraphic section in the Lower Congo Basin can be divided into three parts, and in ascending order they are: the presalt section corresponding to lacustrine sedimentation from upper Jurassic to lower Cretaceous Aptian, the Aptian Salt Formation, and the postsalt section corresponding to marine sedimentation from the Aptian to Quaternary. This study focus on Miocene, in this depositional period deepwater gravity flow deposits are most developed. By the analysis of identification signs of sequence boundaries, Miocene was divided into two second-order sequences and seven third-order sequences. Based on the high resolution 3D seismic, drilling and logging data, deepwater gravity flow depositional system of Miocene has been researched comprehensively through seismic interpretation and geology analysis. The result show that seven kinds of depositional elements of mass transport deposits (MTDs), channel, levee, lobe, abandoned channel, crevasse splay and pelagic mud deposits were identified in Miocene. MTDs display maculose, and chaotic seismic reflection. And channels have U-shaped or V-shaped, and high-amplitude reflection. According to the scale of channels, deepwater channel deposits can be classified into two types, i.e., isolated channel deposits and clustered channel deposits, both formation mainly depends on how much sources supply. The levee deposits, caused by the overflow of gravity flow, display high-amplitude, and wedge-shaped seismic reflection. And with channel deposits constitute channel-levee complexes showing typical gull-wing seismic reflection. In the plane, lobe deposits have fan-shaped or lobe-shaped, and relatively continuous, parallel-subparallel high-amplitude seismic reflection. Pelagic mud deposits, surrounding aforementioned depositional elements, represent low to moderate amplitude, and parallel-subparallel seismic reflection. With the conversion of sediment gravity flow types, MTDs gradually evolve into channel deposits, channel-levee complexes, lobe deposits. On the basis of these, the sedimentary facies distribution of the sedimentary period of the SQ1 to SQ7 of Miocene was discussed. Due to high sea level and shortage supply of sediments, the channels of SQ1, SQ2 and SQ4-SQ6 are relatively small. However, the channels of SQ3 and SQ7 are larger probably because of low sea level, frequent tectonic movement and abundant sediments. So the channel deposits of SQ3 and SQ7 are favorable oil and gas reservoirs.

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The Tongwane Formation: a depositional and diagenetic model from field, petrographic and geochemical studies

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The Tongwane Formation (Chuniespoort Group, Transvaal Supergroup, South Africa) is a Palaeoproterozoic sedimentary succession that rests conformably on the Penge Iron Formation, thus recording the end of significant iron formation deposition on the Kaapvaal Craton. Although undated, the Tongwane Formation is thought to predate the Palaeoproterozoic Great Oxidation Event, and possibly snowball Earth periods. It can thus shed light on environmental conditions on the eve of these important events. Logging and sampling was conducted along the Tongwane type section. Thin sections were prepared from samples and analyses of bulk rock XRF, XRD as well as C and O isotopes were carried out.

Using petrographic and geochemical data, a depositional and diagenetic model of the Tongwane is proposed. Sedimentary structures and facies relationships are consistent with a prograding carbonate ramp environment. Distal, basinal facies are ferruginous mudstones and iron formations which are overlain sequentially by: (i) slope interlaminated ferruginous, siliceous and carbonate mudstones including turbidites and slump deposits, (ii) shallower water carbonates displaying HCS and wave ripples and (iii) low energy mudstones with stromatolitic horizons. Most significant is the presence of slumps and gravity-driven slope breccias in the transition between slope laminated mudstones and HCS-stratified carbonates. They indicate that significant depositional relief existed between ferruginous deeper-water environments and shallow-water carbonate environments. This is one of the rare documented cases of shallow-water carbonate deposition coeval with deeper water deposition of iron formations.

We propose a four stage diagenetic/metamorphic model: (1) carbonate recrystallization, stylolite formation, and dolomitization occurred during early diagenesis and the first km of burial, (2) primary iron oxyhydroxide deposits underwent diagenetic alteration to iron oxide (magnetite, hematite) and iron carbonate (siderite) phases by maximum burial depth of approximately 4 km, (3) interaction of alkaline, metasomatic fluids added significant sodium to the system causing alteration of iron oxides, but mainly siderite, to riebeckite, and (4) medium-grade contact metamorphism (caused by the intrusion of the Bushveld Complex which elevated temperatures above 350 ºC) which facilitated the total replacement of siderite with grunerite, the growth of biotite and andalusite in mudstones and the growth of garnet in the upper carbonates. It is likely that iron oxides weathered to form goethite during late stage (near surface) exhumation and exposure. We present C (carbonate and TOC) and O (carbonate) isotopes but note that, despite the paleoenvironmental significance of the Tongwane Formation, the metamorphic overprint of the section is such that it may be misrepresentative of Palaeoproterozoic water column chemistry.

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Numerical method to differentiate tsunami and storm wave boulders

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Coastal boulders that were deposited along the shore are the important geological evidence of past tsunamis. However, boulders can also be deposited by large storm waves. Although several sedimentological or theoretical methods were proposed to differentiate tsunami boulders from storm wave boulders, there is no appropriate numerical method for the differentiation. In this study, we developed new numerical method and distinguished tsunami boulders from storm waves ones. And we applied this to the coastal boulders at Ishigaki Island, Japan.

Ishigaki Island is located in the southern end of Japanese archipelago and has frequently experienced both tsunami and storm wave events. These waves emplaced and displaced numerous boulders on the coast. Significant difference between tsunami and storm waves can be characterized by the wave period. Storm wave period is several ten seconds, while tsunami wave period is several tens of minutes to hours. Therefore, size and spatial distributions of tsunami and storm wave boulders should be different, affected by the difference in the duration of wave force. In fact, previous sedimentological research revealed storm wave boulders on the Ryukyu Islands were deposited ~300 m from reef edge but tsunami boulders were accumulated over 1.5 km from one.

Based on the difference of such wave properties, we conducted numerical calculation of storm wave using CADMAS-SURF. CADMAS-SURF is a numerical wave-tank flume model which is developed for advanced maritime structure design. We generated a single incident wave at approx. 1500 m offshore from the shoreline. We input the waves with various periods and heights ranging from 10 to 20 s with 1 s interval, and from 10 to 20 m with 1 m interval, respectively. We then calculated maximum acceleration and velocity of storm waves along the transect across this study region. Using these values, maximum wave force along the transect is calculated by Morrison's formula and we judge the maximum transport distance of boulders by the storm waves where wave force and friction force are balanced. As a result, we revealed that the calculated size and spatial distributions of storm wave boulders fits well with the observed ones if we assume storm wave height with 11 m and period with 10 s. Other boulders, which were identified as tsunami deposits by previous studies, were located well beyond the calculated distribution limit of storm wave boulders.

Our numerical model input is bathymetry, size of boulders, and their initial positions, which may or may not be available depending on the local setting. However, we infer that our numerical method is simple and is useful to better identify tsunami boulders.

A Study on Synsedimentary Faults of the Pearl River Mouth Basin and Its Control on Depositional System

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Continental margins, located on the continental and oceanic crust, record the processes of the continental breakup and the ocean opening. These margins are important for research on geodynamics. The Pearl River Mouth Basin is located on the northeastern passive continental margin of the South China Sea and it is additionally a petroliferous basin. The basin can be divided into the rift layer and the post-rift depression layer.

Based on the analysis of seismic data, cores, logs and other geophysical and geological data, applying the theory and method of Sequence Stratigraphy, Seismic Sedimentology, Basin Structure Analysis and starting with the stratum and regional structural evolution, combined with the developmental characteristics of third-order boundaries, we established the third-order Chrono-stratigraphic Sequence Framework of the research area and divided it into 17 third-order stratigraphic sequences from Neogene to present. The interpretation of seismic structural features of the basin show that from 23.8Ma to 5.5Ma, there are two periods of synsedimentary faults with the trend of NW－NWW and EW. The echelon arrangement and branching compound fabric can be seen on the surface. In the vertical profile, these faults mainly show the mode of parallel faulted terrace, pinnate, horsetail, and combined Y-shaped fault assemblages. Through the analysis of the distribution, combination and character of the faults, these synsedimentary faults can be classified into several fault zones.

The calculation of Fault Growth Index and Fault Growth Rate indicated that the faults moved strongly from 23.8Ma to 18.8Ma, and then the movement decreased gradually. Both palaeogeomorphic and movement characteristics of the synsedmentary faultings revealed that sequence depositional systems were mainly controlled by the palaeohigh slope and the slope break zone. The Apatite Fission-Track Analysis (AFTA) was applied to research on the thermal evolution history of the basin. It was based on the measurements of several samples from the wells near the faults that we gain results showing the responses of the thermal evolution and the intensity of faults activity.

Implications from Core ZKA4 for reconstructing the last transgression in eastern China

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Previous research based on numerous borehole sediment samples indicate that almost all the coastal plains of eastern China were subjected to a widespread marine transgression in the late Quaternary. There is a great deal of temporal and spatial variations in the distribution of benthic foraminifers in terms of species composition and abundance, presumably controlled by the extent and timing of the marine transgression. According to borehole data, the transgression at the post-glacial period of last glaciation greatly influenced the eastern region of China, almost covering the entire Jiangsu Province, most parts of Zhejiang Province, Shandong Peninsula, and some areas of Hebei, Liaoning, Fujian, Guangzhou, and Guangxi.

Although numerous boreholes have been drilled in various parts of eastern China and data collected, there has been little study on the Quaternary marine fossils and palaeoenvironments in the western part of Jiangsu Province. In this study, a total of 50 foraminiferal species have been identified from the top 42.0 m of the Core ZKA4 (32°22′, 119°37′), and all but five are benthic forms. Immediately under those foraminiferal layers, 4 species of non-marine ostracoda were recorded between 42.4 and 45.0 m core depth (Layers 43-48).

Optically stimulated luminescence (OSL) geochronology has given an age of 14.2 ± 0.6 Ka for Layer 42, thus indicating that the 42.6-42.8 m interval of the Core ZKA4 was deposited in the late Epipleistocene epoch. It exactly shows the turning point when the paleoenvironment became marine from non-marine.

Further detailed analysis of the stratigraphic distributions of the foraminiferal species allow the recognition of three local stratigraphic assemblages, comprising in ascending order the *Ammonia beccarii-Lagena sreiata* Assemblage (LSA) , *Ammonia beccarii-Cribrononion subincertum* Assemblage (CSA) and *Ammonia beccarii-Orbulina universa* Assemblage (OUA).

The marine sedimentary succession of this event appears to suggest two phases, abbreviated H I-1 and H I-2 respectively.

The H I-2, include the LSA Assemblage and are Late Pleistocene in age. Sedimentary succession mainly filled by gray silt and fine sand, with well developed horizontal bedding and lenticular bedding. At this phase, sea level rose rapidly based on the abundance and diversity of foraminifers of the assemblage, to the extent that an open gulf environment was attained. Succeeding this phase was the Younger Dryas period, represented by layers 31-29, characterized by a sea level drop evidenced by micro-erosional surfaces, a decrease of foraminifer species diversity and the presence of overbank estuarine deposits.

The climate became warmer in the Holocene and sea level rose gradually. The younger transgressive phase, H I-1, is recorded by alternating beds of clay and silt, interbedded with relatively thin sand layers, and development of poorly-defined horizontal bedding. The characteristics of CSA Assemblage and OUA Assemblage indicate that the paleoenvironment of this period can be deduced as estuary- shoreline to tidal estuary. This succession of genetically connected environments has been observed widely in many parts of the world, from the Gulf of Mexico to Japan.

All evidence above confirms that the last transgression arrived in the study area at about 14Ka ago, and was much more extensive and enduring in the late Pleistocene than in the Holocene.

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Perfectly zoned sphaerosiderite at the Triassic-Jurassic boundary

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Perfectly zoned sphaerosiderites are restricted to a specific sandy interval deposited during the end-Triassic extinction event, studied in samples from the Danish Basin (N. Albert quarry, Sweden). Underlying and overlying sandstone intervals, also the non-marine Höganäs Formation, have several other types of siderite morphologies, i.e. poorly zoned sphaerosiderite, spheroidal (ellipsoid) siderite, spherolites (spherical siderite) and rhombohedral siderite. Sparry, microspar and/or micritic siderite cement postdates these features in some concretions. Rhombohedral and spheroidal (ellipsoid-shaped siderite) siderite are known from marine mudstones and sandstones (e.g. Mozley and Carothers 1992; Mortimer et al. 1997). Sphaerosiderite and spherulitic siderite morphologies (spheres of siderite) are contrary commonly of pedogenetic origin (e.g. Browne and Kingston 1993; Robinson et al. 2010). The non-marine Höganäs Formation at the N. Albert locality represents spherulitic to rhombohedral morphologies and renders the probability of other explanations for varying siderite morphologies.

Investigations include, besides sedimentology, petrographical and geochemical characterization of the siderite concretions. All siderite morphologies have almost identical oxygen isotopic values, reflecting groundwater composition. Pedogenic / fresh water origin is supported by a trace element composition of varying Fe:Mn ratio and low Mg contents. The carbon isotopic composition shows the, for sphaerosiderite, characteristic broad span that could originate from multiple microbial activity. Groundwater fluctuations is the most likely explanation for repeated siderite zones of varying Fe:Mn ratios reflecting alternating physiochemical conditions and hostility to microbial life/activity. Bacterial mediated siderite precipitation incorporated Mn and other metals ions during harsh conditions and continued with Fe-rich siderite precipitation as the physiochemical conditions changed into optimal conditions again, reflecting for example the response to groundwater fluctuations.

References

Browne, G. H. and Kingston, D. M. 1993. Early diagentic spherulitic siderites from Pennsylvanian palaeosols in the Boss Point Formation, Maritime Canada. Sedimentology 40, 467-474.

Mortimer, R. J. G., Coleman, M. L. and Rae, J. E. 1997. Effect of bacteria on the elemental composition of early diagenetic siderite: implications for palaeoenvironmental interpretations. Sedimentology 44, 759-765.

Mozley, P. S., Carothers, W. W. 1992. Elemental and isotopic composition of siderite in the Kuparuk Formation, Alaska: Effect of microbial activity and water/sediment interaction on early pore-water chemistry. Journal of Sedimentary Petrology 62, 681-692.

Robinson, S. A., Scotchman, J. I., White, T. S., Atkinson, T. C. 2010. Constrains on palaeoenvironments in the Lower Cretaceous Wealden of southern England, from the geochemistry of sphaerosiderites. Journal of the geological Society, London, 167, 303-311.

Comparing storm and tsunami deposits: Insights from meso-scale numerical simulations of the settling process

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Suspended load is the dominant sediment transport mode for the common near and onshore sand grain sizes in most common storms and tsunamis, which can be shown by simple Rouse number analysis. However, deposits laid down by storms and tsunamis can have very different characteristics although many similarities exist. Despite the vast amount of research on suspended sediment transport, few models focus on the features of the resultant deposits. Our modeling aims at exactly that, and we study how the waves interact with suspended sediment as the sediment settles down and generates a deposit.

We employ the Discrete Element Method to model sediment settling and deposition that produces detailed deposit structure. Sediment transport is modeled as a single phase that does not feedback to hydrodynamics. Interaction between different grain sizes and their concentration – a process known as hindered settling – is incorporated. It should be noted that we assume only silty to sandy grain sizes, and exclude mud due to its cohesive nature and difficulties arising from it. For the water motion, we assume linear long waves, and this limits our model to the offshore region where linear wave theory is most applicable.

In our simulations, we assume that sediments initially distribute uniformly or follow a Rouse concentration profile. Our results indicate that storm deposits show periodic features in terms of vertical grading, because of the relatively short period of storm waves. In contrast, tsunami deposit structures are largely dependent on the relative position between sediments and tsunami wave crest.

Both tsunami and storm deposit structures are the complex interplay between wave amplitude, water depth and grain-size distribution. For a certain grain-size distribution, greater water depth and amplitude result in greater settling distance, and hence better grading of deposits. Moreover, there exists a threshold water depth, beyond which deposit grading does not vary.

Primary dolostone related to the Cretaceous lacustrine hydrothermal sedimentation in Qingxi sag, Jiuquan Basin on the northern Tibetan Plateau

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Based on comprehensive studies in petrography, petrofabric analysis and geochemistry, this paper describes a unique and rare laminated micritic ferruginous primary dolostone crystallized and precipitated from the alkaline hot brine under the conditions of the Mesozoic faulted lake basin. The main rock-forming mineral of this dolostone is ferruginous dolomite with a micritic structure. This dolomite mostly exhibits laminae of 0.1–1 mm thick and is often discovered with other minerals, such as albite, analcite, barite and dickite, which have at least two types of interbedded laminae. Petrogeochemistry reveals that this dolostone contains a large number of typomorphic elements of hydrothermal sedimentation, including Sb, Ba, Sr, Mn, and V. In addition, the LREE is in relatively high concentrations and possesses the typical REE distribution pattern with negative Eu anomaly. Oxygen isotope values ($\delta^{18}O_{PDB}$) range from 5.89‰ to 14.15‰ with an average of 9.69‰. The ratio of $^{87}Sr/^{86}Sr$ is between 0.711648 and 0.719546, with an average of 0.714718. These data indicate that the depositional environment is a stable, blocked, anoxic low-lying hot brine pool in the bottom of deep lake controlled by basement faults. The hydrothermal alkaline fluid is the alkaline hot brine, which is of medium to low temperature, medium to high salinity and density, and rich in CH_4 and CO_2, formed by the combination of the infiltration lake water and mantle-derived magmatic water, consisting of many ions, including Ca^{2+}, Mg^{2+} and Fe^{2+}. We set up a model for the formation of the hydrothermal lacustrine dolomite, based on studying its hydrothermal fluid metallogenic mechanism. And we consider that, under the driving flow power of magmatic heat, gravity and compaction, the hydrothermal fluid overcame the overburden pressure and hydrostatic pressure of the lake water body, and boiled to explosion, and then the explosion shattered the original laminated micritic ferruginous primary dolostone near the vent and then formed a new type of dolostone called shattered “hydroexplosion breccias”. In the low-lying, unperturbed hot brine pool, far from the vent, the laminated micritic ferruginous primary dolostone was quickly crystallized and chemicals precipitated from the hydrotherm. The common hydrothermal dolostone usually discovered in the marine facie is of the metasomatism, and the uncommon hydrothermal dolostone in the lake facie is of the penecontemporaneous metasomatism or buried hydrothermal metasomatism. As primary deposits, and formed by crystallization and sedimentation from the hot brine, the lacustrine dolostone we studied here is very rare. So, this study of special rocks contributes to research into the causes of the formation of lacustrine carbonate rocks and dolostone. In particular, it provides new examples and research insights for future studies of the lacustrine dolomite from the similar Mesozoic and Cenozoic basins in China.

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Key words: primary ferruginous dolostone, hydrothermal sedimentation, fault lakes, Cretaceous, Jiuquan Basin, China

Channels depositional model of Putaohua Reservoir in north of Saertu Oilfield

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The well spacing in development area is more and more intensive with the growth in oil exploration. The infill well pattern makes it possible to regain primitive distributing feature of sand bodies. By detailed core observation and description ,and applying well logging and every geologic information, the article makes careful research on sedimentary environment and sedimentary feature in research area; it also makes detailed dissection on large scale overlap channels of Putaohua Reservoir of Saertu Oilfield in Songliao Basin; it puts up sedimentary feature ,recognition method and sedimentary model about large scale overlap channel sand bodies. So it offers reference for the dissection of large scale overlap channel sand bodies in other districts and it also offers important theoretical basis for exploiting the remaining oil in sand bodies in large scale overlap channels.

Keyword: large scale overlap channels; depositional model; putaohua reservoir; remaining oil ; extraction potential

Tidal signature recorded in burrow fill

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Under normal marine conditions burrowing organisms mix the originally layered stratigraphic record if sediment accumulation is not too severely interrupted by physical reworking or depositional events. On shelves around (storm)wave base and above, waves and currents may reduce sediment accumulation locally for some time or even lead to erosion and result in a stiff to firm substrate. In such a stable sediment, burrowers produce open tubes or tube systems. Because the substrate does not collapse for some time, abandoned open tubes or parts of them may act as sediment traps that record short-term sedimentation rates. Late Miocene sediments outcropping at the Atlantic coast of Argentina, which accumulated in a lower-shoreface to upper-offshore setting on a shallow shelf extending from the Atlantic Ocean to the west into northern Patagonia preserve such natural sediment traps. The infill in open *Thalassinoides* burrows was regulated by tides, that thus represent so-called tubular tidalites.

The thickness variation of individual layers and couplets implies a mixed diurnal semi-diurnal tidal signature while packages of either thick- or thin-layered couplets alternate. Calcarenitic sediment accumulated when tidal current velocity was too high to allow for the deposition of mud, whereas a marly mud layer is interpreted to have formed during more tranquil times of a tidal cycle (in particular low-tide slack water). The tidal record within the burrows covers a few weeks and the corresponding spring-neap cycles. The fill of the *Thalassinoides* shafts is the so far only record to decipher the tidal signature from the otherwise totally bioturbated sediments.

The passive fill provides a record of 4 weeks documented within one example, whereas 3 other specimens contain intercalated unusual thick or even distorted layers and hence, restrict the undisturbed record to about 2 weeks. For the undisturbed intervals the sedimentation rate within the tubes ranges between 100 and 300 cm/yr. These values are in agreement with short-term sedimentation rates in modern tidal settings. The upper value refers to modern high-sediment yield depositional sites.

The fill of all investigated burrows started around spring tide and thus, the behaviour of the burrow producers – probably crustaceans – is speculated to have been affected by tides or the high water level as all studied burrows became abandoned around the same period of a tidal cycle.

The Miocene tidal signature (mixed diurnal semidiurnal, predominantly diurnal) is different from the present one (semi-diurnal). Today, however, the semi-diurnal signal increases toward the north. Therefore, the Miocene palaeogeographic setting accentuated by basins extending into the present-day continent and a shelf wider than today might have led to an extension of the area affected by mixed tides to the south.

Sediment cores from ancient lakes: Linking geological and biological histories

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Ancient lakes, i.e., extant lakes that have continuously existed since the last glacial maximum, harbor a considerable proportion of worldwide endemic freshwater biodiversity.
The processes generating this high biodiversity, however, are poorly understood.
Over the past decades, several ancient lakes were sites of International Continental Scientific Drilling Programs (ICDP) to unravel their geological histories and to obtain information about past evolutionary events. Using biological proxies from sediment cores such as micro and macro fossils, important information could be obtained about past patterns of biodiversity together with some of the underlying processes. However, due to problems such as incomplete sediment records, partially poor recovery and/or poor or missing fossil records, our understanding of their geological and particularly biological histories remains limited. This situation calls for the application of new and independent biological proxies and methods that can be linked to sediment records. Examples include i) molecular clock approaches, i.e., a concept that correlates the number of genetic substitutions in extant taxa to time in order to infer past diversification events, ii) coalescent approaches, i.e., a population genetics approach that models the history of gene copies of extant taxa backwards in time to infer past demographic and spatial expansion events, iii) paleohabitat reconstruction, i.e., a modeling approach that is used to reconstruct extinct habitats by comparing fossil information with extant community structures, and iv) reconstruction of ancestral states, i.e., a phylogenetic approach to reconstruct biogeographical and ecological properties in extinct taxa.
These new biological methods and proxies are currently used in the SCOPSCO project, an international research initiative to study, among others, the influence of major geological and environmental events on the biological evolution of endemic taxa. Target site is Lake Ohrid, the oldest lake in Europe. With more than 200 described endemic species, the lake is one of the most biodiverse lakes in the world when taking lake size into account.
In spring 2013, a total of 2100 m sediments were recovered from four drill sites with a maximum drill depth of 569 m below the lake floor and an overall recovery of > 95%. Initial data from borehole logging, core logging and geochemical measurements indicate that the sediment succession covers > 1.2 million years.
We demonstrate that the evolutionary hypotheses previously established for Lake Ohrid based on the new methods and proxies suggested above are largely confirmed by the preliminary data from the SCOPSCO drilling campaign. We also show that data from sediment cores can considerably contribute to a better understanding of the driving forces of biotic evolution.
Therefore, Lake Ohrid appears to be a first class site to study the link between geological and biological evolution. Moreover, it constitutes a prime example for the high potential of combining geological and biological approaches for testing scientific hypotheses of broad significance.

We thank the SCOPSCO Science Team for providing preliminary data from the SCOPSCO coring campaign, and the ICDP, the German Ministry of Education and Science and the German Research Foundation for financial and logistic support.

Primary porosity characteristics of modern reef-related carbonate sediments: the influence of environments and components

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The grains, or the solid parts of carbonate sediments have been extensively studied because information on grain types, depositional textures, sedimentary structures and mineralogies are utilised in the interpretation of depositional environments, facies relationships and the diagenetic alteration of carbonate rocks. However, the pore networks, or the voids in carbonate sediments that may constitute between 40-80% of the bulk volume of the sediment remain understudied. In particular, an understanding of pore networks in skeletal or bioclastic carbonate sediments remains at best rudimentary, perhaps in part due to their perceived complexity. Yet in many regions such as the equatorial tropics or the temperature regions carbonate sediments may be almost exclusively skeletal in their primary origins.

This study uses combined petrographic and MicroCT imaging techniques to investigate the primary porosity characteristics of reef-related sediments from equatorial SE Asia. Intragranular and likely intergranular porosity were measured in sediments from the varied carbonate systems of the Tukang Besi archipelago. In the archipelago atolls, small-scale build-ups and fringing reefs around uplifted islands are all isolated from major siliciclastic input. Local environments sampled include reef slope, reef crest, reef apron, atoll interior and foreshore sands. The bioclastic components, their breakage and/or alteration, together with sediment grain sizes and textures all influence primary porosity characteristics. The local environmental conditions affecting these pore-controlling factors are investigated.

Evolution of a Tertiary carbonate platform: from rift, drift and 'build-up' to alteration and demise in a fold and thrust belt

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In active tectonic basins the location, sequence development, internal variability, demise and diagenesis of carbonate platforms are often strongly impacted by differential subsidence/uplift, faulting and tectonically-driven subsurface fluid flow. Here, we evaluate depositional and diagenetic changes across an Australasian subsurface buildup during its initiation in a rifted margin setting and subsequent development then demise in a fold and thrust belt. The Elk and Antelope system is a major recent gas discovery hosted in Tertiary reefal, platformal and associated deepwater carbonates in the present day foothills region of the Fold and Thrust Belt in the Gulf Province of Papua New Guinea. A full suite of FMI logs (> 2000 m), > 250 thin sections (mainly from sidewall cores and cuttings) and additional diagenetic data (cathodoluminescence, fluid inclusion, SEM and stable isotopes) from both platform margin and shallow water deposits were evaluated during this study. An additional core, petrographic (>150 thin sections) and geochemical study of 16 onshore and offshore wells mostly from the adjacent Gulf of Papua Foreland Basin was undertaken to further understand controls on regional carbonate development.

A series of rift related structural highs strongly controlled the location of initial, and subsequent, carbonate development. Tectonic subsidence provided the accommodation space for thick carbonate successions. Early Paleogene platforms are dominated by non-framework building biota including foraminifera, coralline algae and echinoderm debris that typically did not build to sealevel and experienced significant post-depositional compaction. Plate tectonic drift through climatic belts, paucity of eustatic fluctuations, oceanography and lack of early cements were all controlling influences. By the late Paleogene and into the Miocene reefal development was common, with many buildups affected by repeated subaerial exposures. There were significant variations in facies and early cements across shelves and buildups. Active faulting, significant differential uplift and subsidence and regional compactional driven subsurface fluid flow associated with formation of the fold/thrust belt and foreland basin all impacted sequence development, platform margin collapse and/or demise, and regional diagenetic trends.

Non-marine depositional environment for the Triassic cover (Vieux Emosson Formation) of the Aiguilles Rouges Massif, southwestern Switzerland

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The Vieux Emosson Formation consists of the Triassic autochthonous sedimentary rocks of the Aiguilles Rouges Massif in the Lac d'Emosson area of the Swiss Western Alps. The Triassic sequence overlies highly weathered gneiss with 1 m of local (and 10 m over a few km) erosional relief, and is overlain by allochthonous rocks of the Helvetic nappes. The Vieux Emosson Formation consists of a basal sandstone-conglomerate unit and an upper shale-dominated unit. On the basis of the quartzose lithology of the sandstone units, previous workers concluded that the Vieux Emosson Formation was deposited in a shallow marine/beach environment with an implication that the regional Triassic paleoslope was southward, towards the Tethyan Sea. However, in this study detailed facies analysis instead indicates deposition in a non-marine setting, and transport northward towards the Germanic basin.

The lower unit, 3-10 m thick, consists of amalgamated, dm-scale conglomerate and sandstone beds in m-scale fining upward sequences, rarely capped by shale beds up to 20 cm thick. Conglomerate beds are sandy matrix-supported, with angular and subangular clasts up to 6 cm in size. Most clasts are quartz, but locally there are abundant metamorphic lithic fragments (MLFs) and shale rip-up clasts. A conglomerate unit, found sporadically overlying basement, contains large clasts (up to 20 cm) of basement gneiss. Conglomerate beds are massive with rare cross beds and internal channel scours. Sandstones are poorly sorted, commonly pebbly, medium to very coarse grained and contain dm-scale trough cross beds. Composition is quartzose, with some plagioclase feldspar and MLFs. Red mottled, dm-thick, silty sandstone beds contain cm-scale dolomite nodules or large desiccation cracks. Paleocurrent data from troughs and ripples have a unimodal pattern with northwest transport direction. Overlying the basal unit, cm-scale interbeds of sandstone and shale transition into overlying shale. They contain abundant current and wave ripple marks, mudcracks, shale rip-up clasts, and rare load casts. *Chirotherium* reptile tracks are found on rippled beds. The shale unit, up to 3 m thick, contains mm- to cm-scale beds of fine-medium sandstone and dolomite. Stratigraphically, the sandstone beds thin and fine upward, and the unit contains similar 20-50 cm nested cycles. Wave and current ripples, shale rip-up clasts, parallel laminae, mudcracks, starved ripples and rare load casts are present. Bioturbation is rare. Thin-section analysis of the shale revealed mm-scale silt-clay graded laminae, often with a fine-grained sand base. Erosional bases, rip-up clasts, parallel laminae and ripple cross laminae characterize the sand component. Thin, weakly laminated dolomite beds (with mudcracks) and cm-scale nodules are present near the top of the section.

Deposition of lower unit was in shallow braided streams. A fluvial interpretation is supported by: high-relief basal erosional surface, immature sediment, large angular clasts (including shale rip-ups), amalgamated fining-upward sequences, mottled paleosol horizons, near absence of bioturbation, and a unimodal paleocurrent pattern. Together the interbedded sandstone and shale (proximal) and the shale (distal) units represent deposition in a terminal splay-playa environment. Desiccation cracks, dolomite, a lack of fossils and rare trace fossils indicate deposition in a playa lake. The fining and thinning upward sequence reflects an overall deepening, and the nested cycles reflect lobe switching. Results of carbon and oxygen stable isotopic analyses of the dolomite are consistent with a playa environment.

Chert-Pulses instead of black shales during OAE's in the deep Hawasina Basin in Oman

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The Oman mountains preserve a Late Jurassic to Cretaceous continental margin transect with the Arabian carbonate shelf and the adjacent deep Hawasina Basin which is outcropping in the nappe pile of the Oman Mountains today. The sediment successions of the Hawasina Basin (Sumeini & Hamrat Duru Group) provide the opportunity to investigate the response of an eastern Tethyan equatorial ocean system to multiple perturbations of the carbon cycle during the Cretaceous.

The Cretaceous sediment successions in the Hawasina Basin start with a "pelagic Maiolica Limestone Facies" (Huwar 1, Lower Sid'r and Nadan Fm). Chemo- and biostratigraphy serve for correlation of the pelagic facies across the Hawasina Basin. Pelagic to hemipelagic conditions existed until the time of the Valanginian carbon isotope excursion. Coarser turbidites indicate that the Arabian carbonate platform prograded during Valanginian and Hauterivian time more than 300 km towards the northeast. Facies changes towards coarser turbidites complicates the use of chemostratigraphy as a correlation tool. However, chemostratigraphy of the Barremian to Cenomanian combined with existing radiolarian biostratigraphy in the Hamrat Duru Group shows episodes of reduced sedimentation rate with an episode of intense silicification during Aptian-Cenomanian time. The reappearance of chert and or highly silicified limestone in all upper successions coincides with a negative shift in the C-isotope values. This shift can be correlated with the C3-negativ shift preluding the OAE1a in the western Tethys and or Atlantic. The equatorial position of the Arabian Platform and the offshore Hawasina Basin provide information on a peculiar oceanographic situation. Wind driven equatorial currents combined with upwelling current were most active during extreme greenhouse episodes. Resulting nutrient rich water masses may explain chert pulses during the onset of the OAE1a and OAE2 and the absence of black shales because of continuous deep water ventilation.

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Variations of sedimentary characteristics on the Hwangdo tidal flat, Cheonsu Bay on the west coast of Korea

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The western tidal flats of the Korean Peninsula are well developed along the coast with gentle slopes and tidal ranges of 4 to 10 meters. Recently, rapid expansion of developed coastal area has changed the coastal environments. Changes in physical energy due to artificial structures have affected ecosystem and sedimentary environments in tidal flats. Cheonsu Bay in the mid-west coast of Korea was reduced in total area after seawalls were constructed for land reclamation in the 1980s. The Hwangdo tidal flats are formed inside Cheonsu Bay. The tidal flat is characterized by complex channels in its center. Tides are typically semi-diurnal with a mean tidal range of 4.59 m. In this study, we attempted to understand variations of sediment characteristics through comparing distributions of surface sediments and elevations on the tidal flat.

The surface sediments for sedimentary analysis were sampled at the tidal flat in March 2004, May 2010 and June 2013. Grain-size distributions were determined by using standard sieving and a Sedigraph 5100. The inclusive graphic method was used to determine sediment type, mean, sorting, skewness and kurtosis. The elevation was measured at one transect line by using a RTK-GPS in May 2010 and June 2013. The short-term sedimentation rates were determined at one transect line by burying a plate at sub-bottom depth and periodically measuring the changes in sediment depth from February 2013 to February 2014.

The digital elevation model (DEM) showed that the central tidal flat was at a high elevation. The elevations showed significant gradients in the west and had relatively low relief in the east. The surface sediments in the tidal flat were generally classified into three sedimentary facies. In March 2004, muddy sand dominated the southeastward tidal flat. The sandy sediments dominated the eastern and southern tidal flat and sandy mud sediments were mostly distributed in the western part. The area of muddy sand sediments extended to the southward tidal flat in May 2010. The area of sandy sediments diminished, but that of sandy mud sediments increased eastward across the tidal flat. In June 2013, the muddy sand sediments were predominant in the middle to eastern part of the tidal flat. The topographic changes were investigated in the transect line in May 2010 and June 2013. Deposition occurred with net deposition of 13.36 cm during three years. The short-term sedimentation rates from February 2013 to February 2014 showed that annual sedimentation rates ranged from -30.2 to 12.35 mm/year with a net erosion rate of -4.20 mm/year. Seasonally, deposition occurred on the western part in summer and eastern part of the tidal flat in winter with an inflow of muddy sediments.

The construction of an island-connecting bridge and dock had been carried out near the Hwangdo tidal flat since 2000s. The construction of Hwangdo bridge after demolition of the dyke resulted in circulation of tidal currents in western parts of the tidal flat since 2012. In comparison of sedimentary facies between 2004 and 2013, the area of muddy sand sediments had increased, but that of sandy sediments decreased for 10 years. The topographic changes on the tidal flat between 2010 and 2013 showed that the deposition occurred with an inflow of muddy sediments by circulation of tidal currents. Local hydrodynamic changes due to demolition of the dyke near the tidal flat are likely responsible.

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Depositional style and carbonate production of the microbe-dominated carbonate platform: the Zhangxia Formation (Cambrian Series 3), China

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The Cambrian Series 3 Zhangxia Formation (about 180 m thick) in the North China platform consists of a thick succession of limestone and siliciclastic fines, underlain by shallow marine mixed carbonate-siliciclastic deposits (Mantou Formation). It is overlain by a thick shale sequence (Gushan Formation). The succession of the Zhangxia Formation can be grouped into six facies associations. Facies association 1 consists of bioturbated wackestone, thin beds of oolite, and patch reefs of thrombolite which formed in lagoonal environments. Facies association 2 consists mainly of thick oolite and intercalated grainstone and thin thrombolites and represents oolitic shoal environments. Biostromal thrombolite, stromatolites, and dendrolites with rare intercalation of skeletal grainstone constitute facies association 3 which represents inner microbial platform. Facies association 4 is characterized by *Epiphyton* bioherms with debris of *Epiphyton* bioherms and skeletal grainstone which formed in marginal part of the platform. Layers of *Epiphyton* and thrombolite bioherms, associated with limestone-shale alternations and calcarenite, comprise facies association 5. It represents outer microbial platform. A thick succession of shale and calcarenite of facies association 6 represents outer platform environments.

The initial deposition of carbonate succession of shoal-lagoon system (early stage of sequence 1) commenced during submergence of the mixed carbonate-siliciclastic environments, represented by the Mantou Formation. Low-relief platform became steeper because of retrograding and aggrading of shallow platform carbonates (FA2 and FA3) during subsequent sea-level rise, which resulted in contrasting facies in the inner and outer platforms. The inner platform environments were dominated by biostromal microbialites (FA 3), whose morphology probably was ascribed to restricted accommodation space during slow rise in relative sea-level. Subsequent rapid sea-level rise caused onset of marginal bioherms (FA 4) on the platform which was followed by oolitic shoal environments (early stage of sequence 2; FA 2). Condensed shaly sediments were deposited in the outer platform (FA 6) during deposition of shallow platform carbonates (FA 2 and FA 3) in the inner part of the platform. The overlying biostromal thrombolites (early stage of sequence 2) formed during slow rise in sea level. The outer platform received large amounts of carbonate material from the inner platform where excess amounts of carbonates were produced. Ensued rapid rise in sea level resulted in a phase of retrogradation of marginal buildups and, eventually caused drowning of the platform, represented by basin-wide abrupt change of the platform carbonates into shaly deposits (Gushan Formation).

The evolution of carbonate platform was controlled mainly by interplay of sea-level change and mode of carbonate production. Continuous sea-level rise with fluctuation in rate formed sequences of retrograding, aggrading, and prograding strata without significant break in deposition. High sea-water saturation of calcium carbonate in Cambrian Series 3 and Furongian and sudden decline of metazoan diversity in the late Cambrian Series 2 might have been responsible for the formation of oolite- and microbe-dominated carbonate production in the platform environments.

The Cambro-Ordovician evolution of the TAZ (Taphonomically Active Zone) and its impact on carbonate facies

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Progressive changes in the early diagenesis of marine sediments during the Cambro-Ordovician are evidenced from the susceptibility of secondary carbonate to exhumation by erosive events. The disappearance of flat pebble breccias from subtidal settings during the Ordovician is currently blamed on the physical disruption caused by the increased depth of burrowing from the Cambrian to the late Ordovician. This simplistic view fails to consider the effects on early diagenesis of such an increase, and the issue of early lithification of shallow buried sea floor sediments. In addition there are other distinctive features of sea floor sediments during this interval that link directly to the progressive shift in burrowing depth such as hardgrounds.

The depth of bio-irrigation is the critical element of the taphonomically active zone (TAZ) which has an upper zone of carbonate dissolution, especially for aragonite, and a lower one of carbonate precipitation; in the Cambrian the TAZ was very thin due to the shallow nature of bio-irrigation by shallow burrowers, and thus carbonate precipitation took place at shallow depths, with a short residence time before being reworked by storms. The result was the abundance of subtidal flat pebble breccias. Subsequent lowering of the TAZ as burrowing depth increased during the Ordovician, produced carbonate precipitation at lower depths, less susceptible to frequent reworking. When reworking did occur, these more developed diagenetic layers were exhumed to produce hardgrounds and intraclasts. Later increases in burrowing depth further lowered the TAZ resulting in carbonate precipitation below the range of typical depths of sediment reworking, reducing the frequency of occurrence of such hardgrounds and intraclasts except in settings with shallow TAZ such as restricted basins. It was the effect on the extent of the TAZ caused by the increase in burrowing depth, interacting with sediment reworking that caused such distinctive changes in subtidal carbonates during the early Palaeozoic.

The paucity of flat pebble and intraclast horizons in open marine, low energy subtidal deposits after the early Palaeozoic suggests that the zone of carbonate precipitation since the Ordovician was below that depth affected by sediment reworking by most storms: by inference this suggests the depth of storm reworking was <300mm.
If the progressive changes in the TAZ were manifested by the changing nature of exhumed carbonate, what other effects in terms of sediment composition were related to these changes? Could, for example, a shallow TAZ in the Cambrian have resulted in a narrow zone of more intense aragonite undersaturation and dissolution compared with the thicker and more diffuse zones in the later Ordovician? If so this implies the “missing mollusc” effect might have been more intense when the TAZ was thin, perhaps explaining the notable paucity of molluscan remains in the Cambrian unless exceptionally preserved.

Sequence architecture and depositional systems of the Lower Cretaceous Abu Gabra Formation in the Fula Sub-basin, Muglad Basin, Sudan

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The Muglad Basin is the largest sedimentary basin in the continental rift basin group (including Muglad, Melut, White Nile, Blue Nile, etc.) that developed in Meso-Cenozoic. In the northeast, the Fula Sub-basin is an active-fault bounded basin with an area of about 3300 km^2. The Lower Cretaceous Abu Gabra Formation was formed during the first of the three rifting cycles, which can be divided into five 3rd order sequences named as SQA~SQE from bottom to top, indicating five stages of tectono-stratigraphy and tectono-sedimentary evolution. The spatial distribution and temporal evolution of clastic depositional systems can be discussed based on integrated analysis of seismic data, core and well logging data. In the Lower Cretaceous Abu Gabra Formation, a variety of typical types of sedimentary facies are recognized, namely delta, fan delta, braided delta, turbidite and lacustrine facies. It is also believed that alluvial and fluvial facies exist in the early syn-rift sequences. Each depositional system is located in specific areas within half-grabens and are developed at specific times within the cycles of lake-level variation: (1) the original rifting sequence (SQA), which is composed mainly of alluvial fan, fluvial, and fan delta; (2) the first flooding sequence (SQB), in which more stable mudstones form in the center of the lake; (3) the tectonic uplifting sequence (SQC), which is comprised of progradational fan delta and braided delta; (4) the second flooding sequence (SQD): which is a response to rapid lake-level rising containing small-scale of fan delta, braided delta, delta sandstones and thick pure lacustrine mud; (5) the late rifting sequence (SQE): which is clearly separated from SQD by a change of lithologies deposited in lacustrine to deltaic setting. In general five main sedimentary systems are established in the Fula Sub-basin. They are fan delta systems in the west and northwest, delta system in the northeast, braided delta systems in the east and southeast. The Fula Sub-basin has passed through a complex and phased rifting history causing the resulting distribution and architecture of both sequence and facies to be influenced by the interactions between tectonics and sediment supply. Four main provenances can be identified during the sedimentation of SQA~SQE and one more provenance from east developed in SQE. Different subsidence rates and types of fault systems are the main factors controlling the sequence framework and depositional systems in this sub-basin by forming distinct paleogeomorphologies. The northeastern step-fault zone controls the development of braided delta which turned into a normal delta during the late rifting stages (SQD~SQE); the western fault-scarp zone controls the development of fan deltas; the southern depression offers accommodation for braided deltas to continue developing; and the eastern half-graben dip-slope zone controls both the development of braided deltas during the sedimentation of SQE and the creation of turbidites in the eastern depression.

Keywords: Sequence architecture, Depositional systems, Rift stages, Paleogeomorphology, Fula Sub-basin

Geochemistry Characteristics and Development Environment of Chang7 Member Source Rocks in Ordos Basin, China

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Chang7 semi-deep and deep lake mudstones, formed during the period of maximum water transgression of late Triassic in Ordos Basin, are the resource rocks of the most favorable quality in the research area. They provide hydrocarbon for the interlayer tight sandstones and result in tight sandstone oil distributing consecutively in the large scale. This essay aims to study Chang7 resource rocks' geochemistry and development environment characteristics by analyzing the outcrops, S^{2-} of the samples, isotopes, biomarkers, etc. The geochemistry index of resource rocks of Chang7 are as below: the average values of TOC and chloroform asphalt "A" are respectively greater than 1% and 0.1%, organic type is $\text{Ⅱ}_1 \sim \text{Ⅱ}_2$, Ro values vary from 0.7%-1.3%. All these characteristics show that the organic matter is at the maturing stage. $\delta^{13}C$ of kerogen distribute mainly from -29‰ to 29.5‰, n-alkanes of saturated hydrocarbon are characterized as single-apex, forward apex type with main number being C_{15}~C_{17}、C_{15}~C_{20}, relatively high ration of $\sum C_{21}\text{-}/\sum C_{22+}$ and $(nC_{21+}nC_{22})/(nC_{28+}nC_{29})$, rather high contents of pregnane and C_{27}~C_{29} regular steranes, sterane ααα20RC_{27}、C_{28}、C_{29} distributing similar to the shape of "V" or "L". Those features show that source materials are mainly lower hydrobiont, such as algae. On the other hand, the contents of S^{2-} are usually less than 6%, the average values of Pr/Ph is 1, the ratios of Pr/nC_{17} and Ph/nC_{18} generally less than 1, the average value of gamma cerane/ C_{30} hopance is about 0.1.Those characteristics indicate the resource rocks are developed in the reducing environment.

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The characteristics and genesis of megaporphyritic dolomite in Wuligezitag Area, NE Tarim Basin, China

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Tough limestones are the main rock types of the Cambrian–Ordovician strata in Wuligezitag area, NE Tarim Basin, China, and dolomites are developed in the middle member of the lower-middle Ordovician HangGuletage Formation which is the deposit of deep-water shelf. At outcrop, greyish yellow fine micro-crystalline dolomites are irregularly developed as giant patches (largest>10m^2) within black thin-bedded micritic limestone. The lithological boundaries between limestone and megaporphyritic dolomite are not controlled by bedding and have various irregular shapes. Coarse-crystalline dolomite was precipitated in fractures in the late stage and affected the carbonate a little.

The dolomitization occurred in a shallow burial environment, forming the micro- crystalline dolomites and megaporphyritic structures. The geochemical characteristics of the megaporphyritic dolomite are special: 1) the order degree is low with the average value 0.6; 2) average high Fe (2001.32ppm), Mn (601.73ppm) content compared with limestone (Fe-1378.66ppm; Mn-63.01ppm); 3) low Sr (33.14 ppm), Ba (8.27 ppm) content vs limestone with Sr-1031.10ppm, Ba-21.85ppm respectively; 4) $\delta^{13}C$ (PDB) and $\delta^{18}O$ (PDB) are slightly higher than that of contemporaneous seawater, $\delta^{13}C$ (PDB) is -0.98‰ and $\delta^{18}O$ (PDB) -6.09‰; 5) the composition and characteristics of REE are similar with that of limestone.

Study reveals that dolomitization occurred in a low temperature, alkaline and reducing shallow-burial environment. The dolomitic fluid generated from the concentrated formation fluid in limestone, fault and fracture may be the main fluid channel that cause the dolomitization.

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Key Words: Wuligezitag; HangGuletage Formation; megaporphyritic dolomite; selective dolomitization; dolomitic fluid

Reservoir Character in Mixed Clastics and Carbonate Systems in Jurassic Sichuan Basin, China

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There are a lot of Jurassic reservoirs in mixed clastics and carbonate systems in Jurassic Sichuan Basin, China. The new oil and gas were discovered in these low-porosity and low-permeability reservoirs in recent years. The sedimentary microfacies and diagenetic phase of siltstones are main factors influencing reservoir quality. A detailed study on systems tract distinguishment, sedimentary model reconstruction of reservoirs and pore community analysis will be efficient measures for predicting favorable oil exploration targets.

There are 8 lines of field outcrops and 5 core wells studied and 100 photographs taken on Sichuan basin included Tanba and Qilixia Jurassic profiles and so on. Also there are 40 pieces of siltstones and fine sandstones sampled from above outcrops and cores, and made into thin section and SEM for observation. Above research of depositional trend, sequence boundary and stacking pattern showed the low density turbidite siltstones were widely distributed in deep water depositional period. During the period of deep water development, there are three types of sediments distinguished in cores of Jurassic Sichuan as follows: A)high density turbidite;B)low density turbidite;C)fine-grained deposits of lake basin(mud and shales). The high density turbidite is characterized by Bouma sequence B and chanellized turbidite sandbodies of proximal fan or distal fan. The low density turbidite is characterized by sub-lacustrine fan or basin floor fan with siltstones and/or fine sandstones.

In view of stacking pattern of parasequence and lacustrine area changes, the Jurasssic basin went through mainly three times of transgression and regression to lead to form multiple mixed clastics and carbonate systems of deep water sediments. The microscopic sample analysis from deep water deposits of Jurassic Sichuan in thin-section shows the mineral contents of calcite and terristrial clasts in rock are similar, in which calcite 50%, quartz 50%. The grayish green siltstones of sample 1469.81m in SEM shows tight cementation and local calcite belts, and pore community discovered in siltstone reservoirs.

The predicting favorable oil exploration targets based on results of sequence stratigraphic framework and diagenesis analysis are reservoirs sweet points of fine sandbodies from high density turbidite in deep lake of Jurassic Sichuan Basin.

Key words：oil reservoir character, lacustrine sedimentary model, mixed clastics and carbonate systems, Jurassic, Sichuan Basin

The depositional model of alluvial mid-fan clastic rocks of the Cretaceous in the Central Zhejiang, China

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The difficult point of Cretaceous oil and gas exploration of the medium-small basins in Southern China lies in the study of clastic reservoirs. This paper will be of great significance in sedimentary characteristics and origin analysis of Cretaceous clastic rock from alluvial fan root to middle fan facies.

The typical sequence appeared in this area including Yiwu and Zhuji city is at Jinhua-Quzhou basin and adjacent Yongkan basin. The Cretaceous in Jinhua-Quzhou basin which has three Formations from top to base is as follows: 1)Qu xiang Formation: brick-red thick and massive congromerates, sandy congromerates interbedded with sandstones and muddy siltstones(not see top), with thickness of 300m-1000m. 2)Langxi Formation(sometimes called Jinhua Formation):mainly coffee brown muddy siltstone and silty mudstone (called "green layer"), which have abundant fossils with thickness of 1 700－2 650m. 3）Zhongdai Formation: the upper part is of brown calcareous siltstone interbedded with argillaceous siltstone, which contains dinosaur fossils "*Chilan—taisaurus zhejiangensis*"; the lower part is build up of purplish red massive conglomerate and sandy conglomerate, with thickness of 800-1120m. In addition, adjacent Yongkan basin has the Cretaceous of Yongkan group and Qujiang group. Of them there is famous Fangyan Formation in Yongkan group with lithology of purplish thick and massive sandy conglomerate and conglomerates, sometimes dove color siltstone and silty mudstones at top. There are fossils of conchostracans and botany etc. with thickness of 734.9m. On basis of biological assemblage, Fangyan Formation is considered as early Cretaceous (Albian). The main geological and sedimentological phenomenon discovered in 9 observation points are as follows: Stop 1—large-scale cross beddings in Cretaceous outcrops in Tongshanyan mountain of Yiwu city in Jinhua-Quzhou basin; Stop2—mid-fan deposits and its scouring base in Cretaceous outcrops in Tongshanyan mountain. Stop 3—stacking pattern of mid-fan deposits and weathering hilly landform in Cretaceous outcrops in Tongshanyan mountain. Stop4—conglomerate and sandy conglomerate deposits and sequence boundary at base in Fangyan Formation in Yongkan basin. Stop5—alluvial sequence and coarse clastic rocks of debris flow at base of Fangyan Formation in Yongkan basin. Stop6—trough flow deposits and braided flow deposits of alluvial fan roots in Jiaolongquan area. Stop7—flake and sheet-like sandstones of sheet flow in mid-fan of Fangyan Formation in Buyunting area in Yongkan basin. Stop8—parasequence and parasequence sets appeared in Feiqiao area. Stop9—imbricated and oriented arrangement of conglomerates in the corner of Fangyan scenic area in Yongkan basin.

The geology investigation to 9 outcrops of Zhejiang Cretaceous continental sedimentary rocks shows that, there are multiple sets of sedimentary cycle of continental clastic rock parasequence sets with a lot of large-scale cross beddings in red sandy congromerates of alluvial fan. Among them, the sandy conglomerates mainly represent the trough flow deposits in fan root and the braided channel deposits in middle fan, while the flake or sheet sandstone in middle fan represents the sheetflood deposits which can be a good oil-gas reservoir.

Keywords: Alluvial fan; Red sandy conglomerate; Sheetflood deposit; Cretaceous reservoirs; Depositional model; Zhejiang Province in China