

Ophiolitic Placer Deposits and Their Ore Potential, Çamköy-Burdur, SW-Turkey

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The investigated area is located between Çamköy and Salda Lake (SW-Turkey) region consist mainly of dunite, peridotite, gabbro and diabase. Particularly, the dunitic portion of ophiolites contains several massive and disseminated chromite or magnetite deposits within the different locations. Within this framework, the geological setting, the spreading and potential of the chromiferous placer sands in the Çamköy area were investigated and for that reason, 10 samples bearing heavy mineral concentrates were collected for microscopic and chemical analysis. Placer environments included chromiferous placer sands typically contain black-sand, a conspicuous shiny black mixture of iron oxides, mostly magnetite with variable amounts of ilmenite and hematite. Valuable mineral components often occurring with black sands are monazite, rutile, zircon, chromite, wolframite, vanadinite, gold and platinum group elements. The detritic materials of chromiferous alluvial deposits derived from eastern ultrabasic source area and the placer ore deposits form as a result of weathering and erosion of chromite and titanomagnetite bearing ultrabasic and ophiolitic rocks. The chromiferous and vanadiferous placer deposits within the investigated area consist mainly of sandstone, conglomerate and siltstones. The conglomerates of the placer deposits are dark greenish, unconsolidated, well drained and poorly sorted. The clasts mainly contain dunite, serpentine, harzburgite, gabbro and diabase, primarily derived from ultrabasic rocks and ophiolite assemblages. In addition to, the field measurements of internal sedimentary structures such as large-scale cross bedding, imbricated clasts, and channel-fill occurrences indicate that the dominant grain transporting was formed from east to the west. Moreover, the thickness of the placer deposits were controlled by the Acıpayam graben faults. The results of microscopic, chemical and XRD analysis indicate that, every sample contained important amounts of chromite, also less amount of ilmenite and titanomagnetite. The average grain size of the chromiferous and vanadiferous heavy minerals changes between 30 and 120 microns. According to chemical analysis, the concentrated ore samples contain varies in between 22 % and 27 % Cr₂O₃; 45 % and 60 % Magnetite, % 3- 3.5 TiO₂ and 0.3 % V₂O₅.

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An influence of the flow velocity on the transportation and deposition of sediments of diverse sizes by the 2011 Tohoku-oki tsunami

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The tsunami triggered by the Mw 9.0 earthquake of 11 March 2011 struck the Pacific Coast of northeastern Japan, and it reached up to 28.1 m above sea level and inundated up to 1750 m inland at the study site, Settai, Iwate prefecture. Layered deposits of various sizes, ranging from mud to cobble, covered the lowland that was mainly occupied by paddy fields. In this study, layered deposits are defined as sediments consisting of particles under 256 mm in size that continuously cover the ground surface. In contrast to such layered deposits, many boulders exceed 256 mm in size and are found scattered over lowland areas. The transportation and deposition of the boulders and layered deposits at the study site is one of the rare cases in the sense that the wide range of sedimentary grains was deposited concurrently by a tsunami.

We report the results of the first comprehensive survey of tsunami deposits composed of sediments of diverse sizes ranging from mud to boulders. The flow velocity was estimated from the stopping position and size of the transported boulders by using the simple calculation. On the basis of our field observations and eyewitness accounts, we reconstructed the tsunami inundation and depositional processes.

The layered deposits were remarkably thick (>0.5–1.0 m) near the beach, where they were composed mainly of gravels, and they generally thinned and fined inland to sand and mud deposits a few centimeters thick. Many boulders were found mainly in three clusters on the lowland, and their size decreased abruptly about 750 m inland from the shoreline, where the thickness and grain size of the layered deposits also showed a sharp decrease. Based on the result of calculation, the flow velocity decreased rapidly about from 9.0 m/s to 5.0 m/s at 750 m from the shoreline. These findings suggest that deceleration of the tsunami flow velocity probably resulted in the rapid deposition of sand and gravel, and variations in the velocity mainly determined the thickness and grain size of the layered tsunami deposits.

Interestingly, the boulders were deposited on top of the layered deposit, not buried within it. This indicates that the sand and gravel must have been deposited before the arrival of the boulders, possibly within minutes of when the tsunami first struck the coast. The first backwash flow and the subsequent run-up flows probably reworked the surface of the layered deposits and the smaller boulders to some extent, but these flows were not powerful enough to modify overall the boulder distribution or the thickness and grain size trends of the layered deposit. Therefore, the stratigraphic relationship between the layered deposits and boulders therefore suggests that both were probably deposited by the first wave.

Upper Triassic conodont, ammonoid, and radiolarian biostratigraphy in a pelagic sequence of Japan - comparison between the Panthalassic and Tethyan realms

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The chronology for the Triassic pelagic deposits in the Panthalassa Ocean is based on the radiolarian zonation, which is well studied in the Middle and Upper Triassic bedded chert successions in the Japanese accretionary complex. Although accurate calibration for the chronostratigraphic stages and substages are established basically by means of ammonites and conodonts, most of the Japanese radiolarian zones were calibrated through correlation with zonal schemes in other regions, and have not been calibrated with ammonoid and conodont biostratigraphy. Here we present the results of Late Triassic (early Carnian-late Norian) conodont biostratigraphy from the two pelagic sections in the Jurassic accretionary complex of southwest Japan. Samples for this study were collected from the Sakahogi section of a bedded chert sequence in central Japan and the Nakijin Formation of a pelagic limestone sequence in the northern tip of the Okinawa Island. We found 56 platform conodonts from 36 samples in the Sakahogi section, where the radiolarian biostratigraphy have previously been investigated. The biostratigraphy of the Carnian-Norian sequence of the Nakijin Formation is based primarily on ammonites, since the rare occurrence of conodonts minimizes the stratigraphic potential of these groups. However, our study revealed that the clastic limestones intercalated within the Nakijin Formation contain rich conodonts assemblages. Based on detailed study of the conodont biostratigraphy from the interval of the Carnian and the Norian in the Sakahogi section and the Nakijin Formation, five conodont zones are recognized in ascending order as follows: lower Carnian *Paragondolella praelindae* - *Metapolygnathus polygnathiformis* zone, upper Carnian *Metapolygnathus lindae* - *Metapolygnathus primitius* zone, lower Norian *Epigondolella quadrata* zone, middle Norian *Epigondolella postera* zone, and late Norian *Epigondolella bidentata* zone. This result is consistent with the presence of the lower to upper Carnian ammonites assemblages in the Nakijin Formation.

Analysis of point bar architecture and left oil based on horizontal well cores

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We studied the meander point bar architecture of the Daqing Oilfield and the mechanisms by which oil stays behind. The main producing layer in the Xingbei area is a delta distributary plain succession with many meandering distributary channels. The sedimentary characteristics are representative in Daqing oilfield. Two straight cored wells were drilled through a dissected point bar and one 352 m horizontal cored well through the top of the point bar. Using these data, the detailed 3-d architecture and the distribution of the remaining oil were studied. Based on the analytical results and on physical simulation results, it was found that the internal architecture is the most important controlling element. The lower, middle, and upper dip angle of the lateral accretion planes is 4°, 9°, and 3°; respectively, and the maximum, minimum, and average width of the lateral accretion mudstones is respectively 41.5 m, 6.5 m, and 22 m. The upper and lower accretion planes are accordingly gentle and the middle one is steep, showing an “f” vs “anti-f” type appearance. Physical properties of the different elements of lateral accretion body are different, and consequently the degree of water flooding is different. It is generally considerable in the middle and lower parts of the lateral accretion body. Remaining oil mainly occurs in the middle and upper part of the lateral accretion body. Physical simulation experiments confirm the above results. The experiment also reveals that the degree of water flooding gradually decreases from the injection point to the location where production takes place; at the production point, the degree of water flooding shows a tendency to increase. The experiment shows that the horizontal well is useful to exploit the middle and upper parts of the point bar, while the lower point bar is the source; parallel lateral accretion units form the seepage system. In this way oil production can be increased, and the residual oil can be produced effectively.

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The evolution of the South China carbonate platform in the mid-Capitanian (Permian) biological crisis: exposed or drowned?

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The South China Carbonate Platform (SCCP) initiates in late Early Devonian time, and expands onward in the process of northward transgression. The SCCP approaches its zenith in spatial distribution in late Cisuralian to early Guadalupian (Permian), and become a giant isolated carbonate platform in the eastern Paleotethysian Ocean. Then it turns to shrink in dimension in the middle and late Guadalupian time, but still dominates in the Upper Yangtze region. Up to now, however, feature and controlling factor of this transition have received little attention.

First at all in relevance is the middle Permian Dongwu movement. This movement was explained as a major uplifting in the middle and upper Permian of the South China region. Phenomenon supporting the movement includes the overlying of the Guadalupian carbonate succession by coal-bearing littoral siliciclastic deposits of early Lopingian in middle and southeastern portions of the South China, and possible stratigraphic hiatus around the Guadalupian – Lopingian boundary (GLB). However, there are still lots of disputes and controversy on the timing, dimension and nature of the movement although more than 80 years passed after the movement was proposed.

Another prominent feature is the middle Permian Emeishan basalt present in the western part of the region. Some of recent works attributed the Dongwu uplift to the rising of the Emeishan mantle plume, and the eruption of the Emeishan basalts. But disagreement exists about the relationship between the rising of the plume and its resultant exposure of the carbonate platform.

If a major uplift did occur around the GLB, then late Guadalupian carbonate succession on the platform should be upward-shallowing, before the platform exposed. On the contrary, lots of late Guadalupian successions with well biostratigraphic constraint are upward-deepening, including sections from northern margin to southern margin.

Importantly, coeval with the shrink of the SCCP is the first phases of mass-extinction events at the end of the Paleozoic. This biological crisis is termed as end-Guadalupian extinction or mid-Capitanian extinction. This extinction had a major impact on reef ecosystems, and severely affected the large, photosymbiotic foraminiferal ecosystems, although consensus has not reached yet with regards to the time, pattern and mechanisms of the biological crisis. Undoubtedly, this phase of biological crisis would have a major impact on the carbonate factory in shallow water. If so, upward-deepening succession would be reasonable. Thus works on the evolution of the SCCP and its controlling factors would be of significance in furthering our understanding about the coeval biological crisis.

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Permian giant bivalve *Alatoconchids* from South China: occurrences and environments

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Alatoconchids are the largest known fossil bivalves in the Palaeozoic. Since first specimen's description in 1968, ten occurrences of early or middle Permian have been reported, including the Croatia, Tunisia, Iran, Oman, Afghanistan, Malaysia, Thailand, Philippines, Japan and Alaska. The former seven occurrences located in the Paleotethys. The Philippines and Japan samples were reported from Permian shallow-marine limestones contained in Jurassic accretionary complexes. The Alaska specimens are from a large limestone block within mélangé of the McHugh Complex. Thus the distribution of *alatoconchids* was of distinctive Paleotethysian biogeographic affinities. This research describes *alatoconchids*, for the first time, from the middle Permian of South China, the main terrain in the eastern Paleotethys.

Present investigation is based on four occurrences. Three of them are present in the vicinity of the southern margin of the Yangtze carbonate platform, including two sections on the platform interior (Guiding and Pu'an, Guizhou), and one on the slope of the platform margin (Luodian, Guizhou). The fourth one is from the northern margin of the Yangtze platform (Zigui, Hubei).

Similar to reported occurrences, most of *alatoconchids* observed in the South China are broken fragments, accumulated as beds of storm deposits in thickness from 10 to 90 cm. It is thus hard to get complete specimen for further morphologic identification. However, taxonomic characters, including the huge dimension, unique lateral flange and prominent prismatic external layer, are obvious, although more morphological information is still in need. Additionally, coeval similar fossils, thought as phylloid algae before from three localities in the Guangxi and eastern Yunnan, probably belong to this unique bivalve group.

The Permian gigantic bivalve family *Alatoconchidae* was interpreted as gregarious fauna associated with photosymbiotic algae, and became extinct in the late Guadalupian biological crisis. Recognition of this bivalve family in South China is of extreme importance, as it occurs in a temporal and spatial framework with well biostratigraphic and paleogeographic constraints, in furthering our understanding about the bizarre clam's living environments and its evolution.

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Superior area distribution estimation in ultra-low permeability reservoir based on diagenesis routes and diagenetic facies distribution: A case from Chang 8 member of Yanchang Formation in Huanjiang oilfield, Ordos basin

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With conventional reservoirs' declining, searching for unconventional reservoirs is increasingly important. Studies show that the ultra-low permeability reservoirs' oil reserve is tremendous, which has high potential for evaluation and development. Diagenesis routes and diagenetic facies are the dominant factors in ultra-low permeability reservoirs' evaluation and in the prediction of superior reservoir distribution.

Chang 8 member in Yanchang formation of Huanjiang oilfield in Ordos basin is a typical ultra-low permeability reservoir. Its diagenesis types are mainly mechanical compaction, cementation, dissolution, metasomatism and alteration. The reservoir is mainly grain-supported. As the mechanical compaction is strong, concave-convex contacts and mosaic contacts are main contact relations between detrital grains. Cementation forms are mainly authigenic quartz accretion cementation, authigenic feldspar cementation, authigenic kaolinite cementation and film-like authigenic chlorite cementation. Dissolution mainly manifests as feldspar dissolution and rock fragment dissolution, which is shown as organic acid dissolving feldspar particles and rock fragments to form honeycomb-like or wreckage-like dissolution pores; metasomatism is shown as calcite replaced by feldspar, quartz or other minerals in calcic or calcareous sandstone; alteration is mainly kaolinization of alkali feldspar, sericitization of plagioclase and the chloritization of biotite or volcanic glass. Dissolution is a key factor in improving reservoir properties.

Based on integrated analysis of detrital material's composition, diagenesis, porosity and pore type, diagenetic facies in sandstone reservoir of the study area can be subdivided into 7 categories: A. Medium compaction-authigenic chlorite coating + quartz accretion- intergranular pore diagenetic facies(Z-LS-L); B. Medium compaction-authigenic chlorite coating + quartz accretion - dissolved pore diagenetic facies(Z-LS-R) C. Weak compaction - ferrocalcite poikilitic cementation - micropore diagenetic facies(R-F-W); D. Medium compaction - authigenic quartz + kaolinite - dissolved pore diagenetic facies(Z-SG-R); E. Medium compaction - authigenic quartz + illite + kaolinite - intergranular pore - dissolved pore diagenetic facies(Z-SYG-L-R); F. Medium compaction - authigenic quartz + authigenic illite - intergranular pore - micropore diagenetic facies(Z-SY-L-W); G. Intense compaction-plastic grain deformation - dissolved pore-micropore diagenetic facies(Q-B-R-W). Among them, reservoir physical properties in well areas where type A, B or C is dominant are superior; reservoir physical properties are fair in well areas where D or E is dominant; reservoir physical properties are poor in well areas where F or G is dominant.

In conclusion, distribution of superior reservoir in Chang 8 member, Yanchang formation in study area is controlled by diagenesis routes and diagenetic facies distribution. Type I - superior reservoir mainly distributes in A, B, C diagenetic facies, which is the advantageous objects of rolling extension development.

Key words: Huanjiang oilfield; ultra-low permeability reservoir; diagenesis; diagenetic facies

Preliminary Study on the Early Cambrian Abnormal Sediments, Northwestern Zhejiang, Lower Yangtze

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The northwestern Zhejiang area is located at the junction of Yangtze Plate and Southern China Tectonic Belt, which is the southeastern part of the early Paleozoic Zhejiang-Anhui marine basin. The Palaeozoic strata is relatively complete and well-studied, among which the Duibian section of Jiangshan is a GSSP of International Cambrian Jiangshan Stage, and the Huangnitang section of Changshan is a GSSP of national Ordovician Darriwilian Stage.

Fossils are very rare in the Dachenling Formation of the Lower Cambrian. There are only a few fossils including floating and nektonic Arthricocephalus, Arthricocephalites and Changaspis in the middle to upper interval (about 0.5m thick) of the Dachenling Formation, but without benthic fossils. Thus, Dachenling Formation is interpreted as deep-water sediment. However, multiple bird's-eye structures typical of shallow-carbonate platform are found in Dachenling Formation, making interpretation difficult. Our field investigation shows that there is a suit of seismic-tsunami deposits within the Dachenling Formation of the Lower Cambrian. The layer recording tsunami deposits is 0.54m thick, discontinuous with regards to the lower dolomitic limestone, and conformably overlain by other strata. In the tsunami sediment, there are multiple laminated structures with irregular cyclicity, which become thin at the top and thick at the bottom. And there are discontinuous layer of abnormal mud clasts. Therefore, the tsunami interval is different from the overlying and the lower sedimentary horizons. In addition, the interval including tsunami deposits includes deep-water fossils and shows a carbon isotope positive excursion.

Deposits from various environments can be mixed together by tsunami events, which would result in abnormal sedimentary rocks. Thus, abnormal sediments within the Dachenling Formation of Lower Cambrian in Western Zhejiang could be interpreted as a signature of tsunami events. The fossils and sediments of the deep-water zone were brought into the shallow-water zone and then deposited by the tsunami events, which also resulted in a brief, sharp positive excursion of carbon and oxygen isotope curves of the coeval sediments.

Key Words: Abnormal Sediments; the early Cambrian; Dachenling Formation; lower Yangtze

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Discovery of a New Karst Model and its Formation Mechanism – Karst Model with the Missing of Vertical Vadose Belts

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After studies of several Sinian field outcrops in Kalpin-Aksu region of Tarim basin, it has been established that the Upper Sinian had been exposed to atmospheric fresh water leaching for a significant period of time. The rock types of the karst zone are mainly karst breccia dolostone, alga-clotted dolostone and algal-laminated dolostone. On the basis of karst model of Loucks and karst facies identification marks summarized by previous workers, horizontal phreatic belts and deep sluggish flow belts can be easily identified in the outcrops according to characteristics of karst fracture-caves and the fillings. They all lack of vertical vadose features, consistent with karstification revealed by wells drilled to Sinian in Tarim basin. The questions therefore arise as to what kind of karst model is it and what were the conditions leading to its formation? Furthermore, what information will it provide for oil and gas exploration and development? To answer these questions, we have propose new special karst model for Upper Sinian, and conclude that it is mainly controlled by rock types, topography, lithofacies paleogeography, fluctuation of sea level, duration of exposure and paleoclimate. Favorable reservoirs are widely developed in regions from the unconformity surface to the lowest water table and are generally of high quality, leading to a profitable zone for exploration. Therefore, we expect this karst model can fill areas of uncertainty in study of karst and as well provide a new research for oil and gas exploration and development in carbonates.

Multiple developing stages of microbialites during the Early Triassic and implications for biotic recovery following the end-Permian biocrisis

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There were at least 4 stages of microbialites in Early Triassic strata. These microbialites appeared in the normal shallow marine environments from the end Permian to the middle Triassic. And the time interval coincided with the end Permian mass extinction to Early Triassic recovery. The types of microbialites include stromatolites and thrombolites, with oolites at the end Permian. However, only stromatolites and few thrombolites appeared in the upper Early Triassic. The distributions of microbialites also shrank during the bio-recovery. The microbialites of the end Permian contain abundant benthic shelly organisms, including foraminifera, microconchids, ostracods, microgastropods, crinoids and bivalves, and some calcified cyanobacteria also occur. Sponges began to appear in the upper Early Triassic in the microbialites. This change indicates the recovery of the reef and also the organisms recover from the end Permian mass extinction. The distributions, types and organisms composition of microbialites from end Permian to early Triassic recorded the shallow marine ecosystems changes and have implications for the bio-recovery.

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The effect of leaching action of meteoric fresh water for secondary pore in clastic rock reservoir

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Because of the importance of secondary pores in clastic rock reservoir, mechanisms of secondary pores in aluminum silicate have been researched. Due to their strong reformation in late diagenesis and thus the loss of evidences, secondary pores formed by leaching action of meteoric fresh water in unstable mineral were not commonly used in reservoir predictions. Through case studies and experimental simulations of water-rock interaction, this paper analyzed the leaching action of meteoric fresh water between aluminum silicate and secondary pores at early diagenetic stage in clastic rock reservoir.

The Cretaceous marine sandstone from Utah, based on the degree of dissolution and cementation, can be classified into two types - the bleached sandstone and the red brown sandstone containing ankerite. The distribution of bleached sandstone is regulated by the presence of coal seams the sandstone is only appearing in the foreshore and shore-face sandstones which are under the coal seam. This obvious regularity indicated that doloclast and feldspar dissolution are related to the existence of meteoric fresh water containing humic acid (HA).

The water-rock interaction experiment simulated the thermostatic reaction between sand-containing lake sediments and lake water at room temperature. The method of Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES) determines the anion-cation content in different water samples. The experimental results revealed that almost all of the cation concentrations have increased significantly after 30 days. Concentration of Si increased from 1.642 µg/g to 8.856 µg/g, while the concentration of Al increased from 0.025 µg/g to 0.208 µg/g. At pH<9, the solubility of SiO₂ was 125mg/L, indicating that SiO₂ in lake water was still unsaturated and Si-containing minerals will continue to dissolve. There was a five-fold increase in the concentration of Si and eight-fold increase in Al after 30 days of experiments, indicating that aluminosilicate minerals have high solubility and are unsaturated in fresh water. As such, meteoric fresh water is an important medium for dissolving aluminum silicate, which subsequently produces secondary pores.

These case studies and experimental simulations indicated that unstable minerals, such as aluminum silicate, are unsaturated in meteoric fresh water in the near-surface. In open diagenetic system, reaction products can be washed away continuously by medium, making secondary pores formation extremely easy due to leaching action.

Key Words : Leaching action, meteoric fresh water, aluminum silicate, secondary pores

Hyperpycnal Flow Deposits in the Late Triassic Lacustrine Ordos Basin, China

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Subaqueous sediment density flows are one of the most important processes for moving sediments from provenance to depositional basins, but they are extremely difficult to monitor directly. A new kind of gravity flow sandstone deposits different from sandy debris flow and slumping turbidity current was discovered in the Yanchang Formation, upper Triassic in the southern part of the deep lacustrine Ordos basin and analyzed based on drillcores and petrography.

Characteristics of the gravity flow deposits dominated by 1) a series of upward coarsening interval (inverse grading) and upward fining interval (normal grading) always exist in pairs; 2) changes of relative high clay content (high – low - high) consistent with that of granularity (fine–coarse–fine) in each size-graded couplet; 3) inner micro-erosion surface sometimes separated a couplet of an upper, upward fining interval and a lower, upward-coarsening interval; 4) sandstone interbedded with dark mudstone and grey siltstone; 5) granularity changes in silty mudstone is similar to that of sandstone. It was considered as flood-generated hyperpycnal flow deposit in the late Triassic deep lacustrine Ordos basin.

The typical deposit of hyperpycnal flow in the Chang 6 and Chang 7 members in the southern part of the deep lacustrine Ordos basin is a compound of a basal coarsening-up unit (deposited during the waxing period of discharge) and a top fining-up unit (formed during the waning period of discharge). Hyperpycnites differ from other turbidites because of their well-developed inversely graded intervals and intrasequence erosional contacts. The lower, upward-coarsening interval represents deposition of waxing hyperpycnal flow. The upper, upward-fining interval was generated from waning hyperpycnal flow. The two parts of the size-graded couplet of upward-coarsening interval and upward-fining interval in pairs represent a cycle of sedimentary event resulting from a flood-generated hyperpycnal flow. The erosional surface that sometimes consists of two parts of the size-graded couplet resulted from waxing flows of sufficiently high velocity to erode the sediment previously deposited by the same flow. Some bed forms and sediment grading patterns in hyperpycnal- flow deposits can record multiple flow acceleration and deceleration even during a simple single-peaked flood.

Hyperpycnites might preserve important records across a variety of climatic and tectonic settings because hyperpycnal flow provides one of the most direct connections between terrestrial sediment sources and lacustrine depositional basin. The basin also must be deep enough, in some cases greater than tens of meters, in order to form turbidity current. As a result, factors favoring hyperpycnal flow include seasonal flood river, deep angle depositional slope, important water depth and large density difference between basinal water mass and discharged flood river. The discovery of hyperpycnite in Yanchang formation in the Ordos basin cannot only provide an example to document hyperpycnal flow deposits in continental lacustrine environment, but also has theoretical and realistic significances to study the genesis of deep water sandbodies, reservoir forecasting and oil-gas exploration.

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Sedimentary and structural hosted gas hydrate in shallow sediments in the Shenhu survey, northern continental slope of the South China Sea

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Gas hydrates are crystalline solids formed of water molecules, with gas, commonly methane, encaged in a crystal lattice. They appear similar to ice. Gas hydrates form when pore fluids are saturated with respect to methane and appropriate low temperature and high pressure conditions are present, commonly within sediments below the seafloor at water depths exceeding, 500 m. Bottom simulating reflections (BSRs), reflections that are sub-parallel to the seafloor and that are mostly associated with free gas beneath the base of gas hydrate stability zone, are probably the most common indicators for marine gas hydrates. At the Shenhu Survey offshore South China Sea, prominent BSRs indicate the presence of gas hydrates.

A set of integrative geophysical identify symbol, which were found at the Shenhu survey during previous studies, including BSRs and blank zones, also indicate the presence of gas hydrate at this area. In addition, plumes and pockmarks associated with gas seeps have also been documented. However, the migration of methane through the gas hydrate stability zone is not yet well understood. There are indications that free gas migrates along faults at the Shenhu area northwest and northeast of the Shenhu survey, but this is not yet well constrained.

In April to June 2007, China Geological Survey and the Ministry of Land and Resources of P. R. China carried out the first gas hydrate drilling expedition in the Shenhu area, northern slope of the SCS, and collected gas hydrate samples here. Drilling results reported that eight boreholes were drilled and gas hydrate was revealed in core samples at Sites SH2, SH3 and SH7. The gas hydrate saturation is calculated from the porewater freshening and its max is up to 48% (v/v) at SH2. The hydrate-bearing sediment zone is located within 10-25 meters above the BSR. On the contrary, there was no gas hydrate at SH5 site, even if all typical geophysical evidences had been recognized here.

Investigators considered that high temperature, caused by high heat fluid at SH5, led gas hydrate dissociate at all. In this study, two drilling site, SH2 and SH5, were selected to calculated depth of base of gas hydrate stability zone. Results showed that there was only small deviation at SH2. It was suggested that the formula was suitable for this area. Then numerical simulation, based on the formula, was applied to calculate that if there was any chance to dissociate all gas hydrate at SH5. The result showed that if the situation mentioned above was true, the temperature here had to be increased by 12 °C. In other words, base of gas hydrate stability zone coincidence with seafloor. That was impossible. Then another sedimentary hosted model was suggested. There were no suitable sediments, because of low porosity, for gas hydrate formation in gas hydrate stability zone. Furthermore, faults system, which reached seafloor, became escape path of free gas (mainly methane).

The Guangzhou Marine Geological Survey provided seismic data. This study was financially supported by the National High Technology Research and Development Program of China (863 Program) (No. 2013AA0925010202), the National Natural Science Foundation of China (No.41206047, 41202080, U0933004, 41376062), the PetroChina Innovation Foundation (No. 2013D-5006-0105), and the Key Research Program of the Chinese Academy of Sciences (KGZD-EW-301).

Sedimentary Characteristics and Depositional Models of Deep-Water Sandstones in Continental Rift Basin with Example of Jiyang Depression, East China

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The function of depositional model is to forecast reservoirs effectively, thus to guide the exploration and development of oil and gas. Because continental basin quite differs from marine basin, it is doubtful to apply the deep-water depositional model in marine basins to continental basins. To solve this question, this study focused on the Paleogene subaqueous sedimentary gravity flows in the Jiyang depression in East China. There are fluid (subaqueous sedimentary gravity flows) and solid mode of transport for subaqueous gravity-driven sedimentary. Based on the distinction of subaqueous sedimentary gravity flows interpreted from the features preserved in the deposits, subaqueous sedimentary gravity flows are divided into: mud debris flows, sandy debris flows, surge-like turbidity currents and quasi-steady hyperpycnal turbidity currents. Solid mode of transport for subaqueous gravity-driven sedimentary mainly include slides and slumps. Gravity flow event can be classified on the basis of depositional compositions of subaqueous sedimentary gravity flows and solid mode of transport for subaqueous gravity-driven deposits into two classes: flood gravity flow event and sediment failure gravity flow event. Flood gravity flow event contain mud debris flows, sandy debris flows and hyperpycnal turbidity currents deposits. While sediment failure gravity flow event contain slides, slumps, sandy debris flows and surge-like turbidity currents deposits. After investigate the genetic mechanisms, sedimentary character, distribution of gravity flow event deposits, sediment failure gravity flow event can be divided into sediment failure triggered by rapid progradation in front of delta and sediment failure triggered by activity of synsedimentary fault, flood gravity flow event can be divided into flood derived from stability inland rivers and flood derived from short-term mountain rivers. Three subdivisions of flood gravity flow derived from short-term mountain rivers based on sedimentary features and gradient are low gradient, moderate gradient and high gradient ones. According to the classification of gravity flow events, depositional models of the gravity flow events in continental rift basin can be classified into 6 classes with combination of the tectonic setting, sedimentary features, sequence features and distribution characteristics. Different kinds of depositional models have particular significance for deep-water oil and gas exploration in continental rift basin.

Synchronous time-stratigraphic units in a nonmarine rift setting – an example from Mid-Permian Lower Quanzijie low-order cycle, Bogda Mountains, NW China

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Fluvial valley fills record ancient conditions in the Earth's surface. However, complexities intrinsic to continental strata hamper time-stratigraphic correlation and accurate environmental and paleogeographic reconstructions. Our study of seven stratigraphic sections of Permian Hongyanchi, and lower and upper Quanzijie low-order cycles in the Tarlong-Taodonggou half-graben and Dalongkou area in Bogda Mountains, NW China, highlights the complex origin and forming mechanisms of low-order cycle boundaries. The lower and upper boundaries of the lower Quanzijie low-order cycle consist of a regionally correlative disconformity, erosional unconformity, and conformity which bound the cycle as a synchronous time-stratigraphic unit. They were identified on the basis of significant and abrupt changes in paleoenvironments and tectonic and climatic conditions, which were interpreted through detailed sedimentological and stratigraphic analysis in a cyclostratigraphic context. The lower boundary is an erosional unconformity and disconformity with a highly variable topography that juxtapose lacustrine deposits of the underlying Hongyanchi low-order cycle with overlying meandering stream deposits, and were caused by a regional tectonic uplift. The upper boundary is a disconformity and local erosional unconformity and conformity, juxtaposing stacked paleosols developed on fluvial sediments with overlying fluvial and loessial deposits of the upper Quanzijie low-order cycle. The paleosols indicate fluvial peneplanation, landscape stability, and a prolonged period of subaerial exposure and minimal deposition and suggest that climatic condition was semi-arid with strong precipitation seasonality in the Tarlong-Taodonggou area and subhumid in Dalongkou area. The fluvial-loessial deposits indicate a renewed tectonic uplift and a change in the atmospheric circulation pattern. The newly-defined lower Quanzijie low-order cycle facilitates accurate paleogeographic reconstruction in the study area. The interpreted tectonic and climatic conditions provide a critical data point in the mid-latitude east coast of NE Pangea during the mid-Permian icehouse-hothouse transition. The results demonstrate that a process-response approach is effective in time-stratigraphic analysis of complex fluvial-lacustrine strata in a highly-partitioned rift basin.

Origin and Reservoir Characteristics of Lower Permian Dolomite in Northwestern Sichuan Basin of Central China — A Case for Hydrothermal Dolomitization

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In northwestern Sichuan basin near Longmen Mountain, it develops widespread medium-macro-crystalline dolomite in lower Permian carbonate. Constraints were placed on the conditions of water-rock interaction using fluid-inclusion methods, cathodoluminescence and plane-light petrography, stable isotopic analyses, and maturity data. It is considered that the medium-macro-crystalline dolomite is formed with limestone replaced by hydrothermal fluid. The origin evidences of hydrothermal dolomitization include four aspects. ①The medium-macro-crystalline dolomites contain lots of two-phase aqueous fluid inclusions and gas-liquid hydrocarbon fluid inclusions. Homogenization temperatures of two-phase aqueous fluid inclusions in dolomite and quartz rang between 100⁰C and 180⁰C. Homogenization temperatures of fluid inclusions in saddle-dolomite are normally higher than 150⁰C ②The salinity of bi-phase fluid inclusions of macro-crystalline dolomite is the twice times of normal sea water. They normally rang between 10 and 20wt% NaCL equivalent. It shows that diagenetic fluid of dolomitization has high salinity. ③The value of oxygen isotope of medium-macro-crystalline dolomite is low. They are often less than -7‰.The value of oxygen isotope in some saddle-dolomite is even lower than -15‰. ④The value of Sr isotope of medium-macro-crystalline dolomite is same to the value of mantle-derived rock. It is suggested that dolomitization fluid comes from deep thermal water.

Inter-crystalline pores of medium-macro-crystalline dolomite were filled by the asphalt. With the bury history of typical formation, homogenization temperature of fluid inclusions and evolution history of the source rock, it is considered that medium-macro-crystalline dolomite formed prior to the early Jurassic. Moreover the thickness of dolomite horizontally changes quickly, and the dolomite normally distributes along the deep faults and volcanic rock areas.

Diagenesis of the reservoir in Longwangmiao Formation, Lower Cambrian in Sichuan basin

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The Sichuan Basin in southwest China is petroliferous and predominant in gas bearing at present, with the production and cumulative proven gas reserve being about $1.8 \times 10^{10} \text{ m}^3$ and $2.0 \times 10^{12} \text{ m}^3$, respectively, by 2009. Cambrian is the most potential petroleum system in Sichuan Basin. In the bottom of Lower Cambrian, the source rock developed well, and its prospective resource occupies the first place in the Lower Paleozoic. In Mid-Upper Cambrian, thousands meters of carbonate rocks developed, in which some good reservoirs formed. Upper Cambrian Xixiangchi Formation in Ziyang and Weiyuan area has obtained some oil and gas shows. Petroleum exploration in Lower Cambrian Longwangmiao Formation has not achieved a breakthrough so that the related research is basically in the blank. However, with a significant gas exploration breakthrough of Longwangmiao Formation in central Sichuan Basin, especially in Moxi area, Moxi Longwangmiao gas field has become the biggest gas field found in China. Longwangmiao Formation becomes a new important hydrocarbon reservoir and it shows great exploration potential.

Reservoir of Longwangmiao Formation is well developed which are mainly composed of dolarenite and fine crystalline dolostone. The main reservoir spaces include dissolved intergranular pores, dissolved intercrystal pores as well as vugs. The reservoir quality is of medium porosity and low permeability, with the porosity locates between 2% to 6%, and the permeability ranges from 0.001 to 0.1md. Combined with the routine physical property analyses, this paper studied diagenesis of the reservoir, especially the shoal reservoir, by means of cores and thin sections observations, SEM and cathodoluminescence emission analysis.

According to the division of diagenetic stages in carbonate rocks in China (2003), it indicates in this paper that the reservoir of Longwangmiao Formation experienced five diagenetic stages, including syngenetic stage, early diagenetic stage, epigenetic stage, middle diagenetic stage and late diagenetic stage (Fig.1).

Syngenetic stage: After the deposition, sediments under the sea water had experienced marine diagenetic process. Micritization, dolomitization, submarine cementation and selective dissolution have been described in detail from cores in Moxi area. The productions of marine diagenesis exert a fundamental control on reservoir properties.

Early diagenetic stage: With gradual accumulation of the overlying strata, formation entered into shallow burial. Compaction was the main diagenetic alteration in this stage, which occupied most of primary pores. Meanwhile, residual primary pores were filled in powder- fine crystalline dolostone, with pores disappeared further.

Epigenetic stage: Affected by the tectonic movement during the Caledonian, the whole Sichuan basin lasted uplifting. Due to the exposure and the erosion of upper strata, the Longwangmiao Formation suffered a supergene karstification related to the meteoric fresh water for a long time. A small amount of karrens and caves filled with the mud, pyrites and breccias were formed.

Middle diagenetic stage: Longwangmiao Formation entered into the continuing burial stage after Dongwu movement. Recrystallization occurred in the Longwangmiao Formation, especially in the dolarenite. Many crystalline dolostone with residual grain texture formed, and some intercrystalline pores can developed during the dolarenite transformed into crystalline dolostone. At the same time, the organism of source rock matured. In this period, fluid contained abundant organic acid, CO₂, and other corrosive components were released from the source rock, lots of dissolved pores, vugs and fissures formed when dissolution fluid got through the strata. This kind of dissolved pores was filled with the liquid hydrocarbon after they formed.

Late diagenetic stage: In deep burial, when liquid hydrocarbon splitted, abundant acidic fluid with organic acid, CO₂, H₂S, CH₄ and other component was released, pores and vugs generated in the early dissolution were enhanced consequently. In this process, many dissolved pores formed while the pores early filled with liquid hydrocarbon just remained some asphalt. Meanwhile, the pores formed as the result of the late burial dissolution were very clean almost with nothing filled in.

Diagenetic alterations have significant meanings to the development of reservoir in Longwangmiao Formation in Sichuan basin, especially kinds of dissolution play important roles in the generation of dissolved vugs and pores in dolarenite and crystalline dolostone.

Keywords: Reservoir; Diagenesis; Diagenetic stage; Longwangmiao Formation; Sichuan basin

Dolomitization genetic model of Longwangmiao Formation in Early Cambrian, central Sichuan basin

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The Sichuan Basin in southwest China is petroliferous and predominant in gas bearing at present, with the production and cumulative proven gas reserve being about $1.8 \times 10^{10} \text{ m}^3$ and $2.0 \times 10^{12} \text{ m}^3$, respectively, as of 2009. Cambrian is the most potential petroleum system in Sichuan Basin. Source rocks developed at the bottom of Lower Cambrian successions, where they are the most important in the Lower Paleozoic. In Mid-Upper Cambrian successions several thousands meters thick exhibit some good reservoirs. The Upper Cambrian Xixiangchi Formation in Ziyang and Weiyuan area has obtained some oil and gas reservoirs. Petroleum exploration in Lower Cambrian Longwangmiao Formation has not been conclusive yet, so that the related research is basically at the beginning. However, with a significant gas exploration breakthrough of Longwangmiao Formation in central Sichuan Basin, especially in Moxi area, Moxi Longwangmiao gas field has become the biggest gas field found in China. Since then, the Longwangmiao Formation gained importance in term of hydrocarbon reservoir with significant exploration potential.

Reservoir rocks of Longwangmiao Formation are mainly composed of dolarenite and crystalline dolostone with residual granular structure. The main reservoir spaces include dissolved intergranular pores, dissolved intercrystal pores as well as vugs. The reservoir quality is of medium porosity and low permeability, with porosity ranging from 2% to 6%, and the permeability ranges from 0.001 to 0.1md. Although the dolomite reservoir in the Longwangmiao Formation is well developed, the genesis of the wide distributed dolomite is not elucidated yet.

This paper studied the characteristics of different dolomites by means of cores and thin sections observations, cathodoluminescence and geochemistry. It shows that the dolarenite and crystalline dolomite has $\delta^{18}\text{O}$ values either similar to, or slightly higher than that of Early Cambrian marine dolomite, and $\delta^{13}\text{C}$ values which overlap these of seawater. The ubiquitous presence of dolomites and the absence of the massive evaporitic minerals or evaporate solution-collapse breccias suggest that the salinity of seawater during the dolomitization was below that of gypsum precipitation. This indicates that dolomitizing fluid was Early Cambrian seawater in a slight restricted evaporitic environment (salinity 72‰-199‰). The dolomitization by the penesaline seawater in Early Cambrian can explain the thick dolomites in the carbonate platform in the absence of evaporate precipitation. A dolomitization model can be established to explain the fluid driving mechanism by the high frequency sea level changes.

Keywords: Dolomitization ; Early Cambrian ; Longwangmiao Formation ; Central Sichuan basin; China

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The Distribution of Terrigenous Organic Matter in Shallow-water Delta in Global Monsoon Setting: A Case Study from North Carnarvon Basin, Australia

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North Carnarvon basin is located south of Northwest Shelf of Australia, having an area of approximately 535 000 km². It is a hydrocarbon-rich basin and occurs continuous subsidence during the late Paleozoic-Cenozoic. Multiple world-class gas fields have been found in this basin. Mungaroo Formation, the main hydrocarbon-bearing strata, consists of thick sediments of shallow-water delta controlled by Circum-Tethys mega-monsoon. The distribution of Terrigenous Organic Matter (TOM) in this kind of delta differentiates from that of other deltas without relationship to mega-monsoon event. Mungaroo delta is a good example to study the characteristics of TOM in the delta controlled by mega-monsoon event.

Under the influence of mega-monsoon, Mungaroo Formation is notable for the followings: 1) well widespread delta plain and narrow delta front and prodelta belts; 2) thick channel sandstone frequently sandwiched with mudstone which is rich in TOM; 3) hygrophytic molecule coexists with xerophytic molecule in sediments.

Based on the analysis of well-to-seismic tie, Mungaroo delta can be divided into four sedimentary sub-facies: proximal delta plain, distal delta plain, delta front and prodelta. Using integrated analysis of geochemistry and organic petrology of source-rocks and palynological assemblage types, the source rocks of Mungaroo Formation are found to be rich in TOM content. The average organic carbon can be up to 2.2%. Inertinite in the organic macerals is generally high with an average content of 48%, while vitrinite is generally low, having an average content of only 38%. The ratio of vitrinite and inertinite of the samples up to 72% is less than 1, and the ratio of vitrinite and inertinite of all samples are less than 3. Peat swamp suffered erosion and caused dispersion of organic matter, while thin coal seam could be developed in the distal delta plain. In addition, organic matter distribution in four sedimentary sub-facies has distinct differences: 1) for the proximal delta plain, sandy conglomerate rocks developed with intercalations of thin layers of mudstone. The average organic-carbon content is 1.17% and the main maceral in the mudstone is inertinite as most of the vitrinite suffered oxidation; 2) peat swamp, characterized by multiple thin coal seams, is well developed in distal delta plain. The mudstone is rich in TOM that average organic-carbon content can be up to 2.73%. The vitrinite in distal delta plain is higher than that in proximal delta plain and prodelta; 3) the content of TOM in mudstone is low within small-scale delta front and prodelta sub-facies belts. The average organic-carbon content is 1.31% and the content of exinite is higher than that of dinoflagellates. In general, the organic-carbon content gradually decreases from distal plain delta to proximal plain delta (landward) and delta front and prodelta (basinward).

Both Monsoon floods and storm currents have an important effect on the distribution of TOM. TOM in the proximal delta plain is easily destroyed and oxidized by strong floods, whereas TOM in the delta front-prodelta is diluted and dispersed by waves and currents. However, the TOM in the distal delta plain could be saved with weaker influence of monsoon floods, waves, and currents. Proposed TOM dispersal patterns should serve as a useful reference for potential reservoir and source rocks in similar deltas around the world.

Key words: Terrigenous organic matter; Global monsoon; Mungaroo Delta; North Carnarvon Basin.

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Reservoir characterization of lacustrine carbonate rocks around Sikou sag in Bohai Bay basin, East China

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Lacustrine carbonates are potential unconventional reservoirs that have not received the attention given to their marine counterparts. Lacustrine carbonate rocks of the Paleogene Shahejie Formation in the Sikou Sag, Bohai Basin, China were systematically studied using whole-core facies analysis, 3-d seismic profiles wireline logs, thin section petrography and, geochemical data.

The results show that the upper Es4 interval of the Shahejie Formation in the Sikou Sag contains a lacustrine depositional sequence with lowstand, transgressive, and highstand facies. These lacustrine carbonates are mainly associated with the transgressive phase. Lowstand and transgressive facies developed in the vicinity of the Shaojia gentle slope and the Yidong fault zone, and in both areas lowstand deposits gradually thin to the edge of sag. Three lacustrine carbonate facies, reef, shoal and salt lake, were recognized in core and associated with specific tectonic settings. Reef facies are associated with the Yidong fault zone. The Shaojia gentle slope zone is dominated by shoal deposition that is divided into a nearshore low-energy and an offshore high-energy shoal. Salt-lake evaporite facies occurred near the center of the Sikou sag.

Porosity is classified into four categories: depositional, fabric-selective, non-fabric selective, and fracture. Diagenetic processes improving reservoir quality include dissolution, dolomitization and fracture development. Reservoir quality was decreased by cementation and compaction. The mostly high quality reservoirs are distributed in dolomitized framestones and grainstones, deposited in the reef and shoal facies of shallow lakes, a high quality reservoir zone also occurs high in the section beneath an unconformity.

Variations in reservoir quality in the Sikou depression are the result of a combination of favorable lithofacies, various dissolution, and tectonics. The favorable lithofacies controlled primary porosities. Restricted depositional facies and high-frequency cyclic depositional architecture caused lateral and vertical reservoir heterogeneity. Various dissolutions influenced secondary porosities and caused occlusion of some porosity. Tectonics resulted in fracturing and regional palaeokarst.

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Tidally-induced cohesive sediment resuspension and transport within the bottom boundary layer in the western South Yellow Sea

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An in-depth understanding of cohesive sediment resuspension and transport processes in shallow marine environments is of great importance in coastal geomorphology, ecology, engineering, and harbor and fishery management. To determine resuspension events and sediment transport processes for cohesive sediment in a tidally dominated environment, we measured near-bed current velocity and suspended sediment concentration (SSC) over two semidiurnal tidal cycles at two observation sites in the southwestern Yellow Sea, China, using a bottom-mounted tripod equipped with acoustic Doppler velocimeter (ADV), conductivity-temperature-depth profiler (RBR) and a shipboard acoustic Doppler current profiler (ADCP), and subsequently estimated tidal-induced bed shear stress, suspended sediment flux and erosion and deposition flux. The near-bed SSC could be decomposed into deposition, resuspension and advection processes by means of harmonic analysis. This result showed that SSC variations were dominated by the local resuspension processes during the entire tidal cycles since it contributed mostly to the total SSC. Further, a significant relationship was present between the near-bed SSC and bed shear stress, which indicated the resuspension domination. At the two observation sites, the critical shear stresses for erosion (when resuspension events occurred) were estimated to be 0.11 and 0.13 N m⁻², whereas the values were 0.18 and 0.16 N m⁻² based on the determination of Shield's threshold curve. The erosion/deposition flux have the same magnitude of 10⁻⁴ kg m⁻²s⁻¹, however, the erosion process was dominated over the entire tidal cycles.

The current data suggested that the tidal current of B4 station is a typical reversing current whereas the current of D1 station presented obvious characteristics of rotating flow. The near-bed currents and SSC are combined to reveal the suspended sediment transport. The temporal variability of suspended sediment transport rate has the similar trend with the current velocity and SSC. The suspended sediment transport is dominated by the flood period and the net suspended sediment flux with a magnitude of 10⁻² kg m⁻¹. The direction of the net transport during the flood and ebb period was relatively stable and indicates that suspended sediment transports landward and accumulates over the radial sand ridges and tidal flats off the Jiangsu coast, which accelerates the growth of Jiangsu coast and has the effect of maintaining the radial sand ridge system of the southern Yellow Sea.

Key words: cohesive sediment, resuspension, suspended sediment concentration, sediment transport, Yellow Sea

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Environmental records and interdependence between climates and the ancients during the middle–late Yangshao culture age in the Yangguanzhai relic site, Shaanxi Province, China

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Introduction. The Yangguanzhai relic site is the most significant among the 10 archaeological discoveries in China, 2006. Excavation of the relic site and related archaeological investigation has yielded fruitful scientific progresses. Environmental background, an important part for archaeological study of this relic site, however, remains poorly studied. This thesis aims to establish a paleoenvironmental framework of the Yangguanzhai relic site. Our study are based on five sections in the study area—two cultural accumulation layer sections (YGZ-1 and YGZ-2) in the relic site; a natural section located in the first bench terrace of the Jinghe river (YGZ-3; 1 km south to the relic site); and two Holocene section at Weinan (WN section; in eastern Guanzhong) and at Fufeng (FF section; in the western Guanzhong). Our study of climatic and environmental conditions of the relic site area and/or the Guanzhong area are based primarily on systematic analyses of particle size, magnetic susceptibility, carbon isotope, pollen, and carbon particle. Furthermore, we also conducted a sedimentological analysis and how ancient floods affected the vicissitudes of the site is also discussed in this thesis.

Methods. About 1g of dried samples were placedt in a beaker and 10 ml of 10% hydrogen peroxide (H_2O_2) were added to remove organic material and 10 ml of 10% hydrochloric acid (HCL) were also added to remove any carbonates. Then the sample residues were washed by distilled water. Sample solution were then pretreated with 10 ml of sodium hexametaphosphate ($(NaPO_3)_6$) to facilitate dispersion. The samples were ultrasonically dispersed for 10 min before grain-size measurement, and grain-size grading was determined with a Mastersizer 2000 particle analyzer. Magnetic susceptibility was measure on a mass of 10g of ground sediment with a Bartington MS2 magnetic susceptibility meter(0.47/4.7kHz). ^{14}C dating was determined with Beat Analytic Inc. Results and discussion.

1. The discovery of settlements in the Yangguanzhai relic site is of the most significance. The Yangguanzhai moat is the biggest in the Yangshao culture relic site. It may have served mainly in preventing of flood, beast, and plunderage. Interpretation for the role of flood control is supported by the occurrence of alluvial deposits in the moat. Whereas interpretations of beast and plunderage defense are only speculative.

2. The Yangguanzhai relic site has subjected to at least five flood destructions. The first, the second, and the fourth flood events caused the backfilled of soils dug out during the construction of the moat. The third flooding, which may have been caused by rainstorms, carried a great deal of material (e.g., charcoal, broken pottery, and loess clumps) into the trenches. Loess stacked outside the moat may have been washed away by the fifth floods which also transported abundant charcoal pottery into the trench of the moat.

3. In the early middle Holocene epoch (ca. 8500–5500 a BP), with the increasingly global warming climate, climatic conditions in the Guanzhong area became more optimum and/or warmer. The temperature reached its peak between ca. 6000–5500 a BP, with a maximum of about 2 degrees higher than it is today. The rainfall reached 750–800 mm, being equivalent to that of in the south slope of the Qinling Mountains today. The Guanzhong area—located in the arid areas of northwest China—began to become wet and thus more suitable for hunting, farming, and living. Subsequently, populations in the Guanzhong area increased rapidly and human habitation expanded greatly. Co-occurrence of massive settlement sites and moat in the Yangguanzhai relic site represents the development of the relic site to be a city. At the same time, the Miaodigou culture appeared.

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Keywords: ancient flood, ancient climate, Yangguanzhai relic site, Holocene

Simulation of tidal flat sedimentation in response to typhoon-induced storm surges: a case study from the Rudong Coast, Jiangsu, China

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Modelling of the spatial distribution patterns of tidal flat accretion/erosion, under both fair weather and storm surge conditions is applied to the Rudong Coast, Jiangsu Province, which is exposed to frequent typhoon attack, and illustrates the sediment dynamic processes and the modification of normal tide-dominated sedimentary sequences by storm surges. The model consists of four parts that deal with the current speed and near-bed shear stress due to tides or combined tide-typhoon effects, suspended sediment transport and vertical (settling and erosion) fluxes, bedload transport and accretion/erosion, and morphological evolution of the bed.

Driven by the tidal water-level curve based on harmonic analysis of data from the study area, the model output reproduces the zonation pattern of intertidal flat sedimentation under the fair weather conditions. Furthermore, its prediction about the tidal flat cross-shore profile associated with a small bed slope, strong tidal currents and a weak time-velocity asymmetry, which is characterized by a “double convexity” shape, is consistent with the observed shape for the study area. According to the model output, the two convexities are located in the vicinity of mean high water and mean low water. Subsequently, the model was run taking into account both tides and storm surges. For a storm surge coinciding with astronomical spring tide, which occurred in 1981 (Typhoon No. 8114), the model predicts that the bed is subjected to mud accretion in the supratidal zone and the upper part of the intertidal zone, while sand erosion occurs in the lower-middle parts of the intertidal zone. Thus, an erosion surface is formed within the sedimentary sequence, representing the storm effect. This pattern is consistent with the *in-situ* observations made following the typhoon event. The model output implies that a storm-influenced sedimentary record can be found in the upper parts of the tidal flat. The results presented here are preliminary: a number of detailed morphological parameters of storm deposits are not available in the model output.

In the future, the model may be further improved by taking into account factors such as the boundary characteristics under extreme shallow water conditions, variability of grain size distribution, combined tidal currents and waves, biological activity, tidal creek migration and land reclamation. In combination with inverse methods, the forward modelling will be beneficial for a better interpretation of the formation of tidal flat sedimentary records.

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The Sedimentary Characteristics and Genetic Model of Lacustrine Platform Argillaceous Dolomite in Tanggu oil field, Bohai Bay Basin, East China

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Lacustrine argillaceous dolomite has been successively found in many different age formations deposited in continental basins in China since 1970s. For example, the lacustrine dolomites deposited in the Paleogene (Bohai Bay Basin, Subei Basin, Qaidam Basin, Nanxiang Basin), Cretaceous (Songliao Basin, Jiuquan basin, Erlian Basin), the Jurassic (Sichuan Basin), and the Permian (Junggar Basin, Santanghu Basin). The oil and gas shows, even industrial flows, have been discovered in lots of lacustrine argillaceous dolomites, which belong to the unconventional tight reservoirs.

In 2011, lacustrine argillaceous dolomite with thickness more than 100 meters was discovered in member Sha3⁵ of Paleogene Shahejie Formation in Tanggu Oilfield, Bohai Bay Basin. In the beginning, the oil yield was up to 99.7 tons/day from one well, indicating a promising oil play. This argillaceous dolomite was rich of analcime and sandy particles, and was named analcime-argillaceous dolomite. Cores, lithology and well logging data were used to analyze sedimentary cycle of member Sha3⁵ of Shahejie Formation. We have identified 5 short-term cycles and 14 lithofacies in this area. The vertical variation of micro-lithofacies reflected a sedimentary cycle changing from relatively shallow water to deep water.

Element geochemistry, micropalaeontology and organic matter analysis were also implemented in well T12C which has most complete coring. Changes in composition and percentages of the ancient vegetation pollen reflected warm subtropical climate. Paleosalinity was brackish in terms of paleontological and trace element analysis. $V/(V+Ni)$ implied the change of water environment from lean oxygen to anaerobism. X-ray diffraction analysis found the high concentration of analcime, indicating the alkaline nature of the lake. The semi-deep to deep lacustrine environments was revealed based on the facts: 1) interbedding of dolomite and dark mudstone; 2) the lack of marks of shallow water and benthic ichnofossils; 3) development of rhythmic beds of dark mud and gray dolomite; and 4) Type I-II₁ sapropel based organic matter. The REY distribution patterns and total amount of REE were very similar for dolomite and mudstone. The Y/Ho also indicated entrance of exogenous mud.

By seismic sedimentology tracking, multi-well lithology identification and isopach map, the distribution area of argillaceous dolomite was controlled by ancient underwater fault-uplift. The reconstruction of the strata denudation thickness indicated that the maximum thickness of dolomite was about 35m, mainly deposited in layer 2-2 and 3-1. Dolomite, argillaceous dolomite, dolomitic mudstone and mudstone microfacies showed a ring shaped distribution from the center to the outside. Due to tectonic deformation and erosion, however, dolomite mainly developed on both sides of the uplift with two thick areas: well T39-5C area and well T29-26C area.

The comprehensive analysis of cores, well logs, mud logs, geochemistry, and seismic data helps to construct the sedimentary cycle and sequence stratigraphy for member Sha3⁵ and determine spatial distribution characteristics and sedimentary system evolution of dolomite. Therefore, we finally established the genetic model of lacustrine argillaceous dolomite, which is semi-deep lake uplift platform dolomite model.

Keywords: Tanggu oil field; Shahejie Formation; lacustrine argillaceous dolomite; deep-lake platform model

Depositional Characteristics and Evolutionary Model of a Cretaceous Incised Valley in the Chepaizi Area, Junggar Basin

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As a special component of a depositional system, the evolution, erosion and filling patterns of incised valley have a great significance for sequence stratigraphic studies and oil-gas exploration. Incised valleys were discovered in the subsurface of the Chepaizi area, Junggar Basin through a combination of 3D seismic data, drilling data and paleontological data. The form of these valleys was mapped and the depositional characteristics and evolutionary model for the valleys described. As defined by coherence slice, the results revealed a series of incised valleys in the study area, which had three different orientations including E-W, S-E and E-S.

E-W oriented incised valleys are mainly located in the northeastern part of the study area. The main channel was easily recognized when compared to the less developed tributaries. S-E oriented incised valleys have well-developed tributaries that extend for a very long distance and have a wide distribution range. An N-S oriented incised valley is a single valley that is located to the south of study area. It shows that the number of tributaries was less and the extension of them was short. The morphology of the incised valleys on the seismic profile portrayed a V-shape. The internal geometries of the fill include progradational, divergent and on lap configurations. Research was also carried out on the sedimentology of the internal valley-fills. The lithofacies of these valley-fills is comprised of two units that include a unit of fluvial valley-fill deposits with gravel and coarse sand (which are relatively thicken) and a unit of fine-grained sediment or mudstones deposited on a flood plain. The valley-filling took place during a stage of relative lake-level rise. Relative changes in the ancient shoreline position resulted in a constant onlap direction towards the northwest. The ancient shoreline first reached the top surface of the incised valleys in the northern part of the basin. This was followed by a gradual transition to south and as such, the basin filled in a clockwise direction.

Regional geological data indicates that during the Hercynian-Indosinian movement, intense uplift of the basement and the rapid lowering of base level in the Chepaizi area led to the incision of the underlying strata, resulting in the formation of the incised valleys. The base level rise from the end of the Jurassic time caused the incised valleys to fill up. These results indicate that the evolution of the incised valley was controlled by base level change, climate, palaeogeomorphology and provenance supply. Base-level change is the background of the evolutionary model, the palaeogeomorphology determined the external form of incised valley, while the internal depositional characteristics of incised valley are clearly affected by climate and provenance supply. These incised valleys play an important role in hydrocarbon exploration which will offer a main potential for future development in this area.

Sedimentary environments and marine redox changes during deposition of Early Cambrian organic-rich sediments in the Yangtze Block, South China

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Organic-rich sediments are widespread in Lower Cambrian carbonate-platform as well as deep-basin deposits of the Yangtze Block. To reconstruct paleoenvironmental and oceanic redox conditions that had influenced the accumulation and preservation of organic carbon in these sediments, sedimentological and geochemical investigations were performed in two sections (Bahuang outcrop and Daotuo ZK102 drill core) in NE Guizhou and one section (Longbizui outcrop) in NW Hunan, South China. Sedimentological analysis is based on field observations, microscopic analysis and mineralogy. Detail logging i.e., description of lithology, texture, sedimentary structures and fossil content were recorded for all sections. For geochemical analyses, X-ray fluorescence spectrometry (XRF) and inductively coupled plasma mass spectrometer (ICP-MS) were used.

The Lower Cambrian organic-rich strata mainly comprise Niutitang, Bianmachong and Balang formations in ascending order. The Niutitang Formation consists of the basal phosphatic shales and upper black shales of deep shelf origin. The Bianmachong Formation is characterized by black shales intercalated with limestones, deposited in mixed carbonate-fine grained siliciclastic outer shelf. The overlying Balang Formation comprises the black shales and silty shales with siltstone layers deposited in deep shelf to basin environments. The temporal environmental shifts during the Early Cambrian were largely controlled by sea-level fluctuations and, possibly, by tectonic activities to some extent.

To elucidate the oceanic changes, geochemical indicators such as V/Cr, V/(V+Ni), Fe_T/Al and authigenic V enrichments are applied as redox proxies, whereas authigenic Ba, Ni, P/Al, excess SiO₂ and TOC are used as paleoproductivity proxies. The different degrees of enrichment point to vast oceanic changes, which could have significantly controlled the organic production and preservation in sediments. High concentrations of Ba_{aut}, Ni_{aut}, P, excess SiO₂ in Niutitang sediments and their positive correlations with TOC contents imply high primary productivity in ocean surface water during deposition of Niutitang. Meanwhile, elevated concentrations of V_{aut} and Ni_{aut} and high ratios of V/(V+Ni), V/Cr and Fe_T/Al in these sediments indicate a predominance of anoxic bottom waters which led to better preservation of OM in these sediments.

The relatively lower contents of V, Ni and Cr in the lower Bianmachong Formation likely point to more oxic water conditions resulting from enhanced water circulation possibly caused by contour currents, although the primary productivity was persistently high as indicated by high Ba concentrations. In the upper part of this formation, the variable contents of V, Ni, and Cr contents and ratios of V/(V+Ni), V/Cr and Fe_T/Al indicate frequent fluctuations of anoxic and oxic water columns, which reconcile well the sea-level fluctuations indicated by alternations of black shales and limestones.

In the Balang Formation, slightly high V_{aut} contents and V/(V + Ni) agree with the inferred anoxic condition, but V/Cr and Fe_T/Al ratios suggest that anoxic conditions were not as severe as those recorded during deposition of Niutitang Formation. However, the lower concentrations of Ba_{aut}, Ni_{aut} and P/Al imply a decrease in primary production, which may account for the decrease in TOC abundance in Balang Formation.

Heavy Metal distribution in Coastal Sediments of Rizhao -Impact of Coastal Development

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The coastal zone is influenced by both land and sea, with increasing human activities in the last century complicating environmental processes and material exchanges. With the rapid industrialization and economic development in coastal regions and river drainage areas, heavy metals are introduced into the coastal environment through river discharge, oceanic dumping and aeolian processes.

Rizhao coast is located in south Shandong, China, opens to the Yellow Sea with active coastal hydrodynamics, and has experienced rapid coastal economic development (industries, harbors and urbanization) in the last few decades.

Surface sediment samples were collected from both land and offshore region. Heavy metal elements were analyzed in the laboratory to study the element distribution pattern and to define the abnormal areas with high potential pollutant risks. In total, 720 land soil samples and 50 offshore surface samples were collected and analyzed. Elements Cd, Cr, Cu, Ni, Pb and Zn were analyzed with ICP-MS, and As and Hg were analyzed with AFS.

We noticed that the heavy metal occurrence and character are different in the land soil and offshore sediment due to the different sedimentary environment and bio-geochemical processes. Rare previous researches have reported the distribution patterns of heavy metals in the coastal zone with both land soil and sea sediments. This study tried to merge the two datasets together to give a general view of sedimentary environment of the heavy metal elements in the coastal zone system, e.g. the distribution patterns and anomalies to understand the pollutant sources, transportation and sinks.

Heavy metals show similar spatial distribution patterns with two high concentration centers in the south and north of the study area. The south maximum center is close to the river mouth of Xiuzhen River and Lanshan harbor. The Xiuzhen River flows through the south of Rizhao and the local industrial area. The Lanshan harbor is a commercial harbor for coal, ore and chemical materials. The North maximum center is close to the Rizhao city urban center and the Rizhao harbor which are impacted by dense human population, industrial and shipping activities. There are several smaller high concentration areas around the local villages and river estuaries. In the offshore area the heavy metal concentration distribution patterns are closely correlated with surface sediment grain size. High concentration areas are positively correlated with the fine grain size sediment close to the two harbors with low hydrodynamic energy, and in the southwest where fine sediments are transported from the Haizhou Bay in the south.

Heavy metals Zn, Ni, Pb and Hg distribution shows a positive relationship between the land and sea, the source of these heavy metals mainly being industry and domestic sewage introduced into the coastal area and becoming sinks of contamination. The middle part of the study area which is distant from the urban center and harbors are generally low in heavy metals content for both land and sea. Mercury (Hg) shows several high concentration zones around the rivers and estuaries indicating discharge from the rivers to the coast. Arsenic (As) shows a different distribution pattern with high concentration offshore but relatively low concentration onland and in the near-shore area. The distribution pattern shows poor correlation with clay content in the surface sediments. This could be caused by the high input of components in background sedimentation, as reported in previous research in this area. Pb and Cd show high concentration in the southeast offshore area that could be caused by the mineralization of calcium nodules found in the samples.

The experimental simulation of widely spread sandstone of Jurassic Shanxi Formation in Ordos Basin

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Located in the central north China, Ordos is one of the largest sedimentary basin and the most prospective exploration area in China. Now more than 60 million tons of oil and gas is produced per year in this area. And large gas fields have been proved in the Triassic Shanxi and Shihezi Formation in this basin. Though the reservoir is believed formed in delta environment, but it is very different from other big delta systems. The Study on distribution of the sandstone and the gas accumulation indicates an elongate, widely spread but relative isolated sandbodies. And the huge difference in the production among wells also indicated high heterogeneities, especially huge different output in wells in a short space.

In order to get a clear understanding of the depositing process of the widely spread sandstone and predict the sandstone with good properties, experimental simulation in tank were done in Yangtze University. The tank is 16 meters long, 6 meters wide and 0.6 meters high. There is a section which could be descendent in the middle of the tank, which made it possible to simulate the subsidence of the lake. The section is made of 4 pieces of square plains with 2 meters long.

The Similar Scale Rule was followed in the experience. The simulation scale was conversed in accordance with the basin scale, and the initial shape of the basin was also calculated and set. Five provenances distinguished in the basin were grouped into two main directions in the experience. One group including 3 channels representing north provenance was studied detailed. In order to distinguish the differences between the three sedimentary source, sands with different colors were used in the simulation. 3 velocity of water were used to simulate the water changes in a year. And the sediment component was also set according to the water volume. Water level changes with seasons were also considered. Several depositing cycles were used in which each stage included 3 sub stages to simulate the courses in the low, medium and high base level respectively. During all the experience, the process was recorded by photos and recorder. After the deposition, densely spaced sections were cut to make a good description of the characters of the deposit after the deposit is dry.

After 26 days experience (with total depositing time about 224hours), the simulation gives a new view of the deposit. The correlation of sand distribution between the real drilled and the simulation indicates that there is much similarity, which means that it is possible to predict the sandstone distribution based on the experience. And the sand deposited in the experience also appears difference in the architecture. In the longitudinal and cross sections, it is clear that more channel sandstone in the places near to the province and more shale near the lake. Scour is common near the province and progradation is obvious near the shore, which makes the sand more continuous. While in the lake the sand is more isolated. The center of the sand is along the shore line, which indicates a good correlation between the subsidence and the deposit supply. But there is also deposit on the places above the base level, which indicates the temporary sediment can also be preserved. The study of the same channel indicates the depositing center moves quickly with the change of the lake level. The progradation and regression of the channel made the sand spread in a large distance along the channel. The shale in the high lake level may compartment the sandstone, while deposit with little shale in the low lake level is more suitable for the formation of wide spread sandstone.

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Seismic architectures of Neocene sandstone in Bohai Bay

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Prospection over the last years revealed important hydrocarbon reserves in the Neocene of Bohai Bay, China. Reservoir rocks are originated from shallow lake deltas. Differences in geometries of the sandbodies, especially their rapid change in thickness, resulted in reservoir architectures making predictions a difficult task for exploration. In order to make a better understanding of the reservoir, the architecture of the sandbodies was analysed using seismic characteristics. After detailed correlation between well logging and seismic data, stratigraphic framework was established and seismic reflection characteristics of typical sandbodies were analysed.

As a main hydrocarbon-bearing layer, Neocene sandstones have a large difference in the architecture of the seismic reflection characteristics including their continuity and amplitude variation. Corresponding proportional slices were used for the inversion of seismic reflection properties, and these properties indicate that RMS (root mean square amplitude) has a good correlation to the lithofacies. High values in RMS indicate thick sandstone bodies, while low RMS indicates shale or shaly sand. In the RMS picture, we use bright yellow and red colour to represent the high values and blue and green colour to represent low values. According to the architecture of RMS values in the slices, especially the high value reflection character, three types of reflection geometry were differentiated.

A narrow string shape with similar direction and large length holding high RMS values characterizes the first type. Two subtypes were identified including bifurcate and converging stripe, and divergent stripe. In the first subtype, the high value area is focused due to very narrow string in all of the slices. There may be several strings distributing along the similar direction. In some places they maybe parallel or cross to each other. As to the other subtype, the divergent stripe has the high value of RMS that is usually a narrow string, bifurcates to two or more stripes and then each string may transfer to several others in certain distance. The whole geometry is present as a fan shape.

In the second type high value areas are continuous and widely developed. The internal architecture is different. On some slices, the high value area shows a good organized internal architecture. It is clear that it corresponds to many small fans indicating similar depositing direction while in other slices, the high value areas are randomly distributed. Although it is continuous as a whole, it is much concentrated in some places.

In the picture of third type, areas of red and yellow colour are limited, irregularly dotted in the blue and green colours, which indicates a poor development of sandstone. The shape of the area of red and yellow colour is also irregular too, and is not clear.

Sedimentary study shows that these deposits formed in a shallow water environment. The shale is mainly grey and green in colour indicating a weak reducing environment, while purple and yellow colours, quite often found in oxidizing environments are also present. Interlayer of different colours indicates quick changes in environment which are often found near shore within shallow waters.

The architecture with string shape of high value area may be the result of meandering river and delta environment. While the second type of architecture with large area high value may be formed by the braided river and delta. The last type of architecture is formed in a lake where waves play an important role.

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Morphology of active cyclic steps created by turbidity currents on Squamish Delta, British Columbia, Canada

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The Ocean Mapping Group of University of New Brunswick, Canada have developed a strategy for precise acoustic resurvey that can resolve active turbid flow and associated fine-scale seabed change. They have performed field observations of turbidity currents and seabed topography on the Squamish delta in Howe Sound, British Columbia, Canada, and found bedwaves actively migrating in the upstream direction in channels formed on the prodelta slope. Their topography and behavior suggest that they are cyclic steps formed by turbidity currents. Because Squamish delta is as shallow as around 150 m, and easy to access compared with general submarine canyons formed on continental slopes, it is thought to be one of the best places for studying characteristics of cyclic steps formed by turbidity currents through field observations. In this study, we have analyzed configurations of cyclic steps with the use of data obtained in the field observation of 2011.

The 70-100kHz multi-sector multibeam sonar (EM710) mounted on the survey vessel CSL Heron had been used to obtain the bathymetry. The area covered includes the delta top channel and the prodelta slope extending from the delta lip to water depths of ~200m over a distance of about 3500m. On the prodelta slope, three major active channels are clearly developed. In addition to the sonar survey, a 600 kHz ADCP was installed in 150m of water just seaward of the termination of the North Channel. Twenty discrete turbidity current events were detected.

We selected images showing large daily differences. From the digital terrain models, the profiles perpendicular to the bedwave crest lines through the center of channels were made by GIS software (QGIS). Then wavelength and wave height for each step, mean slope, and the distance of daily migration of the steps were measured on the software for quantitative image analyses (AreaQ) manually. Wave steepness for each step was calculated using the wavelength and wave height measured as above.

In this abstract we introduce the result for the North Channel from JD175 to JD181 in 2011. The steps move vigorously at the upper 600m parts of the prodelta slope. In the uppermost 164m, mean slope is 6.8°, mean wavelength and wave heights of steps are 30.5m and 4.8m respectively, and therefore the wave steepness is 0.17. From 164m to 325m, mean slope, mean wavelength and wave heights of steps and wave steepness are 4.9°, 32.5m, 4.6m, and 0.15. From 325m to 437m, 3.5°, 28m, 2.9m, 0.09. From 437m to 600m, 2.9°, 24.5m and 2.4m, 0.10. Steps generally show an asymmetrical shape, the longer upstream sides and the shorter downstream sides. As described above, the steps become smaller and flatter toward the downstream. Steps migrate upstream direction actively in this period. Comparing the images of JD175 and JD178, largest amount of migration is about 4.76m. In the other channels, such as Central and South Channels, the largest amount of migration exceeds 10m for one day. Comparing with the cyclic steps developed on the levees in the deep submarine canyon, steps in the Squamish prodelta slopes are smaller in size, and much larger, 10 to 100 times larger, in wave steepness. Steeper slope may affect these differences in morphology.

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Late Quaternary seismic stratigraphy of the inner shelf deposits off the Nakdong River, SE Korea

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The high-resolution seismic profiles from the inner shelf off the Nakdong River in SE Korea can be directly correlated with the lithologic characters in the borehole data. These correlations offer an opportunity to document the evolution of the inner shelf deposits with sediment supplies in response to the late Quaternary sea level changes. The inner shelf sequence in this area consists of four sedimentary units, which comprise a set of lowstand, transgressive, and highstand systems tracts deposited since the last glacial maximum: incised-channel fill (SU1), estuary (SU2), sand veneer (SU3), and subaqueous delta (SU4).

The lowermost unit (SU1), which overlies the sequence boundary, is interpreted as fluvial deposits formed during the last glacial period and the early stage of transgression and belongs to the lowstand to transgressive systems tract. The lower middle unit (SU2) lying below the ravinement surface represents a paralic component that consists of estuarine sandy mud or muddy sand developed between approximately 13 and 8 cal kyr BP, whereas the upper middle unit (SU3) above the ravinement surface corresponds to a marine component that consists of sand veneer produced by the shelf erosion during the ensuing sea-level rise (8 - 6 cal kyr BP). These two units (SU2 and SU3) belong to the transgressive deposits. The uppermost unit (SU4) regarded as the highstand systems tract formed the Nakdong subaqueous delta including the proximal and distal systems developed after the highstand sea level at approximately 6 cal kyr BP. The lateral transition from the proximal to distal facies suggests a prograding delta system in the Nakdong River.

A new method to identify sedimentary microfacies using well logging data

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Vertically and horizontally, sedimentary facies belt controls reservoir's geometrical distribution. Thus, analyzing distribution of under-ground sedimentary microfacies has great significance for oil & gas exploration and development.

Recent developments in petroleum and natural gas exploration & production have raised extensive interest in unconventional reservoir. Undoubtedly, It is important to understand reservoir distribution for finding sedimentary microfacies. Well logging data is extremely important in evaluating reservoir sand body connectivity, from which depositional environments and depositional features can be acquired. Well logging data is characterized with large quantity as well as high resolution especially in areas with lots of exploratory wells, evaluation wells and development wells.

Different depositional environments correspond to different logging curves with unique values and curve shapes. Based on this principle, a novel method is proposed to analyze the distribution of under-ground sedimentary microfacies. In order to characterize the sedimentary environment, thirteen well log parameters are used. Furthermore, The geological condition factors including reflecting hydrodynamic condition, depositional energy, depositional cycle, sedimentary source recharge situation and sea level fluctuations, and microscopic parameters including lithology granularity, porosity, permeability, shale content and rock inhomogeneity, are analyzed. The information extracted from above parameters fullfills the characterization requirements for different depositional environments. Plus, The effective combination of these parameters provides a lot of information for reservoir evaluation. For example, parameters in similar numerical range represents same sedimentary environment; parameters, the values of which vary abruptly, represents the lithology transformation or flow unit transformation. This method is trying to compare and contrast logging waves' patterns and trends, therefore, this method is named Patterns and Trends Comparing and Contrasting.

In this paper the authors review the approaches taken to explore sedimentary facies distribution in an in-situ example which have extensive log, core data and experimental data, which shows that it is reasonable and accurate in detecting the reservoir extent by using the method of Patterns and Trends Compare and Contrast.

The diagenetic evolution modes of the deep formation of Jiyang sub-basin in Bohai Bay Basin, Paleogene

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Methods

The diagenetic evolution modes of clastic rocks in deep formation of Paleogene in the main areas of Jiyang sub-basin were researched through thin-section analysis, scan electricity microscope observation, inclusion analysis, Ro test, and reservoir physical parameters analyses, etc and combining histories of tectonic development and organic maturation.

Results

It was recognized that there are six types of diagenetic alteration modes in it. The first is the diagenetic evolution mode of moderate - strong overpressure, compaction, cementation and dissolution with the multiple diagenetic medium on the gentle slope or in the deep sag. The second is the diagenetic alteration mode of weak overpressure - normal pressure, little strong compaction, moderate cementation and strong dissolution in the deep sag. The third is the diagenetic alteration mode of weak - moderate overpressure, little strong compaction and cementation and strong dissolution with the thermal fluid in the deep sag. The forth is the diagenetic evolution mode of moderate - strong overpressure, strong compaction, little strong cementation and dissolution in the deep sag. The fifth is the diagenetic alteration mode of normal pressure, moderate - strong compaction, strong cementation and weak dissolution with the thermal fluid on the steep slope and the sixth is the diagenetic alteration mode of normal pressure, strong cementation and moderate – weak dissolution with the multiple diagenetic medium on the steep slope.

The properties of reservoir with the diagenetic evolution mode of moderate - strong overpressure, compaction, cementation and dissolution with the multiple diagenetic medium on the gentle slope or in the deep sag and the diagenetic alteration mode of weak overpressure - normal pressure, little strong compaction, moderate cementation and strong dissolution in the deep sag are better than those reservoir with the other modes. The porosity of the reservoir with the diagenetic evolution mode of the normal pressure, strong cementation and moderate – weak dissolution with the multiple diagenetic medium on the steep slope is lowest.

Conclusions

It's considered that the stratum and buried depth, tectonic background, reservoir pressure, deep thermal fluid and multiple diagenetic medium are the main factors influencing the reservoir properties evolution of the deep formation in Jiyang sub-basin of Bohai Bay Basin, Paleogene.

Key words diagenetic evolution mode, porosity, influencing factor, deep formation, Paleogene, Jiyang sub-basin, Bohai Bay Basin

Sedimentary features and patterns of organic-rich shale in Triassic lacustrine facies in the Ordos Basin, China

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Organic-rich shale in lacustrine facies in the Ordos Basin is mainly distributed in Ch7 Member of Triassic Yanchang Fm. It is the most important source rock and target layer for tight oil exploration in Mesozoic System in the Ordos Basin. We compiled industrial maps of lithofacies-sedimentary facies of three sub-members of Ch7 Member, depicted their fine-grained sedimentary systems, and revealed their distributing features of lithofacies-sedimentary facies. With several measures and methods, such as thin section observation, X diffraction, geochemical test, and quantitative calculation on organic carbon logging, we revealed the relationship between petrologic features, laminated texture and organic matter development in organic-rich shale, set up a sedimentary pattern that is dominated by transgression-water stratification, and proposed that sedimentary facies belt is the major controlling factor for the development and distribution of organic-rich shale.

(1) In lower Ch7 Member, shale facies was well developed, and the deep lake sediments are dominant, covering an area of 5×104km²; delta facies were mainly developed in the northeastern area. In middle Ch7 Member, mudstone and fine sand facies are dominant, and shale facies decrease, which means that deep lake facies began to abort; large deltas are developed in the northeastern and southwestern areas and extend to the lake, leading to the development of large sandy debris deposits in deep lake. In upper Ch7 Member, fine sand facies are predominant, which reflects that deep lake facies further decrease to the southeast; large deltas were continually developed in the northeastern, southwestern and northwestern areas; the scope of sandy debris sediments in deep lake extended further. (2) Organic-rich shale in this study area is mainly composed by terrigenous debris minerals, such as clay, quartz and feldspar, followed by organic matters like kerogen and some chemogenic and authigenic minerals like pyrite and calcite. By thin section observation, it is found that laminated textures are well developed in organic-rich shale, and most of them are “ternary” structure composed by terrigenous debris minerals, clay and organic matter bands. Organic carbon content in organic-rich shale is generally 4-12% or even up to 20%. By geochemical test and quantitative calculation on organic carbon logging of typical wells, we discover that organic carbon contents in vertical distribution have apparent cycling feature. Analysis indicates that tuff and organic carbon contents developed during the sedimentation of lower Ch7 Member have positive correlation, i.e., volcanic ash is a favor factor for the prosperity of pelagic organisms. (3) The sedimentation period of Ch7 Member was the most important stage of Triassic transgression in the Ordos Basin. During the sedimentation of lower Ch7 Member, the lake area was more than 10×104km², water depth in deep lake could be 150mm, and water salinity was generally less than 0.01%, belonging to fresh water environment. By investigating the distribution of organic-rich shale in space, we propose that the major controlling factors for organic-rich shale distribution include sedimentary facies, water depth, anoxic environment and lake flow. In deep lake that is far away from delta front, organic-rich shale was well developed, with high organic carbon content and mainly sapropel type kerogen. In deep lake rich in sandy debris flow, organic-rich shale is interbedded with sandstone, which contains high organic carbon content and sapropel type kerogen, and the sandstone in debris flow is favor of the preservation of organic matters in underlying shale. In semi-deep lake that is close to delta front, silty mudstone in wavy-block like styles were developed, mainly with humic-sapropel type kerogen.

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The effect of tectonic evolution on syn-rift sediment deposition in Binhai Structural Belt of Qikou Sag, Bohaiwan Basin

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The Qikou Sag is a significant hydrocarbon bearing basin, which is located in the center of Bohaiwan Basin, eastern China. Its formation was resulted from superimposition of the extension and strike-slip activities and mainly filled with Eocene-Oligocene syn-rift sediments and Miocene to Quaternary post-rift sediments. The Binhai Structural Belt is an important potential exploration target in the Qikou Sag. However, the previous hydrocarbon exploration of this area was seriously restricted by the poor understanding of the location of potential reservoirs due to the complex tectonic features.

In this study, combination of high resolution 3D seismic, well logging data and integrated study of fault-geometry and fault-activity analysis, geomorphologic reconstruction and provenance study was used to examine the tectonic evolution and the sediment dispersal patterns as response to fault growth and geomorphologic evolution, and to predict the potential reservoirs. The results illustrate that the Binhai Structural Belt is characterized by a large-scale oblique transfer zone in the Qikou Sag and two different structural styles (half-grabens in the west and grabens in the east) developed respectively at the lateral sides due to the preexisting differential basement tectonic framework and long-termed activities of basement strike-slip faults. From south to north, the Binhai Structural Belt could be divided into two different anticlines based on their Cenozoic deformed structural geometries. A gentle flexure anticline in the southwest shows slight deformation and a complex fault-related fold in the northeast comprises Paleogene gravitational detachment faults and Neogene flower-like structures. Three distinct sediment supply systems are recognized. Coarse-grained fan delta sediments which were eroded from the Yanshan Thrust Belt and Cangxian Uplift were propagated along the oblique transfer zone and developed on the northeast fault-related fold during the syn-rift stage. The sediments were further transported and deposited along the subaqueous relay ramps and topography formed by horsetail-like faults. Dominant sandy debrites or high density turbidites were deposited in the distal of fan delta front. The west axial drainage was transported through incised channel and fault trough, and formed small fine-grained delta on the top of gentle flexure slope. Scattered low density turbidites (sandy or mud) developed at the center of deep-water lake. Therefore, the results clearly indicate that the typical structural styles and associated topography evolution exerted major impact on the syn-rift sediment distribution and dispersal patterns. The improved understanding of reservoir rocks, especial the subaqueous sandy debrites and turbidites, thus contribute to explore the potential lithologic petroleum reservoirs in the Binhai Structural Belt.

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The Meandering river reservoir architecture patterns based on Ground penetrating radar measurements

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The reservoir architecture of meandering river sandbody is controlled by base level cycle which is a representation of erosion and deposition. Taking the underground reservoir and the analog modern meandering river as the study areas, 3-D architecture pattern of meandering river sand body which controlled by base level cycle is studied based on Ground penetrating radar (GPR) measurements. On the basis of the architecture patterns, using the information from core, well logs, seismic data, and aided by well-seismic correlation, one approach of architecture analysis for single meandering belt, point bar and lateral accretion sandbody within a dense well drilling zone is proposed.

Based on the detailed studies of modern point bar deposit at the northern shore of Hulun Lake in Inner Mongolia, North China, the distribution patterns of point bar complex sets controlled by base level cycle is analyzed. It is found that as A/S increasing, the dimension of point bars complex sets become smaller, the connectivity of the point bars become weaker, and its shape is changing from flaky-like to point-like. The vertical profile of point bars in each cycle is changing from multilayers to isolated ones. The evolution pattern of single point bar in different base level cycle is investigated. As A/S increasing, the dimension of point bars and sinuosity of abandoned channels are decreasing. Based on deposition manner of single point bar which are downstream deposition, lateral deposition and upstream deposition, lateral accretion groups will be formed by several lateral accretion sand bodies and lateral accretion shale beddings which have same lateral accretion manner and distribution characteristics. Thus a simple lateral accretion stage of a single point bar is composed by single lateral accretion sandbody group. And a complex lateral accretion stage of a single point bar is formed by multiple lateral accretion sandbody groups. The abandoned channel architecture pattern is improved, compared with lower sinuous ratio part of a single meandering loop, the abandoned channel profile is more asymmetry, thalweg is closer to concave bank, and the bank full depth is deeper and bank full width is wider.

These architecture patterns instruct the underground architecture analysis, such as single meandering belt, point bar, lateral accretion sandbody and lateral accretion shale beddings and so on.

Sandy Braided River Channel filling Pattern in Yungang Formation, Jurassic, Datong Basin

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The characters of the hierarchy grades architecture elements are systematically analyzed based on the analysis of Wu Guantun outcrop which is the braided sandstone of Yungang formation, Middle Jurassic in Datong Basin, China. Through hierarchy bounding surfaces description, litho-facies analysis, architectural element identification and description, three kinds of braided river channel filling patterns are recognized as: sandy filling braided channel, semi-mud filling channel and mud-filling channel.

The fining upward grain size is one character of the sandy filling braided channel. Its litho-facies is Sm-St-Fsm. The centroclinal sedimentary character is clearly observed in the outcrops. The rapidly lateral litho-facies change is from small scale unregular lamina of oblique bedding in braided river channel to larger scale planar cross bedding of channel bar.

At the lower part of the Semi-mud filling channel is filled sandy sediments and upper part of it is muddy sediments. Although in same sedimentary period, the top of the sandy sediments in braided channel is lower than the sandy sediments of channel bar. The massive subtle cross-bedding can be found at the bottom of the lower part sandy sediments. While, silty and other finer sediments are found at the upper part. The litho-facies along vertical direction is Sm-Fm-Fl.

The mud-filling channel is filled with finer sediments and the main litho-facies is Fsm. The thin interbed of silt sand and muddy-coarse sandstone is found only locally. It can be easily separate the channel and its related channel bars using the clearly boundary surface defined by the litho-facies change. The sedimentary character is showing a character of centroclinal type.

The main explanation of sedimentary characters of those muddy and semi-muddy braided channel are: (1) The braided channel may have migrate laterally in a relatively high frequency. Thus, at the end of braided channel development history, the semi-mud filling channel will be appear at the inverse direction of the channel migration. (2) When it is in overflow stage of flood period, the merge and growth of the channel bar will also plug the braided channel locally.

The braided channel filling pattern obtained from this study brings abundances to the braided channel reservoir architecture pattern. It will instruct the underground channel and channel bar combination analysis.

Lake drying up in Northwest China and sand-dust weather in East Asia

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1 Introduction

Desertification and sand storms have caused widely social attentions for several years. Sand storms repeatedly attack Northern China, and the dust transport to Qingdao, Korean peninsula, and even Tokyo of Japan. Modern drying up lakes and deserts in Northwest China, such as Manas lake in Junggar basin, Juyan lake in Alashan Plateau and Yezhu lake in Minqin basin, have been investigated by the authors. Sediments in the dry lakebeds and granularity of sand dunes have been analyzed.

2 Testing methods

Nine sections were sampled at 5-10 cm interval for grain-size analysis and grading. The pretreatment procedures were designed suitable for samples in transitional zones. About 1g of dried sample was placed in a beaker and 10 ml of 10% hydrogen peroxide (H₂O₂) were added to remove organic material and 10 ml of 10% hydrochloric acid (HCL) were also added to remove any carbonates. Then the sample residues were washed by distilled water. Sample solution was then pretreated with 10 ml of sodium hexametaphosphate ((NaPO₃)₆) to facilitate dispersion. The samples were ultrasonically dispersed for 10 min before grain-size measurement, and grain-size grading was determined with a Mastersizer 2000 particle analyzer.

3 Results and discussion

The results show that more than 60% of surface sediments in dried lakebeds have the grain sizes smaller than 10µm, and that approximately 50% of those of sandy grassland in dried riverbeds have the grain sizes smaller than 10µm. Fine grain sediments lose rapidly in abounded farmland. Clayey sediments are less than 13.9% in abounded farmland in Minqin basin, Gansu Province. The active sand dunes in northwest China have little granular substances of which the grain size are smaller than 63µm, and those smaller than 10µm are less. Therefore, it is considered that sands from sand storms and dust weathers occurred in deserts in northern China and middle and east Mongolia have little affection on North China and East China, because the raising height and moving distance of coarse grain are limited. The material sources of dust weather affecting East Asia come not only from inner continental deserts in Western China, but also, and is more important one, from dried lakes, abounded farmlands and exposed sand and gravel grasslands.

Key words: dry-lake sediments, sand-dust weather in East Asia, Northwest of China

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